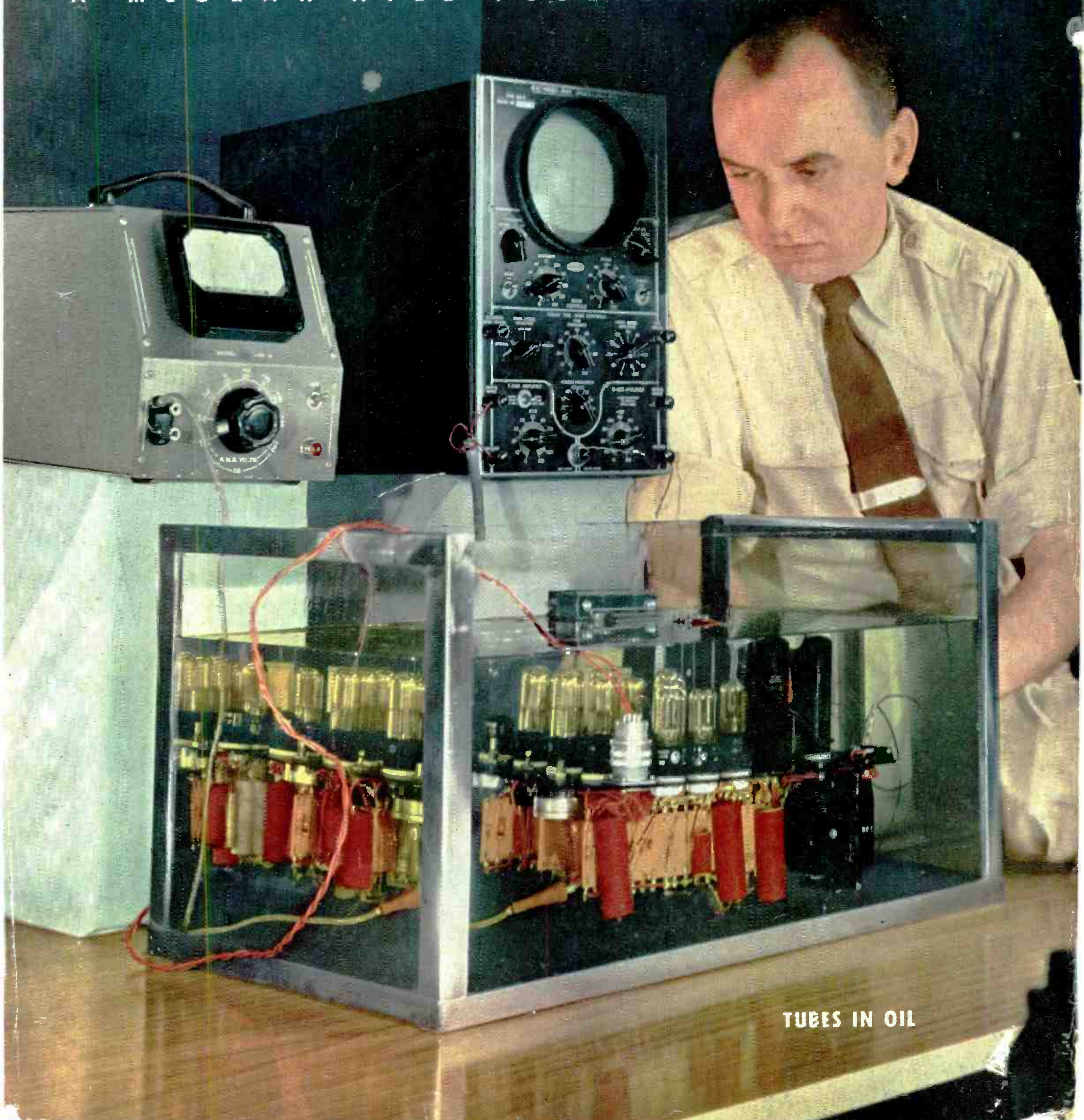
MARCH · 1948

electronics

A McGRAW-HILL PUBLICATION



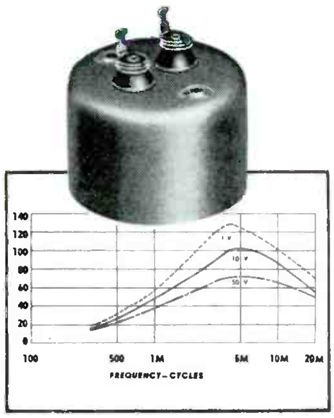
TUBES IN OIL

for HIGH Q TOROID INDUCTORS

There are many applications in the audio, carrier, and supersonic fields requiring inductors of high Q and great stability. The HQ series of units developed for these applications have remarkable characteristics, as illustrated below. HQA coils have high Q (100 at 5000 cycles) and are available in inductances from 5 MHY to 15 henrys. HQB coils have very high Q (200 at 4000 cycles) and are available in inductances from 10 MHY to 25 henrys.

HUM PICKUP is low due to the toroidal winding structure, 70 and 140 microvolts per gauss respectively for the HQA and HQB at 60 cycles.

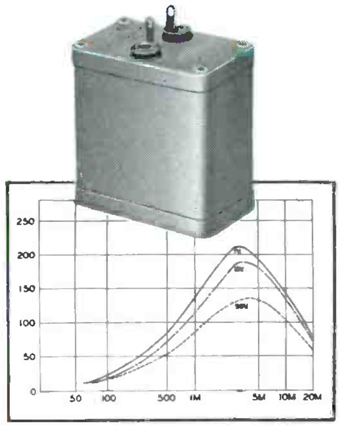
Stability is excellent. For the HQA-7 coil illustrated, inductance change is less than 1% for applied voltages from .1 to 25 volts 1000 cycles. For the HQB-5 coil illustrated, the inductance change is less than 1% for applied voltages from .1 to 50 volts 1000 cycles. Change in inductance due to DC current is approximately 1% per 10 MA linearly for the HQA unit illustrated and ¾% for the HQB. All cased units are hermetically sealed. Standard inductance tolerance is 1%.



TYPE HQA

DIMENSIONS—$1\frac{13}{16}$" Dia., x $1\frac{3}{16}$" H.—
Wt. 5 ozs.

Inductance Value	Type No.	Net Price
5 mhy.	HQA-1	$7.00
12.5 mhy.	HQA-2	7.00
20 mhy.	HQA-3	7.50
30 mhy.	HQA-4	7.50
50 mhy.	HQA-5	8.00
80 mhy.	HQA-6	8.00
125 mhy.	HQA-7	9.00
200 mhy.	HQA-8	9.00
300 mhy.	HQA-9	10.00
.5 hy.	HQA-10	10.00
.75 hy.	HQA-11	10.00
1.25 hy.	HQA-12	11.00
2. hy.	HQA-13	11.00
3. hy.	HQA-14	13.00
5. hy.	HQA-15	14.00
7.5 hy.	HQA-16	15.00
10. hy.	HQA-17	16.00
15. hy.	HQA-18	17.00



TYPE HQB

DIMENSIONS—2⅝" L. x 1⅝" W. x 2½" H.—
Wt. 14 ozs.

Inductance Value	Type No.	Net Price
10 mhy.	HQB-1	$20.00
30 mhy.	HQB-2	20.00
70 mhy.	HQB-3	20.00
120 mhy.	HQB-4	20.00
.5 hy.	HQB-5	20.00
1. hy.	HQB-6	22.00
2. hy.	HQB-7	24.00
3.5 hy.	HQB-8	25.00
7.5 hy.	HQB-9	26.00
12. hy.	HQB-10	27.00
18. hy.	HQB-11	28.00
25. hy.	HQB-12	29.00

UNCASED HIGH Q TOROIDS

We can supply any of the Toroids listed without case. Deduct $1.50. Specify type and inductance value when ordering.

SPECIAL TOROIDS

Sizes other than those shown in our stock list can be supplied on special order at price of next highest value. Type HQC and HQD coils, having maximum Q at 50 kc and 100 kc respectively, are also available.

N E W I T E M S

CG-50 DYNAMIC NOISE SUPPRESSION INDUCTOR

Incorporates two accurately tuned high Q inductors of .8 hy. and 2.4 hy., respectively, for use in dynamic noise suppressor circuits. Write for Circular No. CG-50 for additional details. . . . . List Price $16.00

CGE-1 UNIVERSAL INTERSTAGE EQUALIZER

This new UTC unit is the ideal device for any application requiring frequency response correction. Designed to be connected between two triode audio stages or will match a high impedance (5000 to 30000 ohms) source to grid. The CGE-1 equalizer is not a simple R-C tone control, but employs resonant circuits to permit low or high end equalization without affecting mid-frequencies.

Write for completely detailed manual.

CGE-1 Panel Dim. 2⅜ x 4" . . . . List Price $25.00

United Transformer Corp.

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electronics

A McGRAW-HILL PUBLICATION

MARCH • 1948

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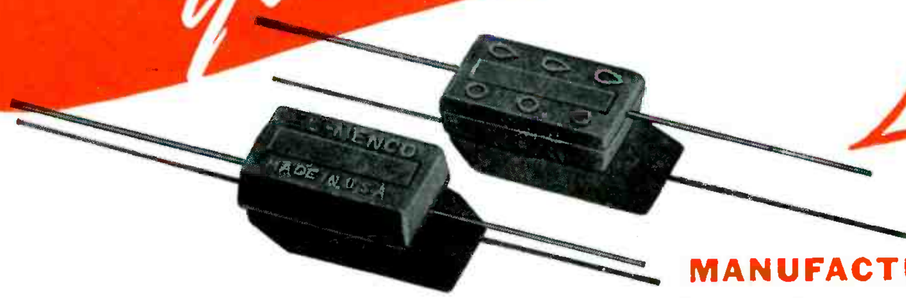

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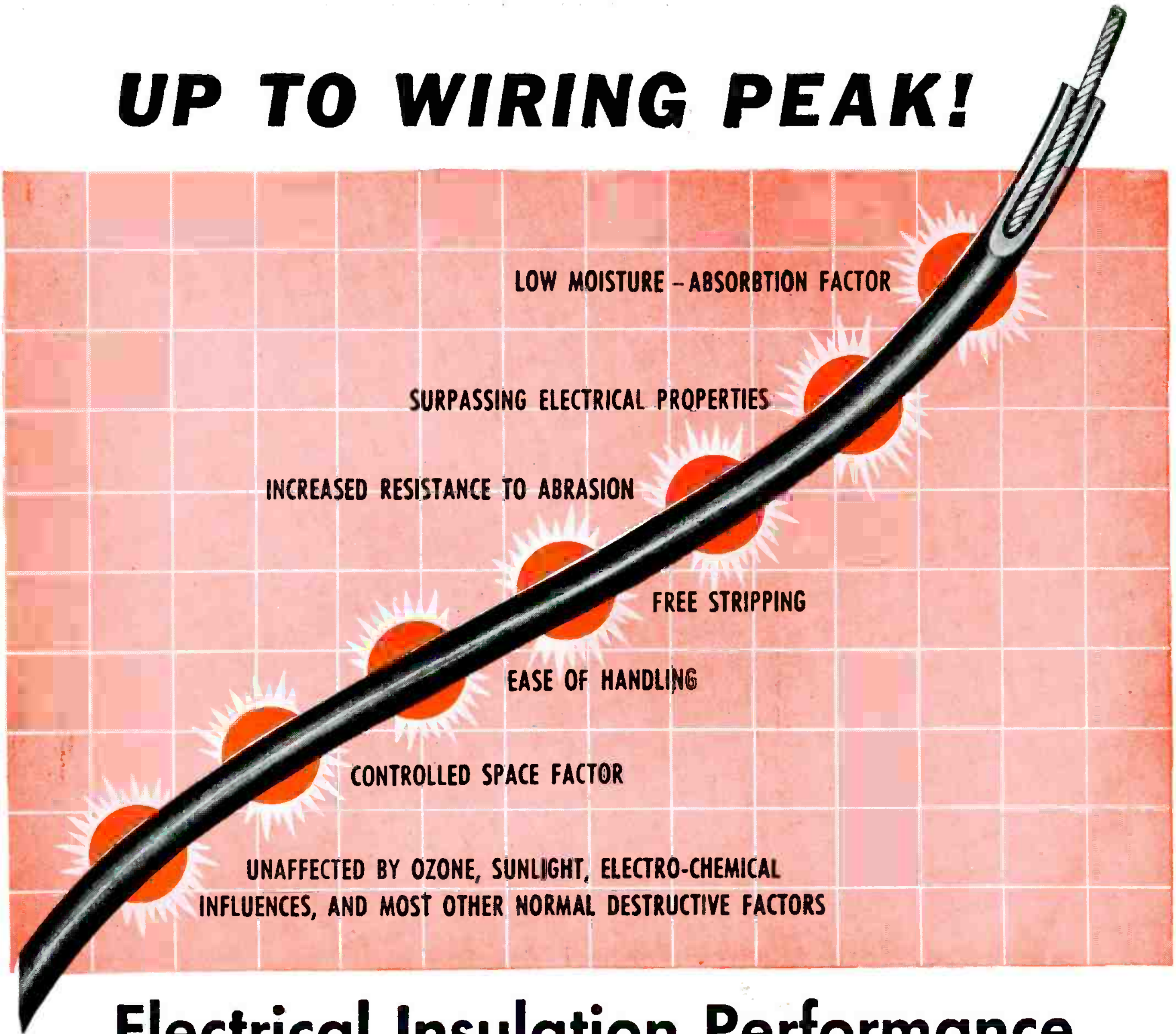

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TURBOTHERM PLASTIC INSULATED WIRE

Beyond which TURBOTHERM Insulated Wire, available with solid or stranded copper conductor, offers a flexible, assembly-facilitating process. This means production-time economy right at your own line and bench-manufacturing points. Your requirements of insulated wire within the gauge range of No. 14 down to No. 30 can be most advantageously served by TURBOTHERM. Ask for samples and become convinced.

Underwriters Laboratories Approved for 80 degree C. Appliance, Radio Hook-up and Instrument Wire; T. F. and T. F. F. for decorative wall brackets and candlelabra lighting fixtures, and small electrical tools and controls, where operation in oil at 60 deg C. is a requisite.

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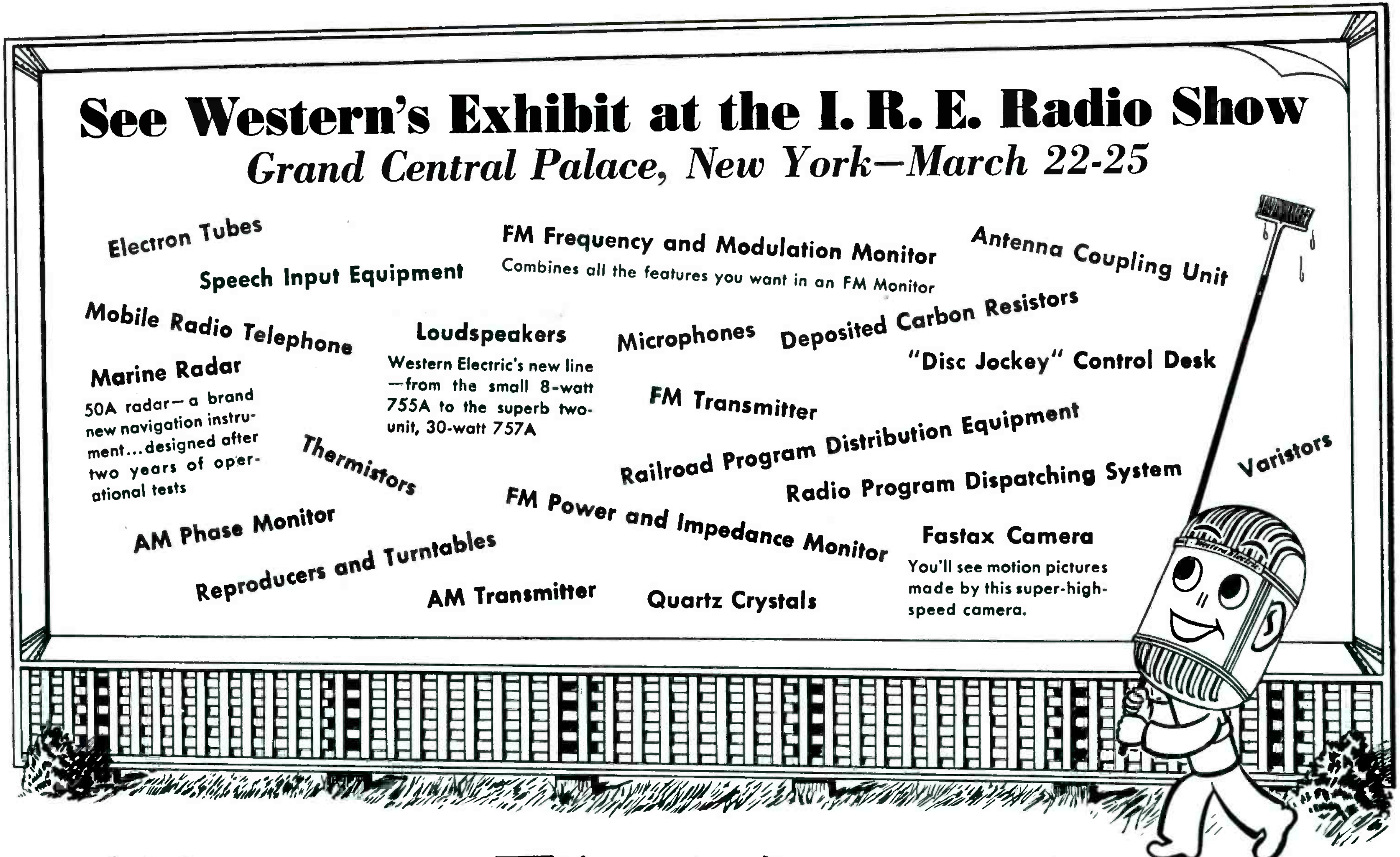

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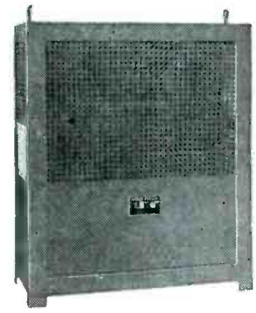
3-Phase Regulation

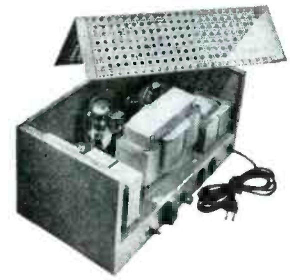
MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
3P15,000	1500-15,000	0.5%
3P30,000	3000-30,000	0.5%
3P45,000	4500-45,000	0.5%

• **Harmonic Distortion on above models 3%. Lower capacities also available.**



Extra Heavy Loads

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
5,000+	500 - 5,000	0.5%
10,000+	1000-10,000	0.5%
15,000+	1500-15,000	0.5%



General Application

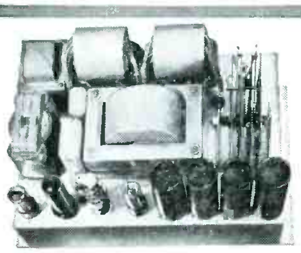
MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
150	25 - 150	0.5%
250	25 - 250	0.2%
500	50 - 500	0.5%
1000	100-1000	0.2%
2000	200-2000	0.2%

400-800 Cycle Line

INVERTER AND GENERATOR REGULATORS FOR AIRCRAFT.
Single Phase and Three Phase

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
D500	50 - 500	0.5%
D1200	120-1200	0.5%
3PD250	25 - 250	0.5%
3PD750	75 - 750	0.5%

Other capacities also available



The NOBATRON Line

Output Voltage DC	Load Range Amps.
6 volts	15-40-100
12 "	15
28 "	10-30
48 "	15
125 "	5-10

• **Regulation Accuracy 0.25% from 1/4 to full load.**

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The First Line of standard electronic AC Voltage Regulators and Nobatrons

GENERAL SPECIFICATIONS:

- Harmonic distortion max. 5% basic, 2% "S" models
- Input voltage range 95-125: 220-240 volts (—2 models)
- Output adjustable bet. 110-120: 220-240 (—2 models)
- Recovery time: 6 cycles: + (9 cycles)
- Input frequency range: 50 to 65 cycles
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- Ambient temperature range: —50°C to +50°C

All AC Regulators & Nobatrons may be used with no load.
*Models available with increased regulation accuracy.

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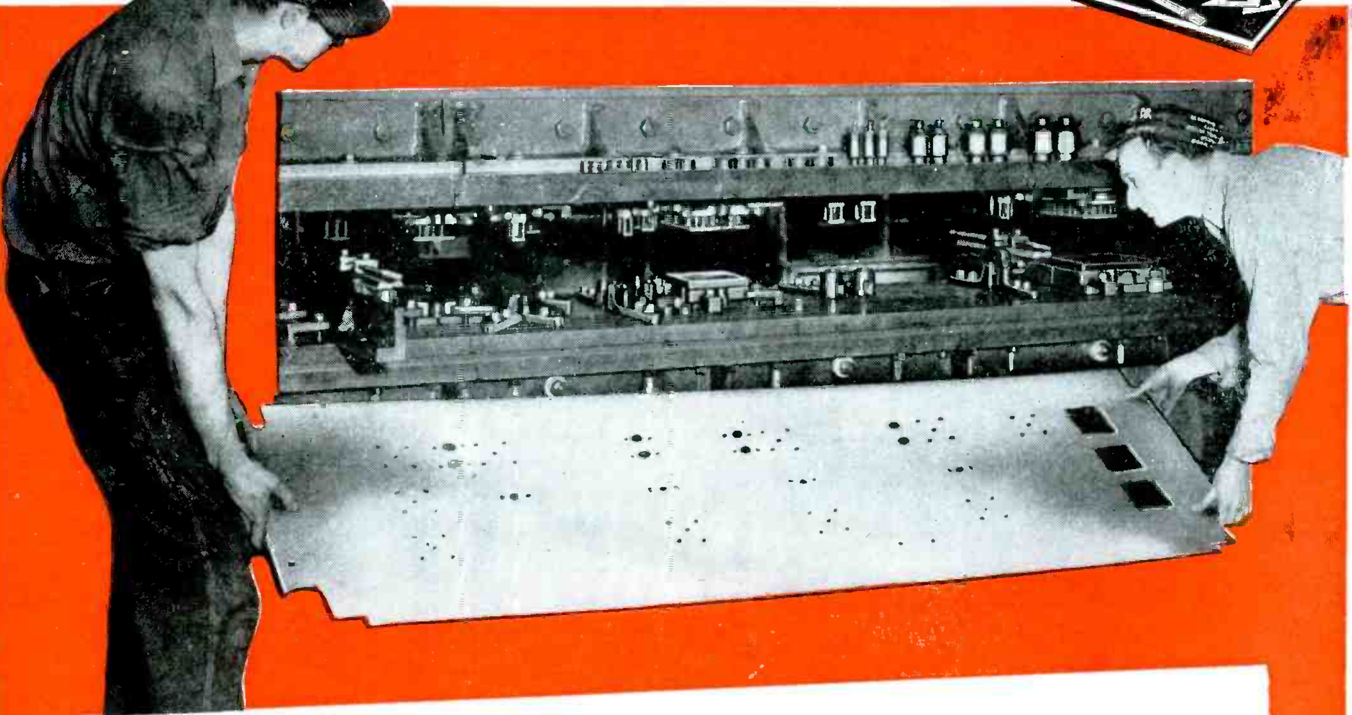
Meet sudden change-orders without tying up Press Production



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quickly and easily rearranged

Change-orders from the engineering department usually cause plenty of headaches in production . . . particularly where die piercing operations are involved.

But . . . if you're using Whistler Adjustable Dies, there is no lost time —no waiting—no extra die expense. The same dies are easy to rearrange to the new design. Add units from stock, or delete sizes and shapes no longer required. Arrange the new set-up right on the press.

Consider the savings in production time alone. Then think how continued re-use of the same dies in subsequent jobs writes off first cost.

Whistler Dies can be used in practically any press. All parts are interchangeable. Precision is assured on long or short runs. Closer centers permit fewer press operations.

Deliveries are quick . . . little or no waiting. Standard round punches and dies up to 3″ are available from stock. Ovals, squares, rectangles and special shapes can be made up in a few days. Write for the Whistler Catalogs today and get all the facts.

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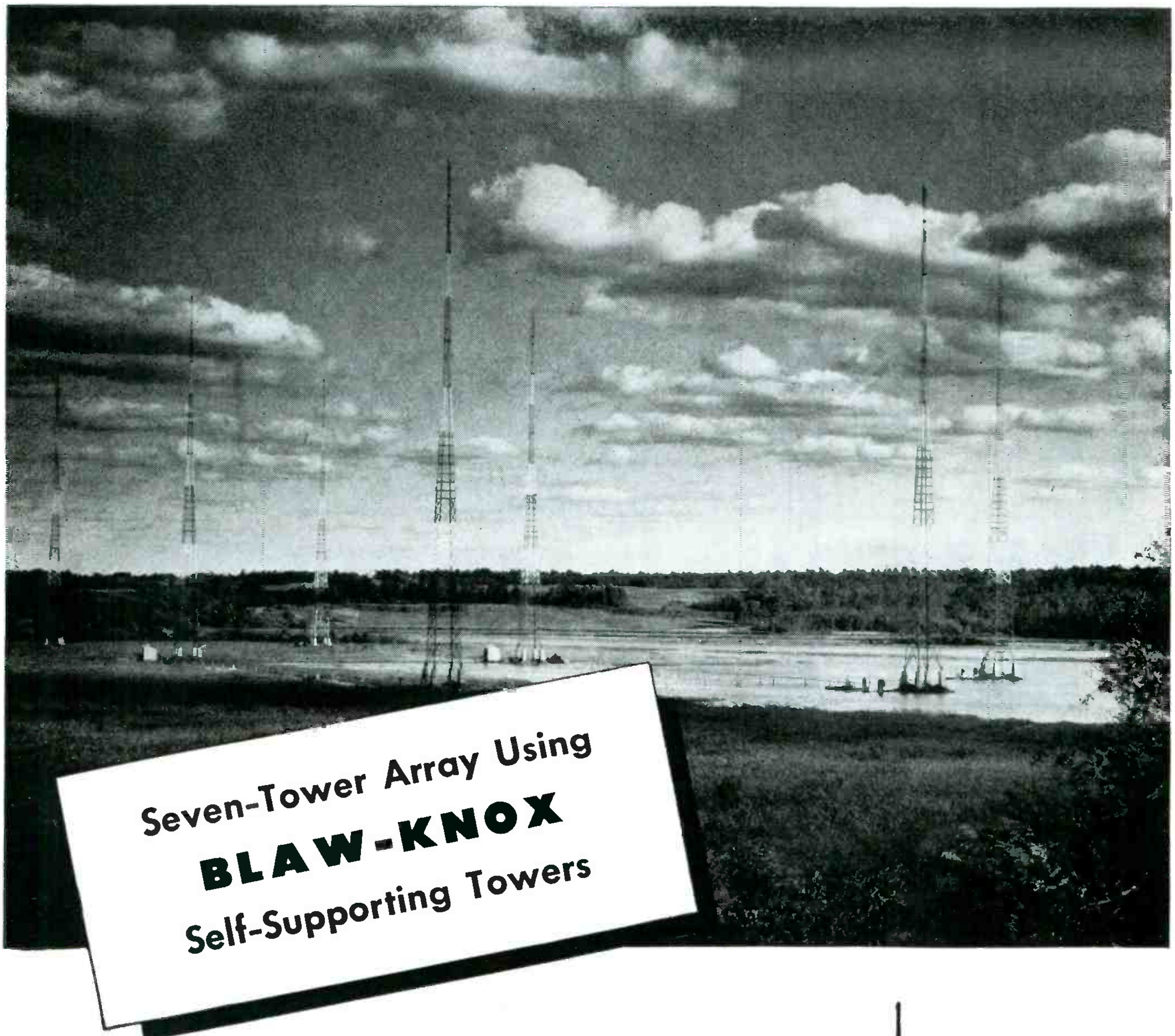

This seven-tower directional array was designed to protect several stations operating on the same frequency. Six towers are used during the night and the seventh, with two night pattern towers, give excellent daytime coverage. Due to the location it was necessary to place gravel fills through the ice to a depth of over 30 ft. before pile foundations could be driven to solid ground. Towers are Blaw-Knox Type CN, base insulated 225 ft. high.

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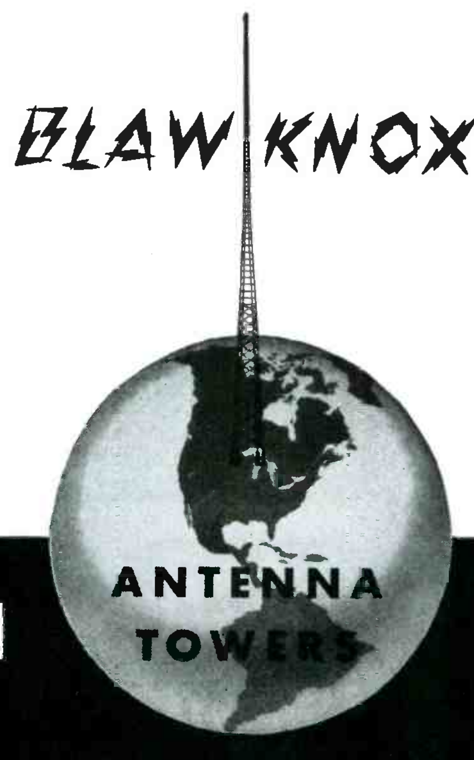

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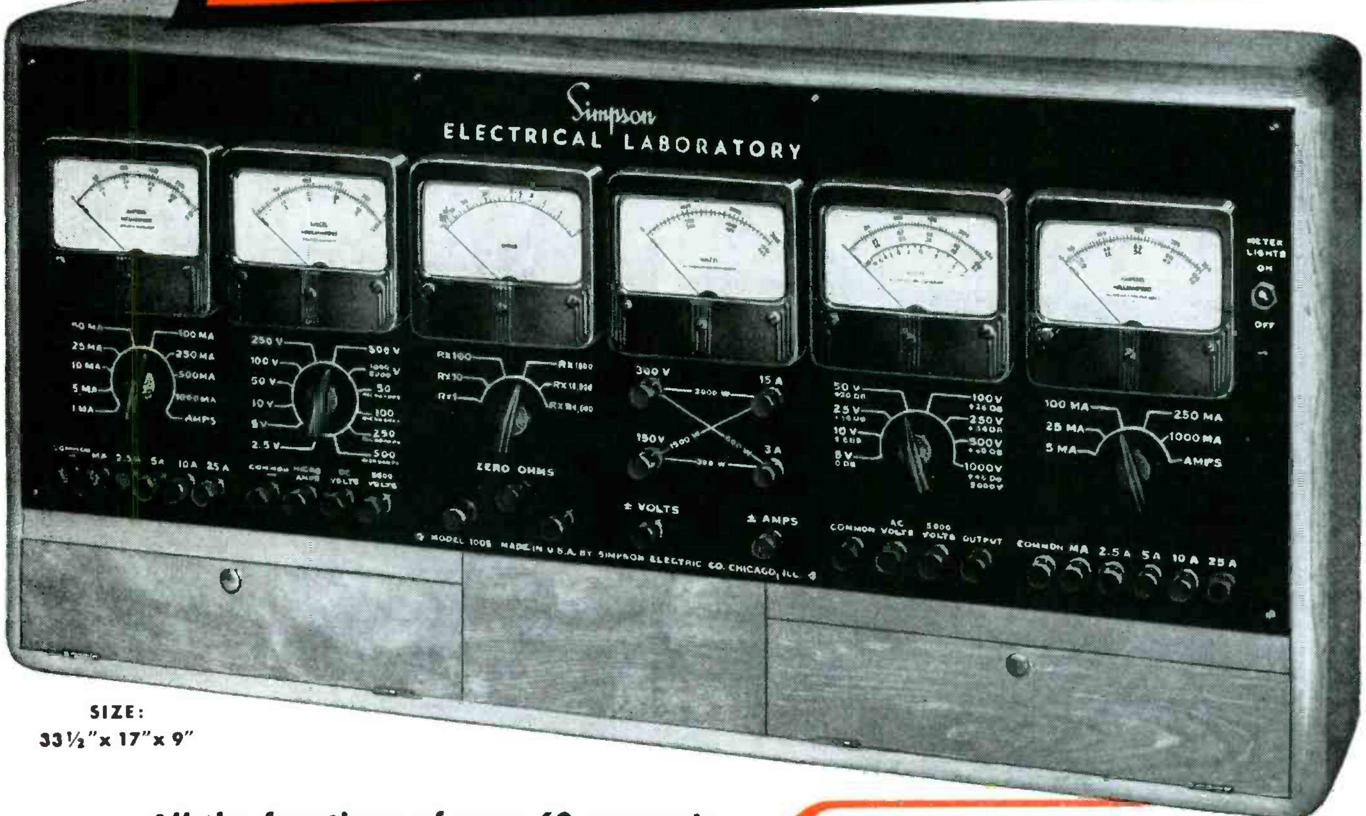
SIMPSON ELECTRICAL LABORATORY
MODEL 1005



SIZE:
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All the functions of over 60 separate instruments combined in one unit!

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In addition to the wide variety of A.C. and D.C. voltage and current ranges, a multi-range ohmmeter and a single phase wattmeter have been incorporated. Also, to meet the need for extreme sensitivity required in testing circuits where only a small amount of current is available, an instrument is provided with a sensitivity of 50 microamperes, providing 20,000 ohms per volt on all D.C. voltage ranges. The Electrical Laboratory incorporates a rectifier type instrument for measuring A.C. voltage with a resistance of 1,000 ohms per volt on all ranges. This latter instrument also has in combination a complete coverage of DB ranges, from minus 10 to plus 54 for volume indications.

This beautiful instrument is Simpson-engineered and Simpson-built throughout for lifetime service.

Dealer's Net Price, complete with Leads and Break-in Plug, $218.00

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Meter No. 1 (D.C. Milliammeter and Ammeter)
0-1 MA. D.C.
0-5 MA. D.C.
0-10 MA. D.C.
0-25 MA. D.C.
0-50 MA. D.C.
0-100 MA. D.C.
0-250 MA. D.C.
0-500 MA. D.C.
0-1000 MA. D.C.
0-2.5 Amps. D.C.
0-5 Amps. D.C.
0-10 Amps. D.C.
0-25 Amps. D.C.

Meter No. 2 (D.C. Microammeter and Voltmeter)
0-2.5 Volts D.C.
0-5 Volts D.C.
0-10 Volts D.C.
0-50 Volts D.C.
0-100 Volts D.C.
0-250 Volts D.C.
0-500 Volts D.C.
0-1000 Volts D.C.
0-5000 Volts D.C.
20,000 ohms per volt
0-50 Microamps
0-100 Microamps
0-250 Microamps
0-500 Microamps

Meter No. 3 (Ohmmeter)
0-500 Ohms (5 ohms center)
0-5000 Ohms (50 ohms center)
0-50,000 Ohms (500 ohms center)
0-500,000 Ohms (5,000 ohms center)
0-5 Megohms (50,000 ohms center)
0-50 Megohms (500,000 ohms center)

Meter No. 4 (Wattmeter)
0-300 Watts A.C.
0-600 Watts A.C.
0-1500 Watts A.C.
0-3000 Watts A.C.

Meter No. 5 (A.C. Voltmeter, Output and DB meter)
0-5 Volts A.C.
0-10 Volts A.C.
0-25 Volts A.C.
0-50 Volts A.C.
0-100 Volts A.C.
0-250 Volts A.C.
0-500 Volts A.C.
0-1000 Volts A.C.
0-5000 Volts A.C.
Rectifier type 1000 Ohms per volt
DB Ranges
—10 to +54
Output Ranges same as volts except 5000 Volt Range

Meter No. 6 (A.C. Milliammeter and Ammeter)
0-5 MA. A.C.
0-25 MA. A.C.
0-100 MA. A.C.
0-250 MA. A.C.
0-1000 MA. A.C.
0-2.5 Amps. A.C.
0-5 Amps. A.C.
0-10 Amps. A.C.
0-25 Amps. A.C.

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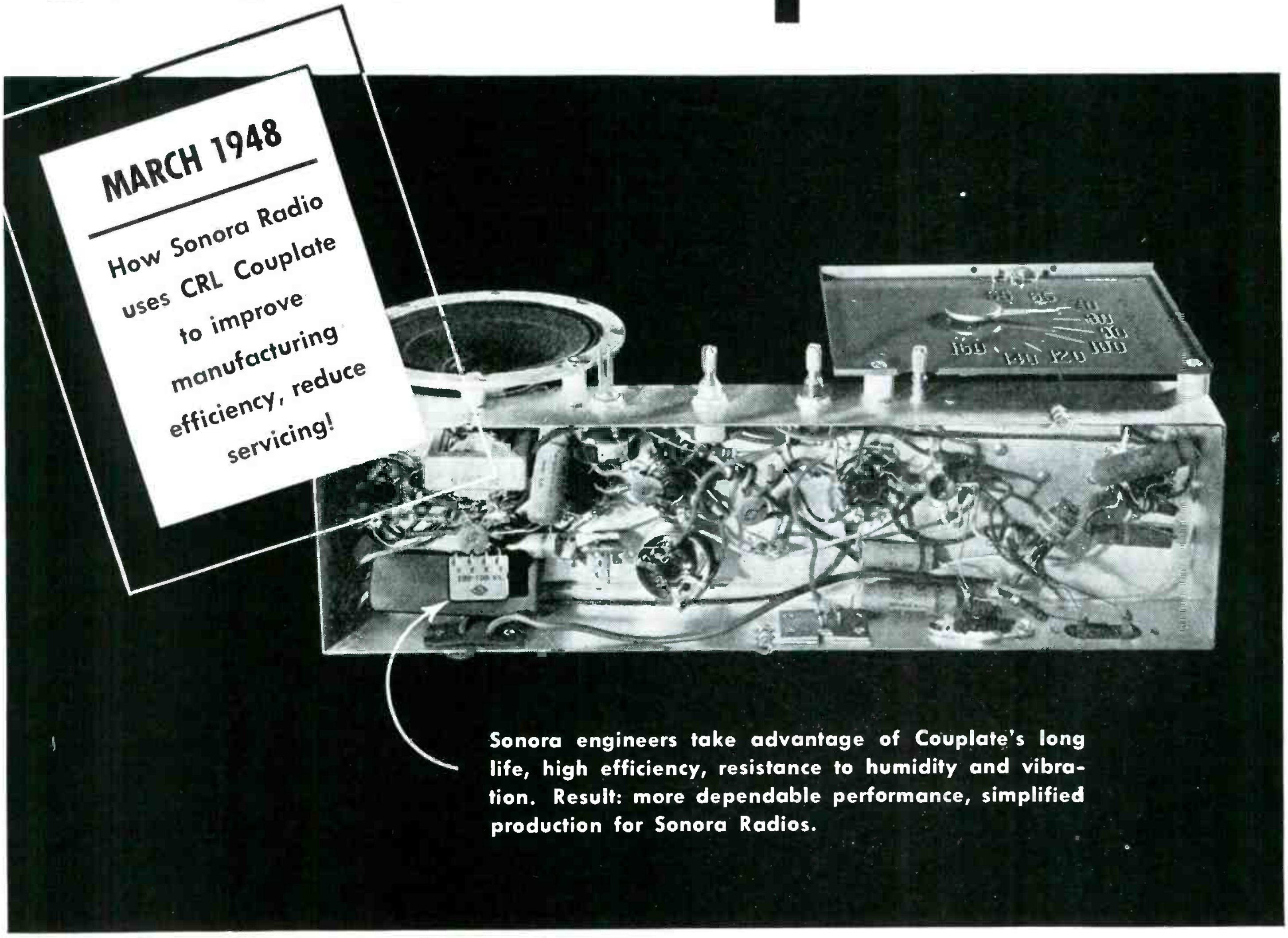
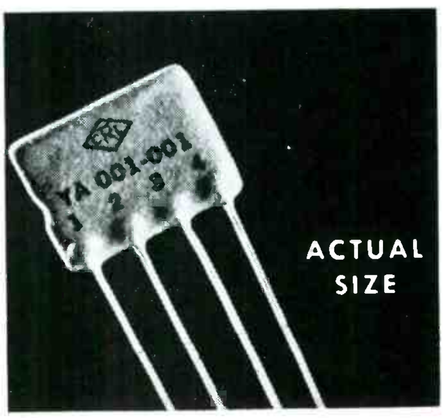
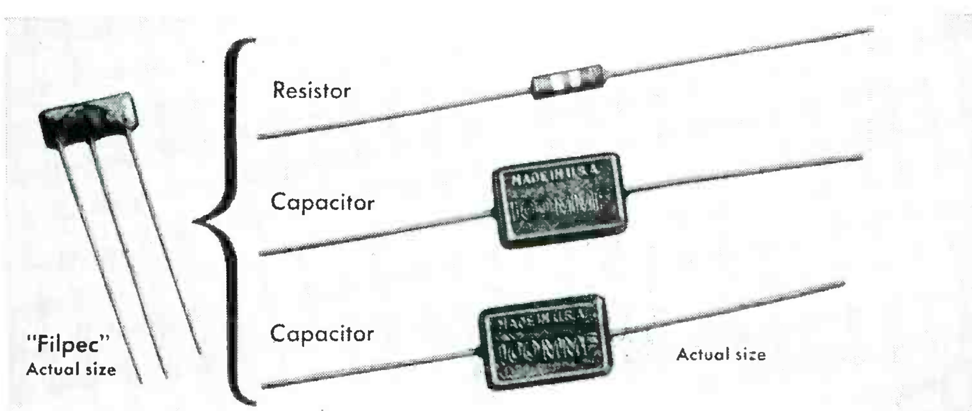


1 First commercial application of Centralab's revolutionary "Printed Electronic Circuit"—the *Couplate* gives you four basic manufacturing advantages: 1) Requires only four soldered connections instead of eight; simplifies wiring and production. 2) Saves space and mass weight, permits more compact and dependable finished equipment at lower cost. 3) Improves set performance by lengthening life, gives you a complete "printed" interstage coupling circuit. Chassis courtesy of Sonora Radio and Television Corp., Chicago.

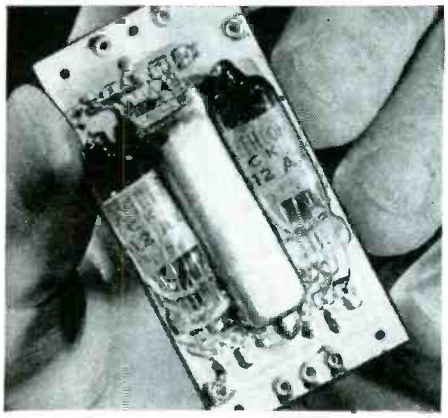


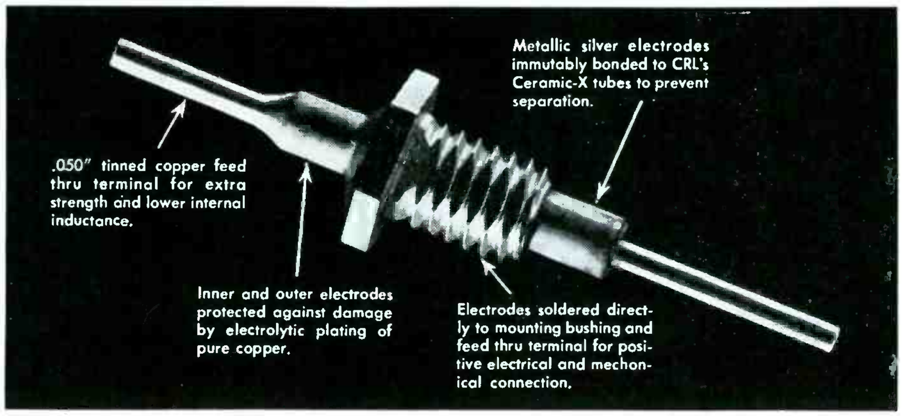


2 CRL's *Couplate* consists of a plate load resistor, grid resistor, plate by pass capacitor and coupling capacitor. Write for Bulletin 943.

3 Another application of the "Printed Electronic Circuit" is Centralab's *Filpec!* Designed for use as a balanced diode load filter, *Filpec* combines up to three major components into one tiny filter unit, lighter and smaller than one ordinary capacitor. Available for other applications. Send for Bulletin 976.

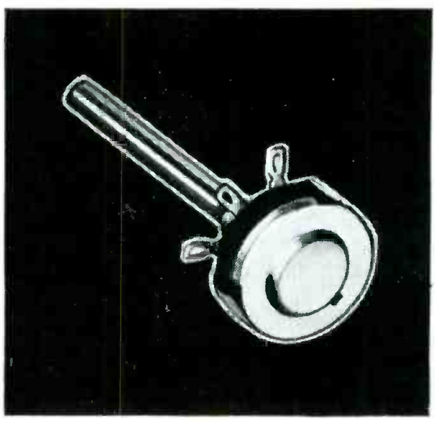
Electronic Industry

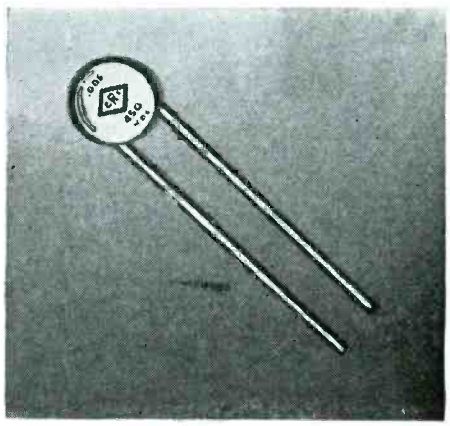


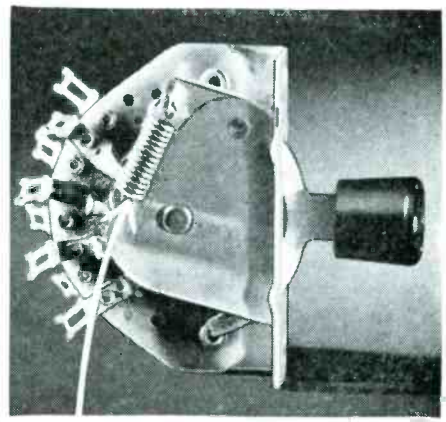


4 Newest development of the "Printed Electronic Circuit", CRL's *Ampec* is a complete 3-stage audio amplifier. Get complete facts in Bulletin 973.

5 Made with Ceramic-X, CRL's new Feed-thru and Bushing Mounted Capacitors eliminate structural and electrical damage during installation. Two special bonds are reason: 1) between inner feed-thru terminal and inside diameter of tube, and 2) between mounting bushing and outside diameter of tube. Send for bulletin 975.







6 Wide range of variations in CRL's Model "M" Radiohm simplifies production and inventory. Bulletin 697-A illustrates convenience, versatility!

7 To CRL's line of high quality ceramic capacitors, these miniature disc *Hi-Kaps* have been added. Combine reliability, capacity. Order Bulletin 933.

8 In its new Lever Switch, Centralab guarantees a minimum life of 50,000 cycles. Reason: an exclusive new coil spring index. Write for Bulletin 970.

LOOK TO CENTRALAB IN 1948! ***First in component research that means lower costs for the electronic industry. If you're planning new equipment, let Centralab's sales and engineering service work with you. Get in touch with Centralab!***

Centralab

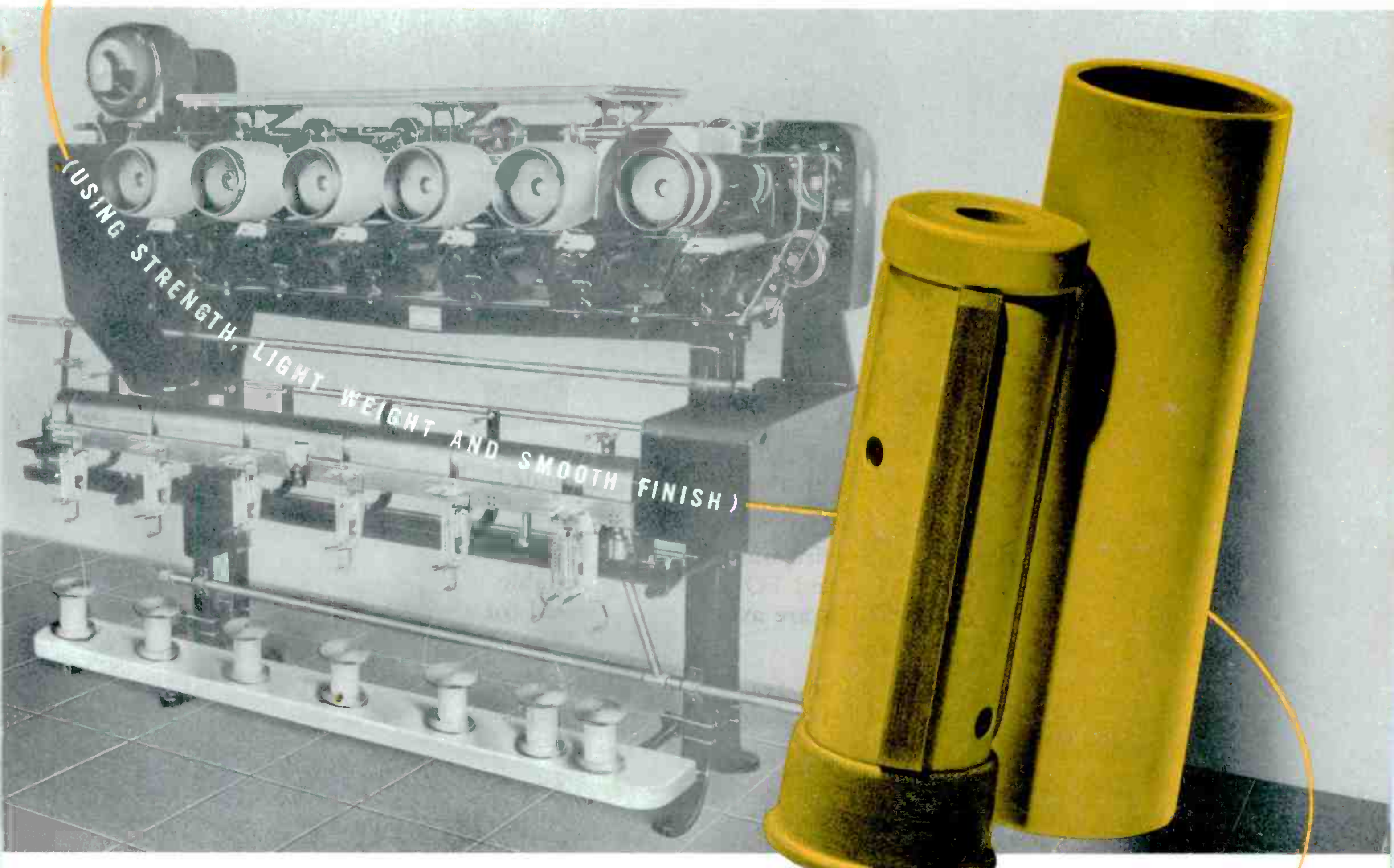
CRL

DIVISION OF GLOBE-UNION INC., MILWAUKEE, WIS.

Plastics where plastics belong

Because of a unique combination of chemical, electrical, and mechanical qualities, Synthane laminated plastics can be applied to an endless number of practical purposes. Moisture and corrosion resistant, light-weight and structurally strong, Synthane has many collective advantages not readily found in any other material. One of the best electrical insulators known, Synthane is hard, dense, durable . . . quickly and easily machined.

Among the interesting occupations of our type of technical plastics are the redraw bobbin and chuck (below) used in winding fine denier nylon for women's hosiery.



Fine nylon filaments can be wound without pulling and sticking because of the smoothness of the bobbin. Light weight of bobbin and chuck allows the spindle to be started and stopped faster and with less effort. Greater crushing strength of tube permits larger amounts of nylon to be wound. This is an appropriate job for Synthane, an interesting example of using plastics where plastics belong.

If any of Synthane's many properties suggest a use for it in your plant, let us help you before you design. Write for our complete catalog of Synthane plastics today! Synthane Corporation, 6 River Road, Oaks, Pa.

SYNTHANE S

where Synthane belongs

DESIGN • MATERIALS • FABRICATION • SHEETS • RODS • TUBES
FABRICATED PARTS • MOLDED-MACERATED • MOLDED-LAMINATED

DON'T IMPROVISE!

Rather use Du Mont Tubes in your cathode-ray oscillography because

only the RIGHT TYPE with the RIGHT SCREEN can do the RIGHT JOB!

and here's why:

Only Du Mont makes ALL types of tubes and all types of screens to serve the needs of ALL users—scientific, industrial, educational.

Regardless of what your oscillographic requirements call for, Du Mont has the *right tube* with the *right screen*. Tubes for high-accelerating potentials; multiple-gun tubes; tubes for low-accelerating or medium-accelerating potentials—all are included in Du Mont listings. And with each type there's a choice of screens for short, medium or long persistence; for photographic recording; for visual observation; for high-speed transients; for recurrent phenomena at any speed.

Definitely, for every oscillographic application there's one best tube to use—and only Du Mont provides that adequate choice. Why improvise?

As the outstanding specialist in this highly specialized technology, Du Mont maintains the highest standards of quality, precision design, and dependable craftsmanship.

DU MONT CATHODE-RAY TUBES AVAILABLE

3AP1-A	3JP11	5JP1-A	5LP11-A
3AP11-A	5BP1-A	5JP2-A	5RP2-A
3GP1-A	5BP11-A	5JP7-A	5RP11-A
3GP11-A	5CP1-A	5JP11-A	5SP1
3JP1	5CP2-A	5LP1-A	5SP2
3JP2	5CP7-A	5LP2-A	5SP7
3JP7	5CP11-A	5LP7-A	5SP11

DU MONT SCREENS AVAILABLE

P1: Medium-persistence green. High visual efficiency. For general purpose applications.

P2: Long-persistence blue-green fluorescence and yellow-green persistence. Long persistence at high writing rates. Short interval excitation.

P5: Extremely short-persistence blue for photographic recording on high speed moving film.

P7: Blue fluorescence and yellow phosphorescence. Long persistence at slow and intermediate writing rates.

P11: Short-persistence blue. For recording high writing rates.

DU MONT IS *always* YOUR BEST BUY!

DUMONT *Precision Electronics & Television*

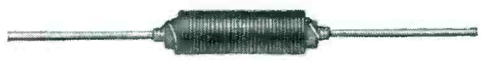
ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

Specify HI-Q COMPONENTS *for* UNIFORMITY...

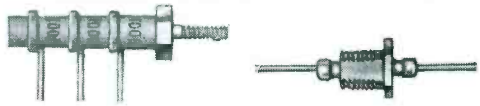
GENERAL PURPOSE CAPACITORS

HI-Q General Purpose Capacitors can be supplied in any size from .200 x .375 to .340 x 1.875, with capacity range from 5 to 33,000 MMF. They are insulated with a clear non-hydroscopic styrene coating. I.R. of 10,000 Megohms, working voltages up to 500 volts D.C. and power factor well under 3 per cent can be assured.

CHOKE COILS



STAND-OFF CONDENSERS



WIRE WOUND RESISTORS

HI-Q components are uniformly superior because of rigid quality control throughout all stages of manufacture. Final individual inspection insures their conformance to electrical and physical specifications. When you specify **HI-Q** components, you can be sure they meet your most stringent requirements for precision, dependability, compactness and uniformity. Write for complete information and engineering data.

HI-Q COMPONENTS BETTER 4 WAYS

PRECISION Tested step by step from raw material to finished product. Accuracy guaranteed to your specified tolerance.

UNIFORMITY Constancy of quality is maintained over entire production through continuous manufacturing controls.

DEPENDABILITY Interpret this factor in terms of your customers' satisfaction . . . Year after year of trouble-free performance. Our Hi-Q makes your product better.

MINIATURIZATION The smallest BIG VALUE components in the business make possible space saving factors which reduce your production costs . . . increase your profits.

HI-Q **Electrical Reactance Corp.**

FRANKLINVILLE, N. Y.

Plants: FRANKLINVILLE, N. Y. — JESSUP, PA.

Sales Offices: NEW YORK, PHILADELPHIA, DETROIT, CHICAGO, LOS ANGELES

TO HELP YOU PICK THE BEST

Here are a few facts to help you choose the best: In approximately 90% of the new commercial mobile transmitter designs, you will find Hytron instant-heating tubes. Over 2,500,000 Hytron gaseous voltage regulators speak for themselves. Ratings of Hytron vhf tubes are CCS and based on actual equipment performance which you can duplicate. No other transmitting triode can touch the new all-purpose 5514 for economical versatility. Famed for transmitting tubes, Hytron also originated the popular "GT", and is the oldest manufacturer specializing in receiving tubes. You pick the best when you pick Hytron.

HYTRON TRANSMITTING AND SPECIAL PURPOSE TUBES
CONTINUOUS COMMERCIAL SERVICE RATINGS

Description	Type No.	Filament Ratings Volts	Filament Ratings Amps	Filament Ratings Type	Max Plate Volts	Max Plate Ma	Max Plate Dis	Amateur Net Price
LOW AND MEDIUM MU TRIODES	10Y	7.5	1.25	Thor	450	65	15	$1.95
	HY24	2	0.13	Oxide	180	20	2	1.50
	801A/801	7.5	1.25	Thor	600	70	20	3.00
	864	1.1	0.25	Oxide	135	5	--	1.50
	1626	12.6	0.25	Cath	250	25	5	1.60
HIGH-MU TRIODES	HY31Z §	6	2.55	Thor	500	150*	30*	5.50
	HY1231Z §	6 / 12	3.2 / 1.6	Thor	500	150*	30*	5.50
	5514#	7.5	3	Thor	1500	175	65	4.95
VHF TRIODES	2C26A	6.3	1.15	Cath	3500	NOTE	10	7.75
	HY75A# §	6.3	2.6	Thor	450	90	15	4.70
	HY114B §	1.4	0.155	Oxide	180	12	1.8	2.25
	HY615	6.3	0.175	Cath	300	20	3.5	2.25
	955	6.3	0.15	Cath	200	8	1.8	3.10
	9002	6.3	0.15	Cath	200	8	1.8	2.15
BEAM PENTODES AND PENTODES	2E25# §	6	0.8	Thor	450	75	15	5.50
	2E30 §	6	0.65	Oxide	250	60	10	2.25
	3D21A	6.3	1.7	Cath	3500	NOTE	15	7.50
	HY69 §	6	1.6	Thor	600	100	30	5.50
	807	6.3	0.9	Cath	600	120	25	2.30
	837	12.6	0.7	Cath	500	80	12	4.15
	HY1269 §	6 / 12	3.2 / 1.6	Thor	750	120	30	5.50
	1625	12.6	0.45	Cath	600	120	25	2.30
	5516 §	6	0.7	Oxide	600	90	15	5.95
ACORNS MINIATURES	954	6.3	0.15	Cath	Sharp cutoff pentode			4.90
	9001	6.3	0.15	Cath	Sharp cutoff pentode			2.70

Description	Type No.	Filament Ratings Volts	Filament Ratings Amps	Type Rect	Peak Plate Ma	Max D-C Ma †	Inv Peak Pot.	Amateur Net Price
RECTIFIERS	816	2.5	2.0	Mer	500	250	5000	$1.25
	866A/866	2.5	5.0	Mer	1000	500	10000	1.75
	1616	2.5	5.0	Vac	800	260	6000	7.50

Description	Type No.	Average Operating Voltage	Operating Ma Min	Operating Ma Max	Av Volts Reg	Min Starting Voltage	Amateur Net Price
GASEOUS VOLTAGE REGULATORS	OA2	150	5	30	2	185	$2.00
	OB2	108	5	30	1	133	2.30
	OC3/VR105	108	5	40	2	133	1.20
	OD3/VR150	150	5	40	3.5	185	1.20

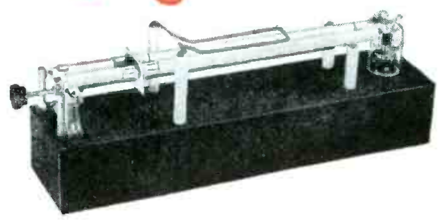
*Both sections of twin triode. NOTE: Special pulse tube, not recommended for c-w, consult Hytron Commercial Engineering Dept. for data. #5514 supplants the HY30Z, HY40, HY40Z, HY51A, HY51B, and HY51Z; the HY75A the HY75; and the 2E25 the HY65. †Current for full wave. §Instant-heating.

For better reception, it's also Hytron — GT, G, lock-in, or miniature.

New data sheets: 2E25, 2E30, HY31Z, HY69, HY75A, HY1231Z, HY1269, 5514, 5516. Free.

Keep up to date with the Hytron Reference Guide for Miniature Electron Tubes. Free.

New transmitting and special purpose tube catalogue. It's yours for the asking.

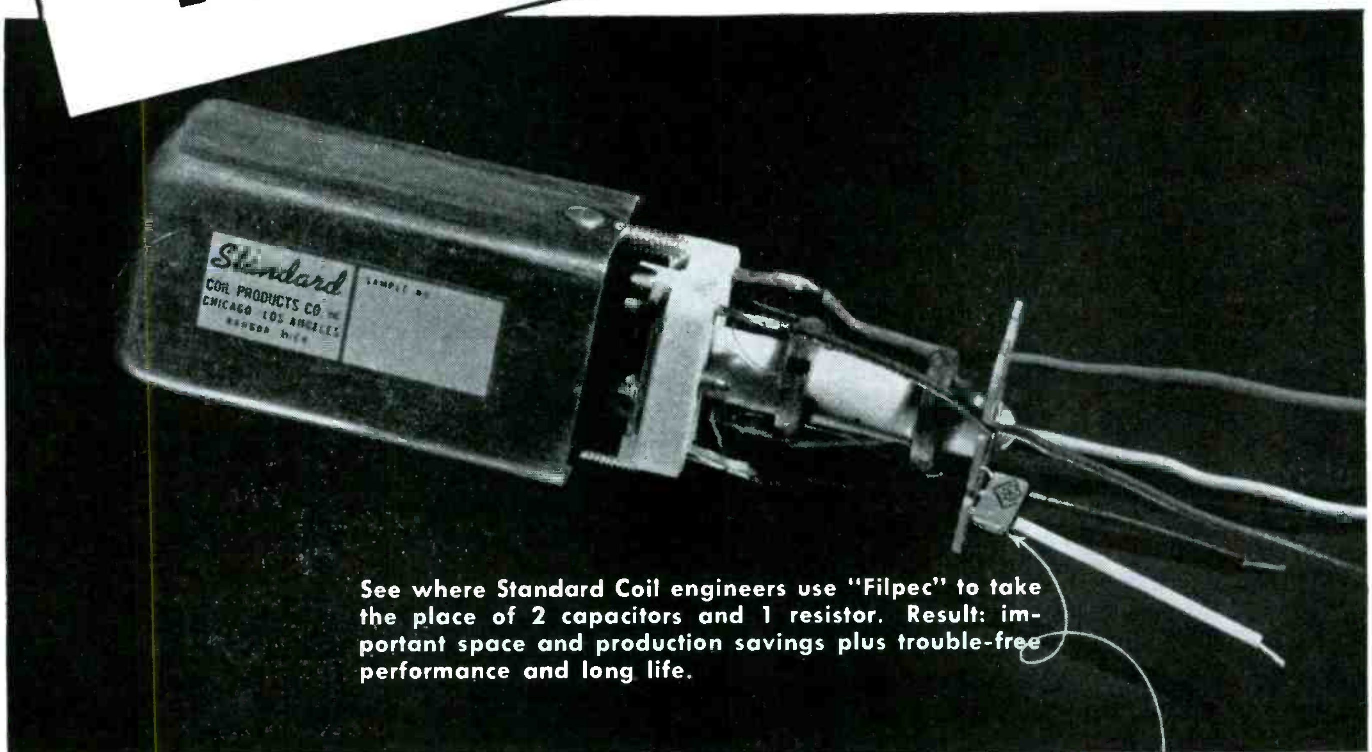


Simple, sure-fire vfo for 1¼ or 2 meters. HY-Q 75 kit: unassembled, $9.95; assembled, $11.95.

HYTRON RADIO & ELECTRONICS CORP.
SALEM, MASSACHUSETTS

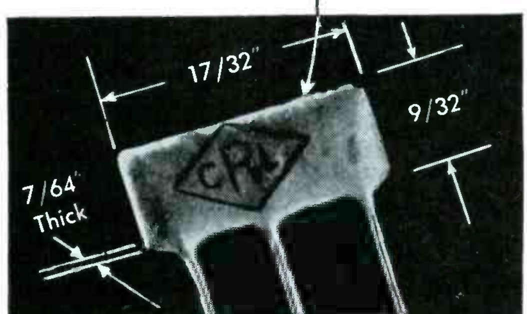
PROGRESS REPORT ON P.E.C.*

How Standard Coil uses Centralab "Filpec" to simplify production, save space on I. F. Transformers

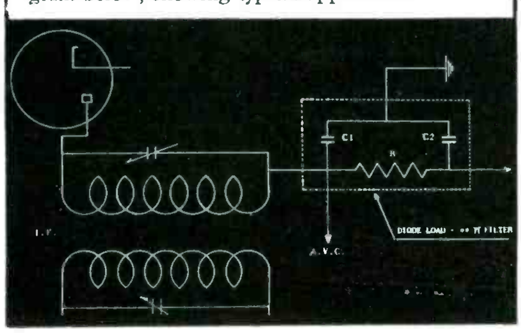


See where Standard Coil engineers use "Filpec" to take the place of 2 capacitors and 1 resistor. Result: important space and production savings plus trouble-free performance and long life.

I. F. Transformer courtesy of Standard Coil Products Co.



"Filpec" gives you integral construction! Made with high dielectric Ceramic-X, CRL's *Filpec* assures long life, low internal inductance, resistance to humidity and vibration. Note schematic diagram below, showing typical application.



*Centralab's revolutionary Printed Electronic Circuit — Industry's newest method for stepping-up manufacturing efficiency!

FOR SMALL SIZE, light weight and long life, there's nothing like Centralab's new *printed electronic circuit filter!* That's why the Standard Coil Products Co. uses *"Filpec"* in its new I. F. Transformers. And that's why you'll want to see how it gives you higher circuit efficiency, more dependable performance as well as a reduction of line operations in set and equipment manufacturing.

Filpec combines two capacitors and one resistor into one tiny balanced diode load filter unit, saves space, cuts inventory, is highly adaptable to a variety of circuits. Capacitor values from 50 to 200 mmf. Resistor values from 5 ohms to 5 megohms. Resistance rating: 1/5 watt. 100 WVDC. Flash test: 200 VDC. For complete information about *Filpec* performance, see your Centralab representative, or write for Bulletin 976.

LOOK TO **Centralab** IN 1948!

Division of GLOBE-UNION INC., Milwaukee

miraglas

TAPES

TUBINGS

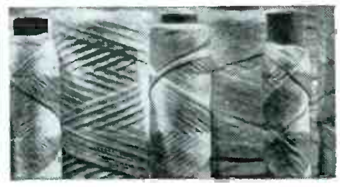
SLEEVINGS

CORDS

and

CLOTHS

treated and untreated



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...with the strength, power and energy to resist the destructive forces of overloading, extreme high and low temperatures, moisture, corrosion from vapors, fumes and acids, oils, grease, dust and dirt . . . the destroyers that play havoc with electrical equipment protected by ordinary insulations.

Miraglas Tapes, Tubings, Sleevings, Cords and Cloths have the stamina that adds life to the electrical apparatus they protect . . . they feature fewer breakdowns, less maintenance, reduction of waste, savings in labor and materials . . . and in every way they prove the standing they have earned as the optimum in electrical insulation protection.

Take note of **MIRAGLAS ELECTRICAL INSULATIONS** . . . they stand for the ultimate in electrical insulations woven of Fiberglas Yarn . . . write today for details and characteristics.

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Communications are vital. Meeting the high standards of this field is our business—our only business. For coaxial transmission lines and related accessories that are service-tested and proven dependable, follow the leaders using CP equipment.

Sold by RCA and GENERAL ELECTRIC. Distributed nationally thru 98 service stations of GRAYBAR ELECTRIC COMPANY and distributed internationally by WESTREX CORPORATION.

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WAIM—Anderson, S. C.
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WATG—Ashland, Ohio
WBGE—Atlanta, Ga.
WBNY—Buffalo, N. Y.
WBOC—Salisbury, Md.
WBRE—Wilkes Barre, Pa.
WBTM—Danville, Va.
WCBS—Springfield, Ill.
WCIL—Carbondale, Ill.
WCOA—Pensacola, Fla.
WCOH—Newman, Ga.
WCOM—Parkersburg, W. Va.
WCRO—Johnstown, Pa.
WCSC—Charleston, S. C.
WCTS—Cincinnati, Ohio
WDAF—Kansas City, Mo.
WDEF—Chattanooga, Tenn.
WDLP—Panama City, Fla.
WDNC—Durham, N. C.
WDOD—Chattanooga, Tenn.
WEBC—Duluth, Minn.
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WEEX—Easton, Pa.
WEWS—Parma, Ohio
WFAA—Dallas, Texas
WFAH—Alliance, Ohio
WFAS—White Plains, N. Y.
WFIL—Philadelphia, Pa.
WFLB—Fayetteville, N. C.
WFMR—Taunton, Mass.
WFRO—Fremont, Ohio
WGAL—Lancaster, Pa.
WGGG—Gainesville, Fla.
WGBC—Miami, Fla.
WGNI—Wilmington, N. C.
WGPA—Bethlehem, Pa.
WGYN—New York, N. Y.
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WHK—Cleveland, Ohio
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WHPE—High Point, N. C.
WHRV—Ypsilanti, Mich.
WHYN—Holyoke, Mass.
WIBA—Madison, Wis.
WIBW—Topeka, Kans.
WIBX—Utica, N. Y.
WINX—Washington, D. C.
WITH—Baltimore, Md.
WJAS—Pittsburgh, Pa.
WJBK—Detroit, Mich.
WJDX—Jackson, Miss.
WJEJ—Hagerstown, Md.
WJHP—Jacksonville, Fla.
WJMC—Rice Lake, Wis.
WJNO—W. Palm Beach, Fla.
WJSW—Altoona, Pa.
WJW—Cleveland, Ohio
WKAT—Miami Beach, Fla.
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WLBZ—Bangor, Me.
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WOR—New York, N. Y.
WOV—New York, N. Y.
WOW—Omaha, Nebr.
WPEN—Philadelphia, Pa.
WPGH—Pittsburgh, Pa.
WQAM—Miami, Fla.
WQXQ—New York, N. Y.
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WRVA—Richmond, Va.
WSAN—Allentown, Pa.
WSB—Atlanta, Ga.
WSFA—Montgomery, Ala.
WSLI—Jackson, Miss.
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WSPD—Toledo, Ohio
WTAG—Worcester, Mass.
WTAR—Norfolk, Va.
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WWNC—Asheville, N. C.
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KENI—Anchorage, Alaska
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KFMB—San Diego, Calif.
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KFXD—Boise, Idaho
KGA—Spokane, Wash.
KGFN—Grass Valley, Calif.
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KTYW—Yakima, Wash.
KVCV—Redding, Calif.
KVVC—Ventura, Calif.
KVWA—Ellensburg, Wash.
KWEI—Weiser, Idaho
KWIK—Burbank, Calif.
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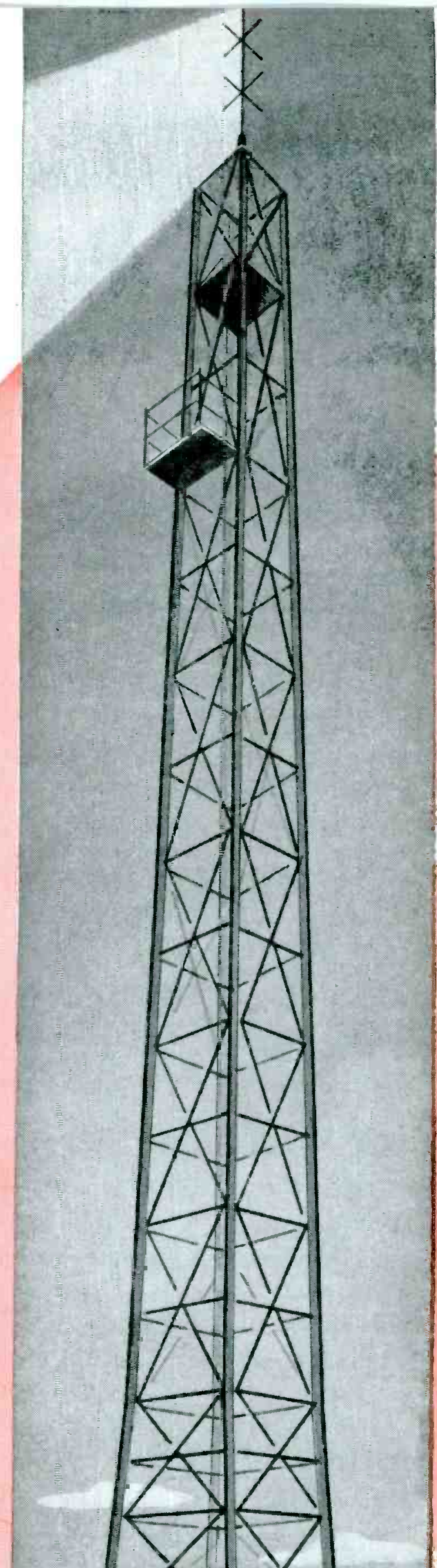

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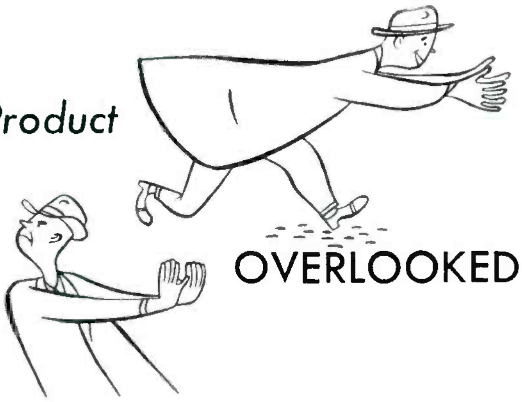
To Keep Your Product SOUGHT-AFTER

Instead of an OVERLOOKED HAS-BEEN . . .



REMEMBER: ROCKBESTOS WIRES and CABLES

RESIST HEAT, AGING, FUMES, FLAME and GREASE

The product you build today must be a better self-salesman than the one you built 12 months ago—because the U. S. consumer dollar is doing an increasingly more thorough *value searching job,* week by week and day by day.

Rockbestos wires, cables and cords will help you avoid repairs, servicing, replacements and customer dissatisfaction, as well as sales-killing publicity that soon means NO CUSTOMERS.

From airplanes to waffle irons, from calculators to locomotives, here are the advantages which go to buyers of Rockbestos-wired products:

Permanent insulation with impregnated felted asbestos.

No rotting, blooming or swelling from oil, grease or corrosive fumes.

No baking brittle from conductor-heating overloads.

No destructive and expensive wire-fires.

No deterioration from age or oxidation.

Stepped-up current carrying capacity via high heat resistance.

125 *permanently insulated* constructions—from Firewall Hookup Wire to 5000 Volt Rockbestos A.V.C. Power Cable — give you a wide range of failure preventing wires, cables and cords to select from. Write to our nearest district office or the address below for recommendations, samples or information.

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CHICAGO PITTSBURGH ST. LOUIS
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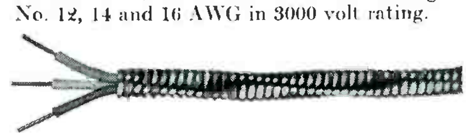
ROCKBESTOS FIREWALL HOOKUP WIRE

This heat, flame and moisture resistant wire, insulated with high dielectric tapes and impregnated felted asbestos and covered with color-coded, lacquered glass braid, has a maximum operating temperature of 125° C. Ideal for radios, television, amplifiers, calculators or small motor, coil, dynamotor and transformer leads. No. 22 to 4AWG in 1000 volt rating—No. 12, 14 and 16 AWG in 3000 volt rating.



ROCKBESTOS THERMOSTAT CONTROL WIRE

A multi-conductor control wire for fuel burner controls, safety pilots, intercommunications and signal systems. Its asbestos insulation and steel armor assure trouble-free circuits. Sizes No. 14 to 18 AWG in two to five conductors with .0125", .025" or (for 115 volt service) .031" of impregnated asbestos insulation.

ROCKBESTOS A.V.C. MOTOR LEAD CABLE

Use this 600 volt apparatus cable for coil connections, motor and transformer leads exposed to overloads and high ambient temperatures. Insulated with impregnated felted asbestos and varnished cambric, and covered with a heavy asbestos braid, it is heat-proof and resistant to oil, grease, moisture and flame. Sizes 18 AWG to 1,000,000 CM.

A few of the 125 permanently insulated wires, cables and cords developed by Rockbestos to protect product performance and give lasting service in 300 to 5000 volt applications.

ROCKBESTOS PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES ***The Wire with Permanent Insulation***

GOOD SOLDER, AND ALL THIS TOO!

In Federated solder you get the exact metal you specify, PLUS all these intangible ingredients. These background factors mean service and security . . . they mean that you get *consistently* better solder to help you do a *consistently* better job.

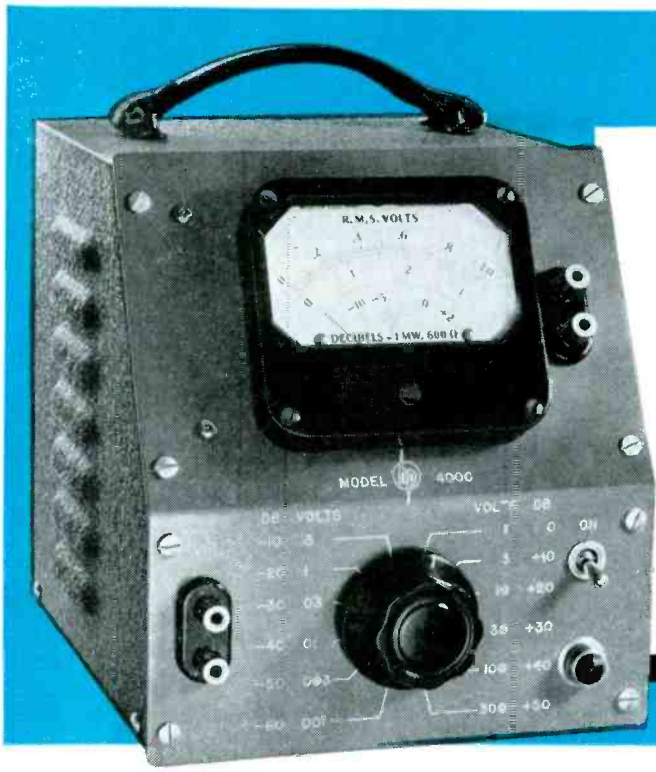
For any size, form, or composition of solder—bar, pig, body, drop, foil and ingot; acid core, rosin core and solid wire; triangle, strip, wiping and segment — see Federated first.

Federated
METALS DIVISION

AMERICAN SMELTING AND REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.

Federated first in the non ferrous field FMD

F-CCIs



VOLTAGE RANGE:

3,000,000 to 1

READINGS:

.1 mv to 300 v

FREQUENCIES:

20 cps to 2 mc

THE NEW *-hp-* 400C VACUUM TUBE VOLTMETER

Increased sensitivity. Wider range. Easy-to-read linear scale. Space-saving, time-saving versatility! Those are but a few of the many advantages of the new *-hp-* 400C Vacuum Tube Voltmeter.

30 times more sensitive than the *-hp-* 400A voltmeter, the new *-hp-* 400C accurately determines voltages from .1 mv to 300 v. Its measuring range is broad and new—3,000,000 to 1. And with it you can make split-hair measurements all the way from 20 cps to 2 mc!

The big, clearly-calibrated linear scale reads directly in RMS volts or db based on 1 mw into 600 ohms. Generous overlap makes possible more readings at mid or maximum scale, where accuracy is highest. A new output terminal lets you use the *-hp-* 400C as a wide-band stabilized amplifier, for increasing gain of oscilloscopes, recorders and measuring devices. As a voltmeter, the new instrument has still wider applicability—for direct hum or noise readings, transmitter and receiver voltages, audio, carrier or supersonic voltages, power gain or network response.

Naturally the new *-hp-* 400C includes the familiar advantages of the *-hp-* 400A voltmeter. Range switch is calibrated in 10 db intervals providing direct readings from −70 dbm to +52 dbm. Overall accuracy is ±3% full scale to 100 kc. High input impedance of 1 megohm means circuits under test are not disturbed. And the rugged meter movement is built to safely withstand occasional overloads 100 times normal.

In every respect, the convenient, durable *-hp-* 400C is the ideal new voltmeter for precision work in laboratory, plant or repair shop. Complete details are available at no obligation. Write today!

Hewlett-Packard Company
1556A Page Mill Road • Palo Alto, Calif.

CHECK THESE SPECIFICATIONS

VOLTAGE RANGES:
12 ranges. Full-scale readings.

.001 v	.100 v	10.0 v
.003 v	.300 v	30.0 v
.010 v	1.00 v	100. v
.030 v	3.00 v	300. v

FREQUENCY RANGE: 20 cps to 2 mc

ACCURACY:
±3% full scale 20 cps to 100 kc
±5% full scale 100 kc to 2 mc

INPUT IMPEDANCE:
1 megohm shunted by 15 uuf, on .01 v to 300 v ranges.
1 megohm shunted by 25 uuf, on .001 v to .003 v ranges.

METER SCALE:
3" linear. Voltage ranges related by 10 db steps. Db calibrated −12 to +2 db. Zero level 1 mw into 600 ohms.

OUTPUT CIRCUIT:
Maximum 0.5 v full scale. Internal impedance 1000 ohms.

POWER SUPPLY:
115 v, 50/60 cps, 45 watts.

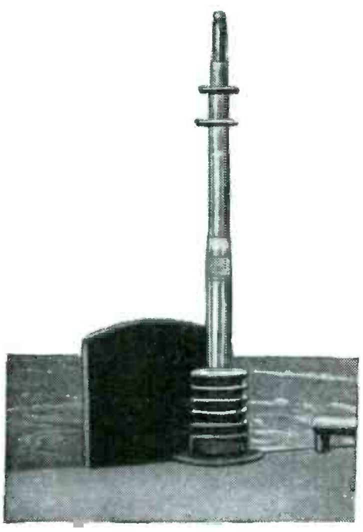
CABINET SIZE:
8" high. 7½" wide. 9" deep.

hp laboratory instruments
FOR SPEED AND ACCURACY

Power Supplies · Frequency Standards · Amplifiers · Electronic Tachometers · Frequency Meters · UHF Signal Generators · Square Wave Generators · Audio Frequency Oscillators · Attenuators · Audio Signal Generators · Noise and Distortion Analyzers · Wave Analyzers · Vacuum Tube Voltmeters

HOW TO PULL SIGNALS OUT OF A SAVAGE ETHER

Roaring into action on fighting PT boats, Premax Monel antennas defied salt spray, weather, and whipping wind.



Premax Monel Antennas are built in multiple sections of tough, cold-drawn Monel tubing, telescoped one inside the other. Above illustration shows antenna in fully telescoped position.

Are antennas one of your headaches? Maybe the story of how the antenna problem was solved aboard PT boats will be of some help to you.

PT antennas had to fight corrosive salt air and water. They needed strength and stiffness to withstand whipping winds and plunging boats. They had to function in arctic cold and tropic heat.

An answer was worked out for the Navy by Premax Products Division of Chisholm Ryder Co., Inc., Niagara Falls, N.Y. It consisted of telescoping tubular antennas, made of sections of seamless tubing furnished by the Superior Tube Co., Norristown, Pa.

The metal that met the combination of conditions?—Monel.* To quote Premax engineers:

> *"Monel has been found to be the most practical material for radio antennas. Sudden shocks do not affect its toughness . . . its fatigue strength exceeds the limits of mild steel or all brasses and bronzes.*
>
> *"Rigid tests by both Government and private agencies have shown Monel antennas to be dependable and satisfactory under all conditions."*

Do you have an electrical problem that can be solved by the combination of properties obtainable in Monel . . . or the other Inco Nickel Alloys?

All are strong, tough, and corrosion resistant. In addition, each has special properties needed for special jobs. Write us describing your problem. Our technical assistance is yours whenever you ask for it.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N.Y.

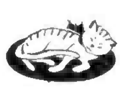
Monel*

EMBLEM OF SERVICE
NICKEL INCO ALLOYS

MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL
INCONEL* • NICKEL • "L"* NICKEL • "Z"* NICKEL *Reg. U.S. Pat. Off.

Illustrated: The Leland Loadstar Type KL Capacitor Start-Induction Run Motor

COOL-RUNNING! *Internal fan air-cooling, and newly developed ventilation features.*



QUIET! *Exceptionally close tolerances eliminate vibration, prolong motor life. Engineered throughout for smooth, silent operation under most exacting conditions.*

SELECTION! *1/6 to 3 HP. Types—ball bearing and sleeve bearing; open and enclosed; horizontal and vertical. Thermomatic control optional. Special-purpose motors built to specifications.*

LOADSTAR-POWERED, your product will encounter smoother sailing at the point of sale. However high your production and performance standards—you'll find the self-same qualities in Leland Loadstars. Thus, the Leland nameplate—on hushed, sweet-running, cooler motors—becomes an important factor in the service of your product and in the satisfaction it is built to render. Specify Leland Loadstars for HP per cubic inch as high as any—for HP per pound higher than most. *Write for complete descriptive folder.*

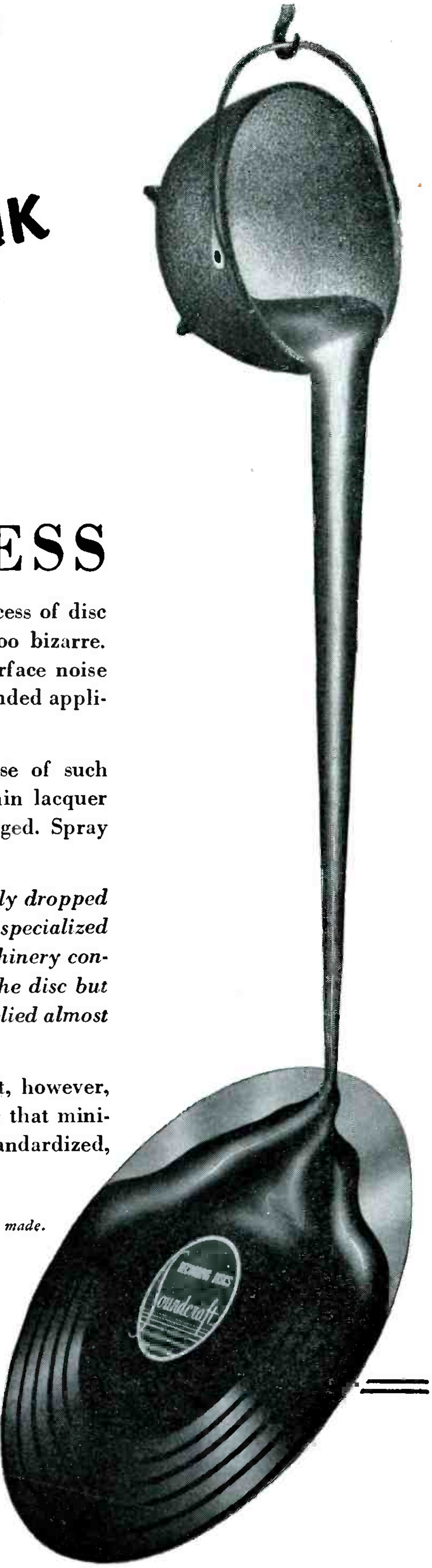
THE LELAND ELECTRIC COMPANY, DAYTON 1, OHIO. ***Branches in all principal cities.***

LELAND *LOADSTAR* MOTORS

MOTORS OF ALL TYPES—ENGINEERED TO INDUSTRY'S SPECIFIC NEEDS

No. 3

WHAT MAKES A GOOD RECORDING BLANK GOOD?*



The COATING PROCESS

So secret have some disc manufacturers kept the actual process of disc coating that even the crude method illustrated might seem none too bizarre. The development of the Soundcraft disc coating to combine low surface noise with high mechanical strength (quietness with high response) demanded application of heavy viscosity (fine grain) lacquer.

- To coat smoothly such a molasses-like liquid precluded the use of such common processes as dip-coating wherein layer upon layer of thin lacquer built up the required thickness as the disc rotated half submerged. Spray build-up was also out of the question.
- *The answer was flow-coating, a method by which lacquer is virtually dropped on the disc. To obtain uniform distribution by flow-coating, highly specialized equipment was developed. So accurately does this Soundcraft machinery control not only the direction and rate of flow of lacquer as it hits the disc but also the movement of the aluminum base, that the heavy film is applied almost as though a dry plastic were being laid over the aluminum.*
- To visualize such a process is often difficult. Final evidence of it, however, is the precision surface of your Soundcraft disc—one more factor that minimizes uncertainty and establishes disc recording anew on a standardized, predictable basis.

**Watch this space for succeeding ads in this informative series on how Soundcraft discs are made.*

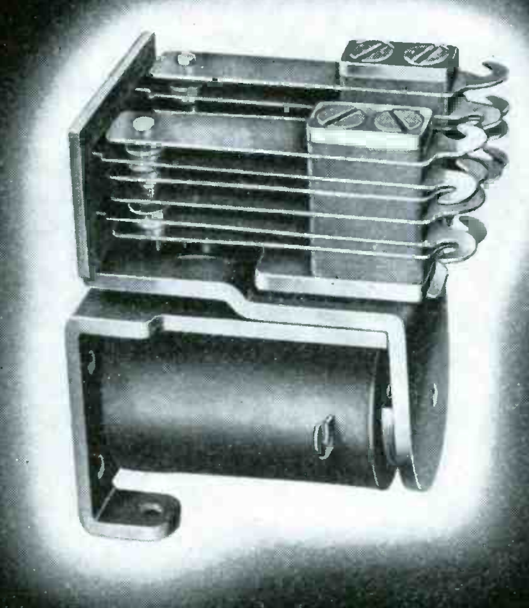
REEVES Soundcraft CORP.

10 EAST 52nd STREET • NEW YORK 22, N. Y.

The 'Broadcaster'   The 'Playback'   The 'Audition'   The 'Maestro'

THE ALLIED "PR"

A COMPACT Power Relay for a WIDE range of applications



The new Allied "PR" Relay meets the demand for a small versatile relay.

This new addition to the Allied line of precision relays has been designed to simplify your relay problems. Its availability in 1, 2, 3, or 4-pole, double-throw, normally-open or normally-closed and in double-break contact arrangements make it suitable for use in an even wider range of applications than the well-known "CR" type which it replaces.

These are some of the important reasons why this small relay is equipped to do a big job:

- Contact Rating—10 amperes, or 30 amperes for double-break contacts, at 24 volts D.C. and 110 volts A.C. non-inductive with standard silver contacts. This rating is attained by high contact pressures which usually are obtainable only in a much larger relay.

- Coil Rating—D.C.—up to 120 volts. A.C.—up to 220 volts with a maximum contact arrangement of double-pole, double-throw.

- Mounting—horizontal or vertical mounting frame for maximum adaptability.

- Terminals—easy-to-wire contact and coil terminals are conveniently located.

These features plus the skillful workmanship and superior materials that go into the manufacture of every Allied precision relay mean better relay performance . . . longer relay life in your equipment. Write for complete information on this and other Allied relays.

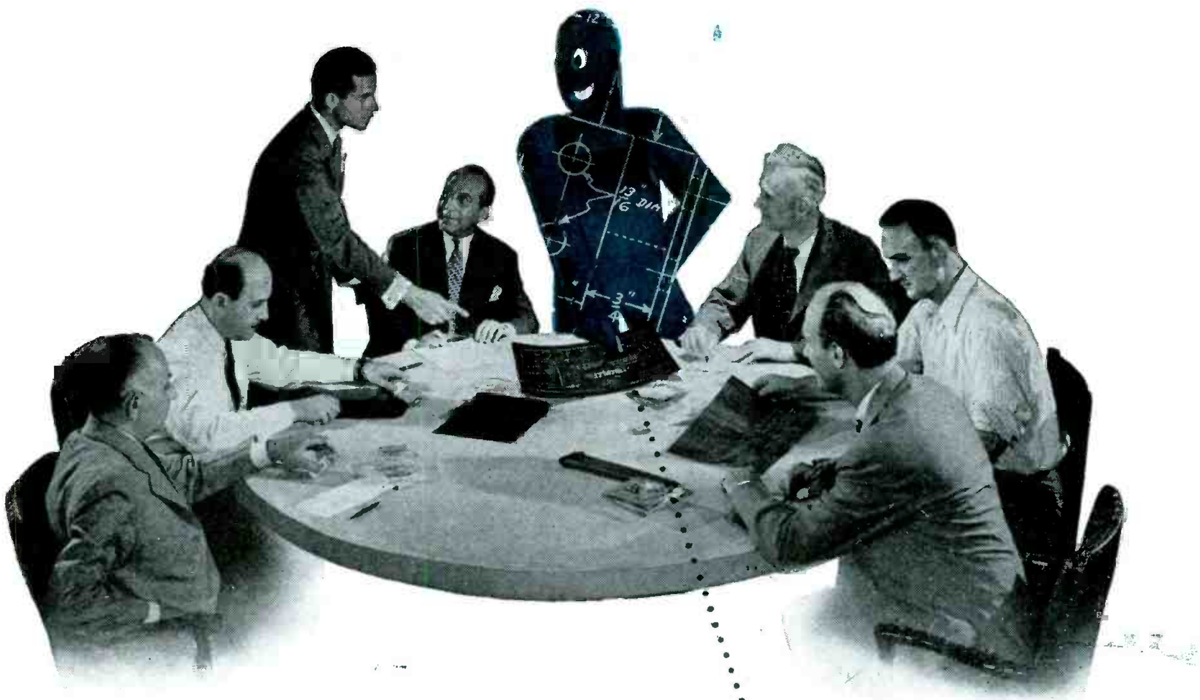
HERMETICALLY SEALED TYPE PR RELAYS

TYPE PRH—Solder terminals. Up to four-pole, double-throw.

TYPE PRHO—Standard octal plug-in base. Up to three-pole, single-throw, normally open or closed or any combination of six contact arms.

AL-113

ALLIED CONTROL COMPANY, INC.
Dept.A, 2 East End Avenue • New York 21, N. Y.



YOU GET A SQUARE DEAL AT OUR ROUND TABLE

When you bring your sheet metal fabrication problems to KARP, you immediately set in motion a "round table" board of experts whose combined specialized skill and experience is without an equal in the field. This group includes the president, chief engineer, chief draftsman-designer, chief toolmaker, plant superintendent, production manager and cost accountant.

These men make a detailed study of your special requirements. They plan, design and engineer the job with your needs and uses in mind. They determine the best manner of producing it, utilizing KARP'S superior equipment and facilities to your greatest advantage.

When your job is finished, it will be correctly designed for its application, handsome, rugged and built for long service life. You will have no costly problem of assembly . . . no need to spend additional time and labor on finishing touches. The job will be COMPLETE, ready for the installation of your electrical or mechanical operating parts with ease and simplicity. No matter how many units you order, every last detail will be absolutely uniform.

This custom service not only gives your product added value, but under KARP methods may often save you money.

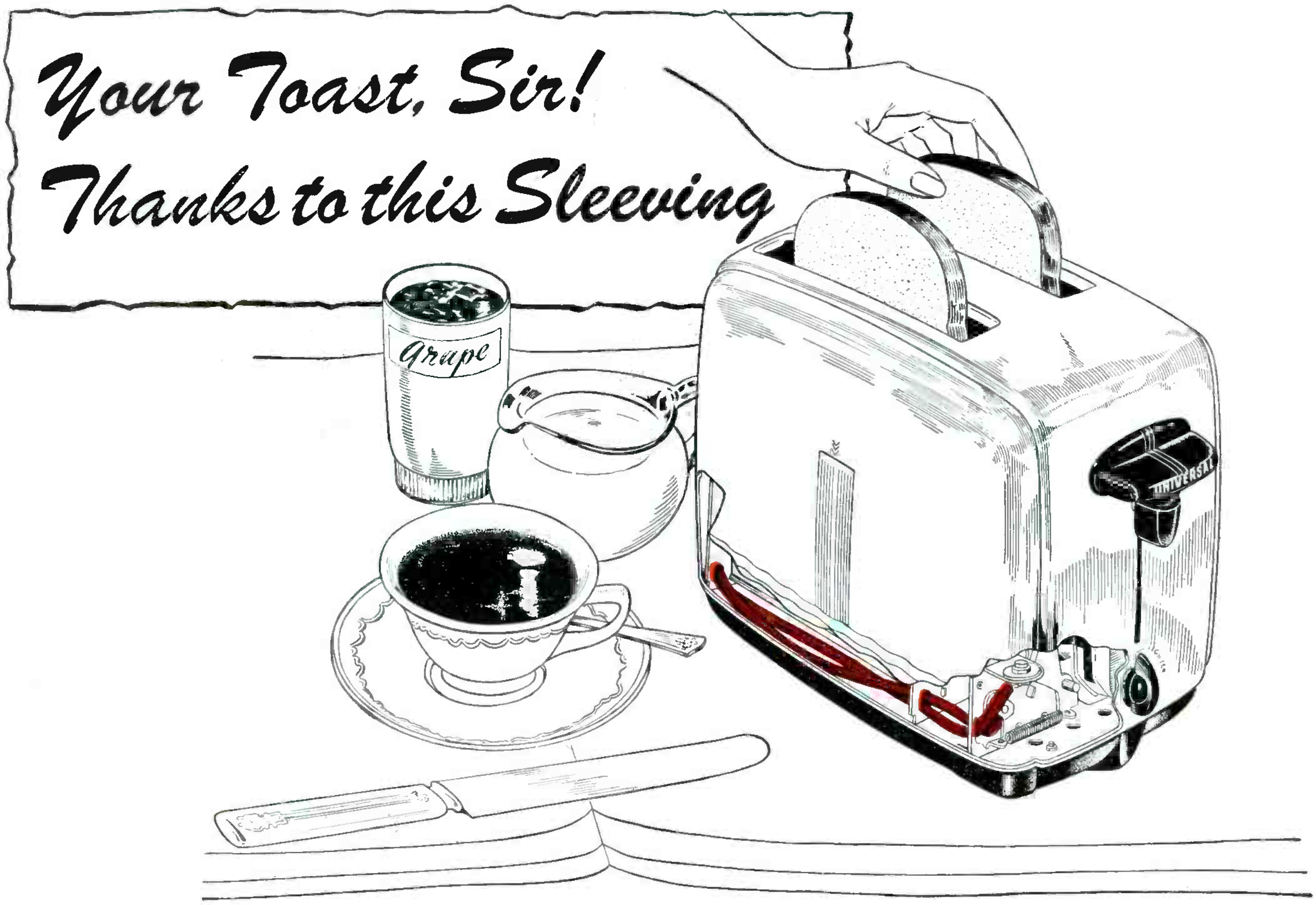
Consult us for cabinets, housings, chassis, racks, boxes, enclosures or any type of sheet metal fabrication.

Write for Our New Catalog.

Karp METAL PRODUCTS CO., INC.

Custom Craftsmen in Sheet Metal

124 - 30th STREET, BROOKLYN 32, NEW YORK



It's the clock that makes an automatic toaster pop up at exactly the right second. High heat . . . current leakage . . . abrasion and wear—these are some of the clock lead insulation problems that make "never fail" insulation a necessity.

In the new Universal Automatic Toaster, the leads from the clock assembly to the heating element are protected with double braided BH Fiberglas Sleeving, special treated for heat resistance up to 1200° F.

"We have found BH Fiberglas Sleeving to be the precise answer to an application requiring resistance against heat and current leakage, and dependability over a long period of time." So say the makers of Universal Toasters.

Try BH Fiberglas Sleeving in your own plant, in your own product. See how it stays flexible as string, cuts without fraying. Compare it with ordinary saturated sleeving. Learn why leading manufacturers of home appliances, radios and industrial equipment have standardized on BH Fiberglas Sleeving.

BENTLEY, HARRIS MFG. CO., CONSHOHOCKEN, PA.

BH *Fiberglas** SLEEVINGS

*BH Non-Fraying Fiberglas Sleevings are made by an exclusive Bentley, Harris process (U. S. Pat. No. 2393530). "Fiberglas" is Reg. TM of Owens-Corning Fiberglas Corp.

USE COUPON NOW

Bentley, Harris Mfg. Co., Dept. E-20, Conshohocken, Pa.

I am interested in BH Non-Fraying Fiberglas Sleeving for ______________ (product)
operating at temperatures of ____°F. at ____ volts. Send samples so I can see for myself how BH Non-Fraying Fiberglas Sleeving stays flexible as string, will not crack or split when bent.

NAME ______________ COMPANY ______________

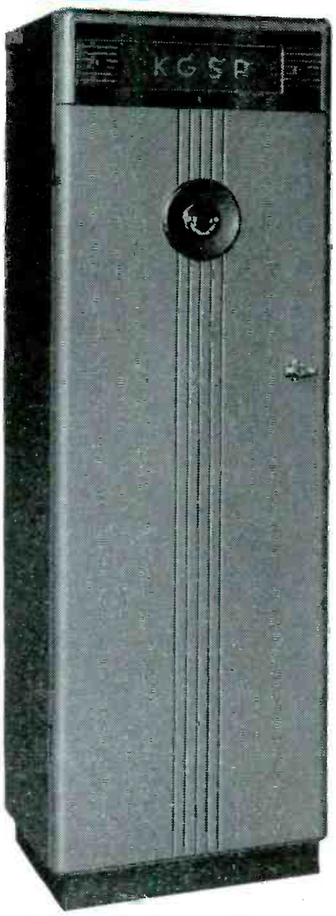
ADDRESS ______________

Send samples, pamphlet and prices on other BH Products as follows:

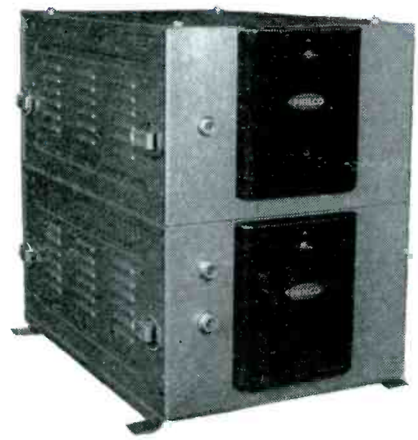
- ☐ Cotton-base Sleeving and Tubing
- ☐ Ben-Har Special Treated Fiberglas Tubing

Check ✓

these specifications for 152-162 Mc-FM Radiophone Communication Systems



by PHILCO the leader



• specifications

RECEIVER	152-162 Megacycles
Dimensions	8¼x12x19¼"
Sensitivity	0-.5 microvolts for full audio output
Selectivity	Band width 40KC at 6 Db down. Adjacent channel (60KC) —60 Db minimum. Alternate channel (120KC) —106 Db minimum.
Spurious response	—60 Db minimum.
Squelch	0.3 microvolts minimum 6.0 microvolts maximum
Power supply	Synchronous vibrator
Frequency range	152-162 megacycles
TRANSMITTER	
Modulation characteristics	±20KC at 3,000 cycles equal 100%
Frequency stability	±.005%
Spurious emission	—60 Db minimum
Power supply	Dynamotor
Antenna relay	Built-in for transmit-receive operation
Temperature range for normal operation	—30° C to 60° C

- Philco Radiophone Systems are Available for Operation on All Frequencies Assigned for Mobile Communication.
- Free Engineering Consultation Service.
- Nationwide Service Organization.

MAIL COUPON TODAY FOR FULL DETAILS ➔

Dept. J-2, Industrial Division
Philco Corporation
C and Tioga Streets
Philadelphia 34, Penna.

Gentlemen:

Please send me information about the new PHILCO FM Radiophone Communication System.

NAME____________________

ADDRESS____________________

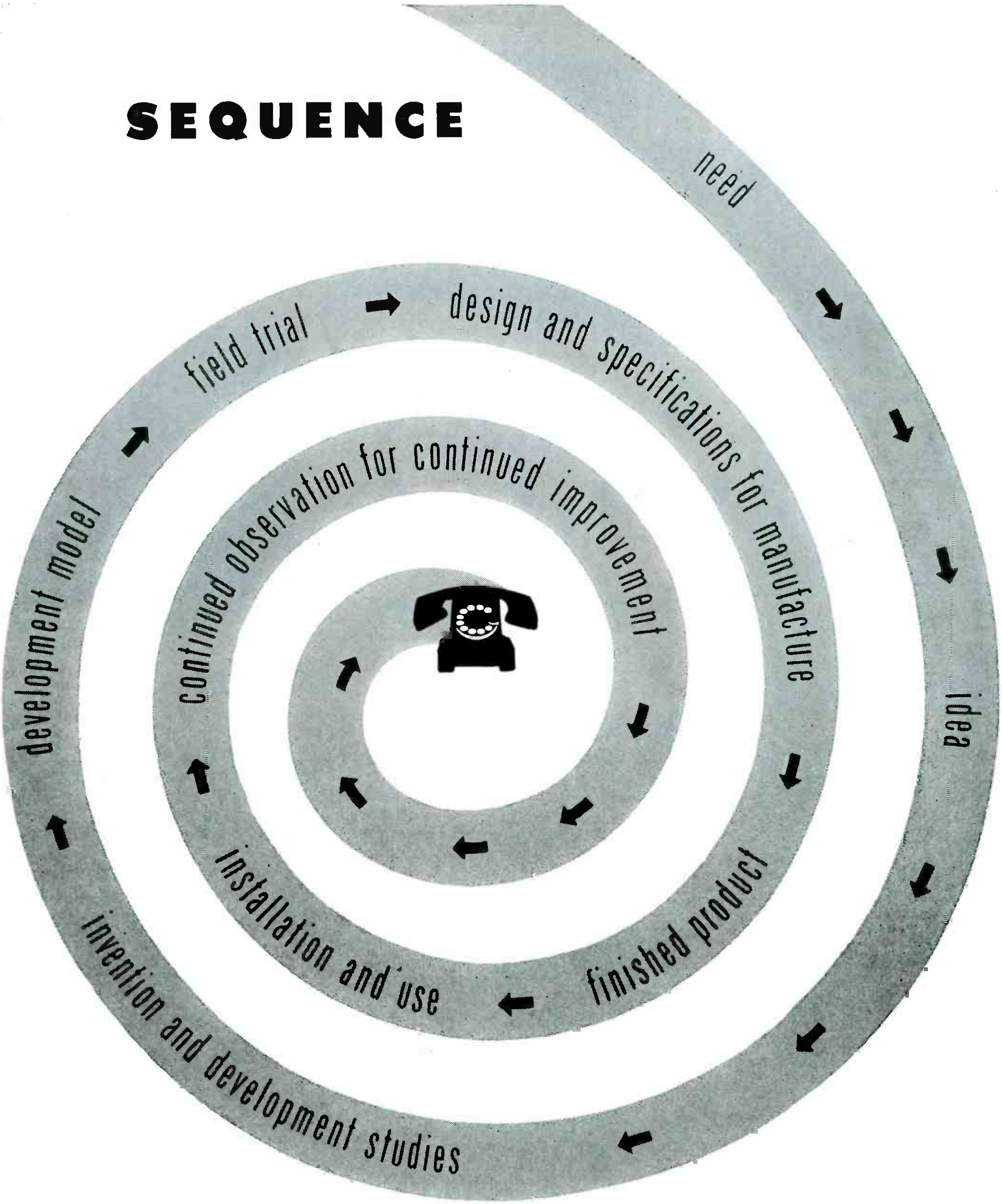
CITY____________________

PHILCO

INDUSTRIAL DIVISION

PHILADELPHIA • PENNSYLVANIA

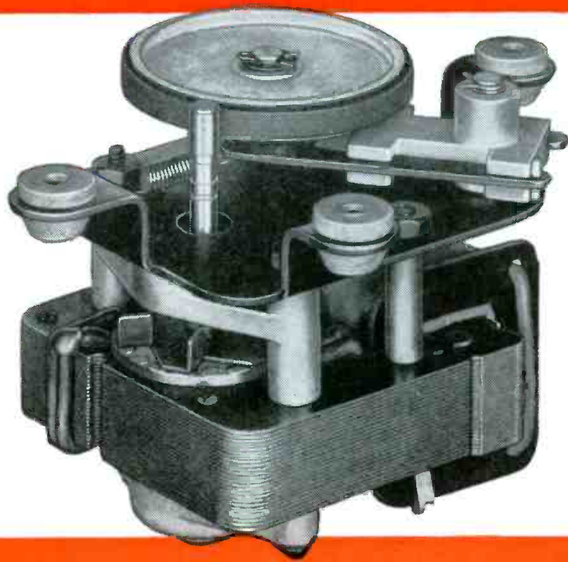
SEQUENCE



At Bell Telephone Laboratories, more than 2300 scientists, engineers, and their associates are continually exploring and inventing, devising and perfecting for improvements and economies in telephone service.

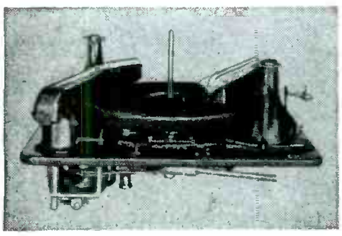
BELL TELEPHONE LABORATORIES

HERE'S *Smooth Power* TO PLEASE YOUR CUSTOMERS

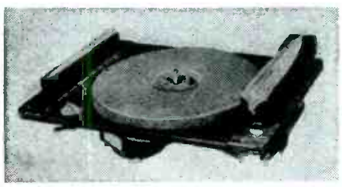


QUIETER . . . MORE COMPACT . . . LONGER LASTING . . .

Model LX Rim Drive Constant Speed Electric Phonograph Motor



Model RC-130 Combination Record-Changer Recorder



Model R-90 Dual-Speed, Home Recording and Phonograph Assembly

● Yes, it's your customers who will appreciate the plus features of General Industries' Model MX Phonomotor—*split-second pickup to full constant speed . . . dependable, quiet operation . . . and a full measure of famous GI Smooth Power.*

In this up-to-date motor, no detail which could contribute to increased customer satisfaction has been overlooked. Scientific noise elimination through accurate balancing and improved cushioning . . . superior idler arrangement which positively eliminates vertical wobble . . . anti-friction bearing construction for long trouble-free service . . . are but some of the reasons why the MX stands out as the top-quality value for top-quality phonographs and record-changers.

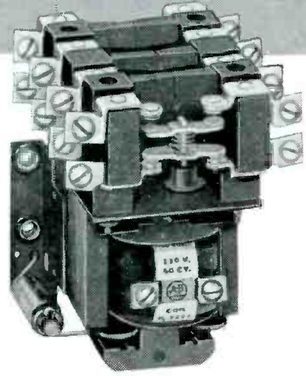
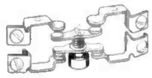
From the drawing board to the final inspection line, the MX has been designed, engineered and built to be the finest phonomotor of its type available. Plan NOW to give your customers the extra quality that's inherent in every General Industries' phonomotor, recorder and combination record-changer recorder. Complete information is available upon request.

The GENERAL INDUSTRIES Co.

DEPARTMENT B • ELYRIA, OHIO

RELAYS • CONTACTORS • LIMIT SWITCHES

for ELECTRONIC APPLICATIONS

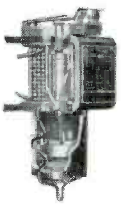



Change from Normally Open to Normally Closed contacts simply by shifting connections.

Dimensions 3¾ in. x 3 in. x 3⅞ in.

BULLETIN 700 UNIVERSAL RELAYS have two banks of contacts for quick changes from Normally Open to Normally Closed contacts . . . or vice versa. Available in 10-ampere rating with 2, 4, 6, and 8 poles; double break, silver alloy contacts need no maintenance. No pins, pivots, bearings, or hinges to bind or stick.

A-B TIMING RELAYS



BULLETIN 848 TIMING RELAYS are ideal for any service requiring an adjustable, delayed action relay. Have Normally Open or Normally Closed contacts.

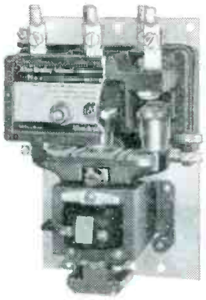
Magnetic solenoid core is restrained from rising by the piston in fluid dashpot. Adjustable valve in piston regulates time required to pull piston through fluid seal and trip the contacts, which open or close with quick, snap action. Ideal for transmitter plate voltage control.

• • •

A-B HEAVY DUTY CONTACTORS

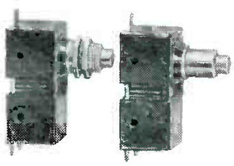
BULLETIN 702 SOLENOID CONTACTORS for heavy duty ratings up to 300 amperes. Arranged for 2- or 3-wire remote control with push buttons or automatic pilot devices.

Enclosing cabinets for all service conditions. Double break, silver alloy contacts require no maintenance. Solenoid mechanism is simple and trouble free. These Allen-Bradley solenoid contactors can be furnished in a variety of enclosures to meet any service requirement. Write for Bulletin 702, today.



A-B LIMIT SWITCHES

for Radio Transmitter Cabinet Doors



Precision Limit Switches with solder lugs or screw terminals.

Push Type. Slow action. N. O. or N. C. contacts.

Spring return roller type limit switch. Setting is adjustable.

Limit switches serve many electronic applications. Those shown above may be used for safety interlocks on transmitter cabinets. They serve as pilot controls for actuating Allen-Bradley 702 Heavy Duty Contactors which will disconnect all electrical apparatus in the cabinet if the doors are opened.

Limit switches are also used for electrical sequence switching; restricting machine motions; starting, stopping, and reversing motors, etc. The Allen-Bradley line of limit switches fills a 70-page catalog. Let us send you a copy.

Allen-Bradley Company
110 W. Greenfield Ave., Milwaukee 4, Wis.

A-B Quality

ALLEN-BRADLEY
RESISTORS RELAYS
QUALITY

NEW!

LAPP GAS-FILLED CONDENSERS

- ✓ SMALLER DIMENSIONS
- ✓ LOWER LOSSES
- ✓ HIGHER CURRENT RATINGS
- ✓ HIGHER EFFECTIVE VOLTAGE RATINGS
- ✓ GREATER SAFETY FACTORS
- ✓ TUNING SHAFT AT GROUND POTENTIAL

For capacitance at high voltages or high currents, the Lapp Gas-Filled Condensers have long been known for their operating dependability and space-saving design. Now these condensers are offered in a new design, about 70% of the previous size, with current paths only one-third as long. Fixed or variable capacitors are available, as standard, in five voltage ratings up to 58 Kv peak, 1 mc. current ratings up to 390 amperes, capacitances to 30,000 mmf. Higher capacitances and ratings on special design order. Write for new descriptive bulletin No. 265.

Lapp

LAPP INSULATOR COMPANY, INC., LE ROY, NEW YORK

What's your problem?

Fine Wire? Tungsten? Molybdenum?

Problem 1

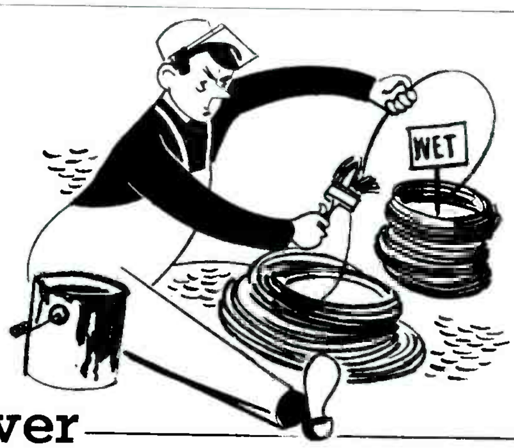
Mr. Hi Hott needed molybdenum sheets for forming into parts. High hot strength and good ductility were required. North American Philips supplied him with Elmet Molybdenum sheets that met his specifications exactly.

Problem 2

Mr. N. O. Emission, II, required plated grid wires. He solved his problem with a call to Fine Wire Headquarters. We shipped him some gold plated tungsten and molybdenum wires. Result: no secondary emission.

Problem 3

Mr. Insulate needed enamelled fine wire. So he ordered from Fine Wire Headquarters, and received fine enamelled copper wire made to his specifications.



the answer

WHY not call Fine Wire Headquarters when you have a question about fine wire? We can't do the impossible, but we can do lots of things that can bring you the right fine wire for the job.

So—when you have a problem on Fine Wire, Tungsten or Molybdenum—wire, phone or write to North American Philips, makers of NORELCO Fine Wires, and ELMET Tungsten and Molybdenum products.

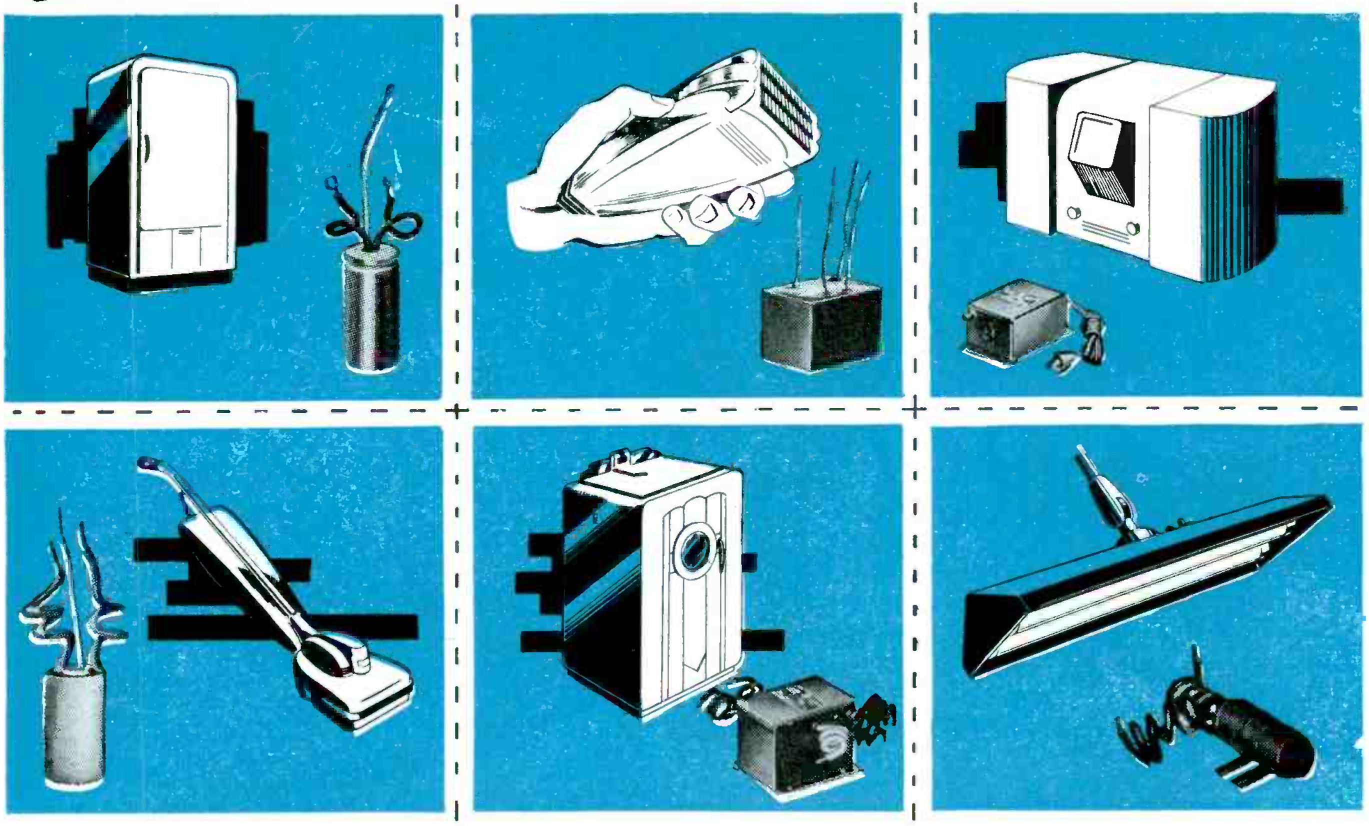
NORTH AMERICAN PHILIPS COMPANY, INC.

Dept. E-3, 100 East 42nd St., New York 17, N. Y.

YOUR PRODUCT, TOO

CAN BE RADIO NOISE-PROOFED WITH C-D *Quietones*

Reg. U.S. Pat. Off



When we say Radio Noise-*Proofed*—we mean Radio Noise-*Proofed.* It's no trick at all to build a filter with high attenuation at 150 kc *or* 100 mc . . . but to build one which filters at 150 kc *and* 100 mc—*as well as all points in between*—is a horse of a different color. We know because we've done it. It is only one of hundreds of *available* types of C-D Quietones designed for all standard requirements.

Among these stock types there may be one which will bring the interference level of your product down to the level of a rabbit's bark. If not, we invite you to make full use of our Radio noise-proofing laboratory and our engineers for the development of a unit designed for your specific needs.

Your inquiries are cordially invited. Address: Cornell-Dubilier Electric Corporation, Dept. K-3, South Plainfield, N. J. Other large plants in New Bedford, Worcester and Brookline, Mass., and Providence, R. I.

Make Your Product More Saleable With C-D Quietone Radio Noise Filters and Spark Suppressors

1910 1948

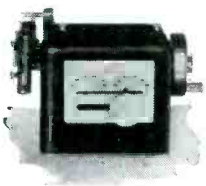
MICA • DYKANOL • PAPER • ELECTROLYTIC

PROFESSIONAL PERFORMANCE — that keeps the original sound alive!

Make Each Record a

"Personal Appearance"!

— with precision control of recording quality



Listen critically: Your station is on the air. There's your announcer's voice . . . the opening music . . . the song . . . the chatter. Is it a 'live' or a 'recorded' program? Not even your trained ears should be able to tell!

Today, truly professional recording reproduces all of the quality and natural beauty of music or speech with full naturalness. It keeps the original sound alive.

You can sum up the reasons for the unexcelled 'live' performance of the Fairchild Unit 523 Studio Recorder in one simple statement: It provides a maximum flexibility of mechanical operation that permits the operator to secure unexcelled quality of reproduction. Fairchild provides instant, infinite variation of pitch from 80 to 160 lines-per-inch by means of a unique planetary-driven lead screw. Operation is controlled by a single, easily accessible knob, as illustrated at the left. This makes it possible to record a very loud passage at 90 lines-per-inch and to follow it with soft passages at 120 or 130 lines-per-inch without dial twisting or the danger of overcutting the next groove.

Timing is accurate to a split-second. Operation is 'WOW'-free. Turntable noise, rumble and vibration are non-existent. And the performance of the Fairchild Unit 541 Magnetic Cutterhead — which is standard equipment on the Unit 523 Studio Recorder—has been engineered for full dynamic range; minimum distortion content and broad frequency range. Want more details? Address: 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

Studio Recorders
Magnetic Cutterheads
Transcription Turntables
Portable Recorders
Lateral Dynamic Pickups
Unitized Amplifiers

FCI *Fairchild* CAMERA AND INSTRUMENT CORPORATION

AM FM SOUND EQUIPMENT

Fireless Furnace

Heats Homes the Modern Way with

NICHROME*

This new, fireless home-heating furnace, manufactured by Electromode Corporation, heats a house noiselessly by electricity. No dust, no ashes . . . no fuel storage tanks, no elaborate installations.

The furnace, which is only 40" x 26½" x 58", contains six heating elements, each consisting of an insulated NICHROME resistor wire in metal sheath, embedded in a finned aluminum casting. A master thermostat inside the house controls two of the units. The four remaining units are controlled from exterior thermostats set at various temperatures. As outside temperature falls, additional heating units are cut "in" as the various thermostat settings are reached; conversely, when outside temperature rises, units are cut "out". Thus maximum heating flexibility is combined with economical operation. Room temperatures vary only about 3° from floor to ceiling.

In developing this heating equipment, the Electromode Corporation encountered the problem of providing electrical heating elements efficient enough to heat an entire home yet sufficiently compact to fit into a space-saving outer cabinet. They selected NICHROME as the resistance wire for this exacting job, in order to assure top-level performance and a life-time of trouble-free operation.

Whatever your product, if it requires a resistance element combining high efficiency with long life, specify NICHROME. And remember, there are more than 80 Driver-Harris electrical resistance alloys specifically designed to fill the numerous requirements of the Electrical and Electronic Industries . . . get in touch with us for expert advice.

SPECIAL PURPOSE ALLOYS SINCE 1899 · TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris

COMPANY

Exclusive Manufacturers of Nichrome

HARRISON, N. J.

BRANCHES: Chicago • Detroit • Cleveland
Los Angeles • San Francisco • Seattle

THE B. GREENING WIRE COMPANY, LTD.
Hamilton, Ontario, Canada

*Trade Mark Reg. U. S. Pat. Off.

REVERE ALUMINUM TUBE
for Home Antennas

Problems encountered in the manufacture and erection of home antennas for television and FM receivers are most easily solved by using Revere Aluminum Tube. Note these features:

Strength. Revere 61S-T6* Aluminum has high strength for masts. Typical properties are 40,000 p.s.i. yield strength and 45,000 p.s.i. tensile strength.

Workability. Revere 61S-T4* Aluminum can be easily bent if desired for the formation of dipoles. Both this and 61S-T6* are easily cut, drilled, and threaded. Typical properties of 61S-T4* are 21,000 p.s.i. yield and 35,000 p.s.i. tensile.

Lightness. Aluminum tube, being only about one-third the weight of steel, reduces transportation charges and facilitates installation work.

Beauty. Aluminum can be anodized and given almost any desired color. Most people, however, prefer it in its silvery beauty without adornment.

Revere Aluminum Tube is available in practically any size that might be required, and thus each design can be engineered to its own requirements. Revere and any Revere distributor will gladly quote you prices and delivery dates on your requirements. The Revere Technical Advisory Service will cooperate with you on technical matters concerning the use of aluminum tube or any other Revere Metal. Revere supplies the radio industry with many non-ferrous metals and alloys, in such forms as tube and pipe, rod and bar, sheet and plate, extruded shapes and forgings.

REVERE

COPPER AND BRASS INCORPORATED

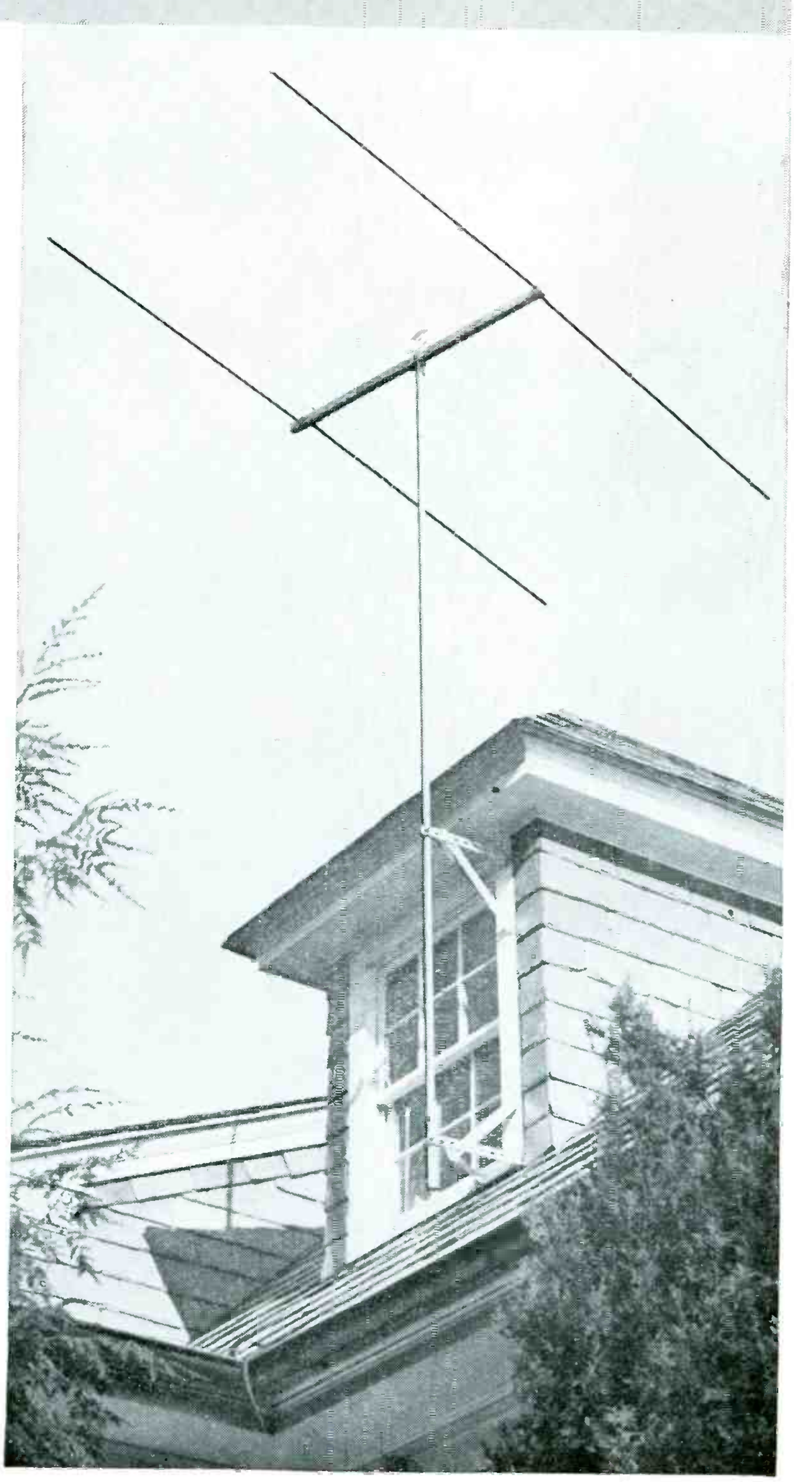
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

• • •

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities.

*These are new temper designations effective January 1, 1948. Formerly 61S-T6 was designated 61S-T and 61S-T4 was 61S-W.



RCA Television and FM receiving antenna, using Revere Aluminum Tube

Frequency Effects Must Be Considered

No. 5

. . . in a series of advertisements on electrical insulation. The effects of frequency on dielectric breakdown are discussed, together with the influence of duration of voltage application. Illustrated are applications of insulating materials to high-frequency and high-voltage equipment.

In selecting electrical insulating materials, it is important to understand the effects of frequency on dielectric breakdown voltage. While present-day knowledge has not fully explained these effects (which are closely related to time, temperature and other conditioning factors) certain useful generalizations can be made.

DIELECTRIC STRENGTH vs. FREQUENCY

As a rule, an increase in frequency lowers breakdown voltages of electrical insulation, all other conditions being equal. The typical curve in Figure 1 shows a sharp drop in breakdown voltage with increasing frequency gradually leveling off at higher frequencies. The rate of lowering of breakdown voltage varies from one insulating material to another.

Frequency effects are related to thermal effects. Through a given time interval, higher frequencies usually produce greater dielectric loss, though the loss per cycle may not be constant as frequency increases. The dielectric loss increases the temperature of the insulating material, which in turn lowers its dielectric strength.*

FREQUENCY AND DURATION OF APPLICATION

The time-voltage relationship in frequency effects is an important factor in dielectric breakdown.

As the time of voltage application is extended, for example, breakdown voltage is lowered. The curves in Figure 2 indicate that this drop is rapid for shorter time of application, then more gradual as duration of voltage application is extended.

Another illustration is afforded by the breakdown of insulation materials under impulse tests. Impulse breakdown voltage is higher than normal-frequency alternating-current breakdown for most insulation (see Table I). The ratio of impulse breakdown to normal-frequency breakdown is called the "impulse ratio," and is greater than unity for most materials.

Comparisons of impulse breakdown with direct-current breakdown are inconclusive. Material thickness affects results, direct-current breakdown values being higher for thicker samples. Impulse tests of comparatively long duration also give breakdown values lower than direct-current tests. Particularly useful information for comparing insulation materials is provided by impulse tests employing a standard impulse wave-form similar to that of lightning.

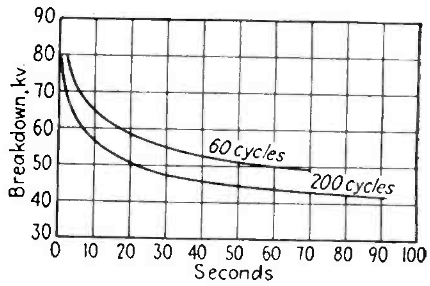


Figure 2: Effects of frequency and time. Pressboard in oil at 25° C. (S. Whitehead)

The factors of frequency, temperature and duration of voltage application are thus intimately related, and any evaluation of electrical insulating materials must be based on a knowledge of their combined effects.

*See advertisement No. 4 of this series.

Source	Crest Kv. per Mm.
Single impulse (equivalent to 200,000 cycles or 2.5 microsec. to crest) . . .	108
D.c.	85
60 cycles (short-time)	53
60 cycles (1 min.)	46
90,000 cycles (1 min.)	17.6

Table I: Comparison of various voltage forms on the breakdown of two layers of varnished cloth, total thickness 0.60 mm. (F. W. Peek)

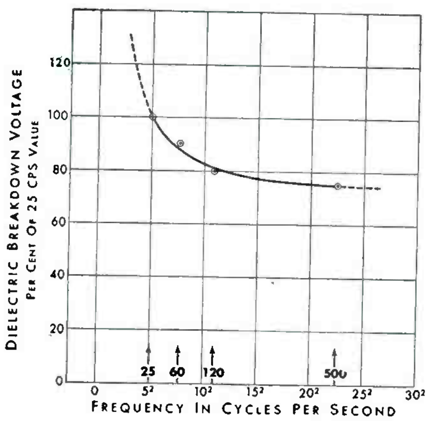


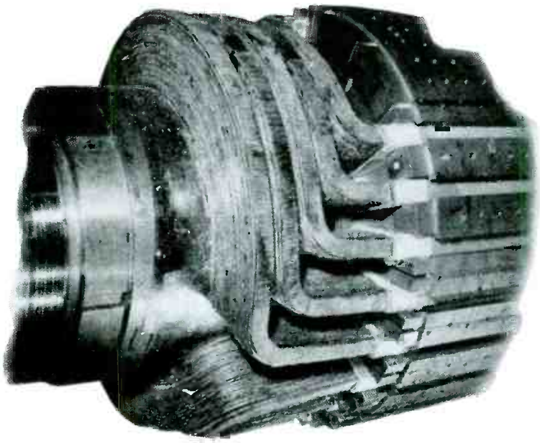
Figure 1: Effect of frequency on dielectric breakdown of transformer insulation. (Curve is based on findings of F. W. Peek)

MICA

in Selecting Electrical Insulation

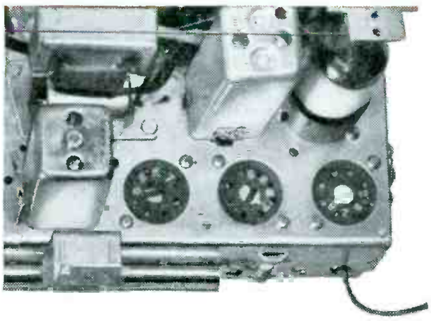
MICA INSULATOR PRODUCTS FOR HIGH-FREQUENCY AND HIGH-VOLTAGE REQUIREMENTS

The successful performance of high-frequency and high-voltage equipment depends in large part upon the quality and properties of the electrical insulating material selected. The homogeneity, high dielectric strength and excellent physical properties of Mica Insulator Company products have contributed to unusual efficiency in many applications.



EMPIRE

Varnished Fiberglas Tapes, Micanite sheets and mica tapes are the materials used for coils and core insulation on the rotor for 43,750-kva, 13,800-volt, 80%-pf turbine generator. These materials provide dependable insulation that withstands dampness and high temperature and protects equipment against overload.

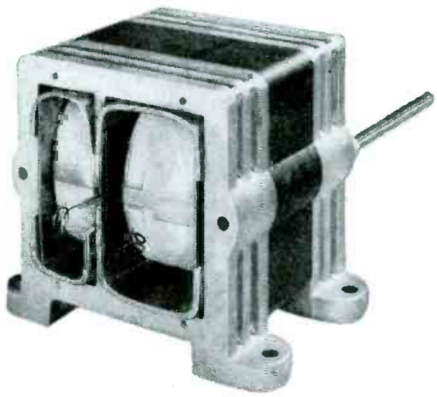


LAMICOID

tube socket bases provide strong mechanical support as well as the low dielectric loss and high dielectric strength characteristics well suited to the protection of electronic equipment. Lamicoid sheets, rods and tubes are used for many applications in radio and electronic equipment.

MICA

stampings, accurately punched for use as vacuum tube element separators, provide unusually high dielectric strength and temperature resistance for electronic and radio equipment. Mica is so basic an insulating material that it finds application in virtually every type of electrical and electronic equipment.



MICANITE

in transformers provides the extra margin of protection needed against surges or impulse voltages caused by lightning or switching. The exceptional dielectric strength of mica is secured in minimum space in a highly flexible plate which is easy to install, since it may readily be bent over small radii at room temperature.

Experience counts in the selection of insulating materials for exacting applications. Mica Insulator Company has specialized in this field for more than fifty years, and has developed a complete line of electrical insulation to meet every requirement. Bring your insulation problems to our Technical Service Department for accurate and unbiased recommendations.

MICO
ELECTRICAL
INSULATION

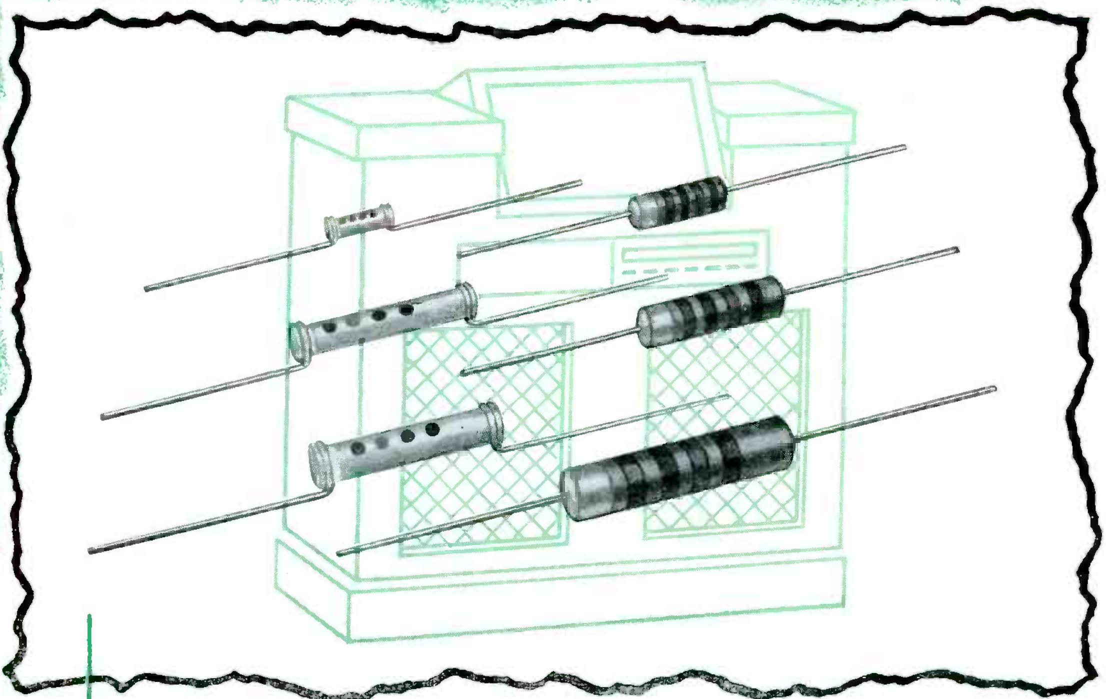
Trade-mark

Mica Insulator COMPANY

SCHENECTADY 1, NEW YORK

Atlanta • Birmingham • Boston • Chicago • Cincinnati • Cleveland • Detroit • Houston
Los Angeles • Milwaukee • New York • Philadelphia • Rochester • St. Louis • San Francisco

Erie "GP" Ceramicons*



Going Places
. . . in FM and Television

The basic, simple construction of ERIE "GP" Ceramicons give them higher resonant frequencies, which make them the ideal condensers for FM and Television applications.

The same basic, simple construction makes possible the mass production which accounts for the surprisingly economical cost of high quality condensers. They are designed for practically all applications in which the condenser is not definitely frequency determining.

ERIE "GP" Ceramicons are not only cheaper to buy—they are cheaper to use than other types of condensers. Their wide range of adaptability reduces the number of condensers necessary to stock. Their campact tubular form and their sturdy construction make them easy to install on the assembly line.

ERIE "GP" Ceramicons are made in insulated styles in popular capacity values up to 5,000 MMF, and in non-insulated styles up to 10,000 MMF. If you are not already using them, write for detailed information.

*Ceramicon is the registered trade name of silvered ceramic condensers made by Erie Resistor Corporation.

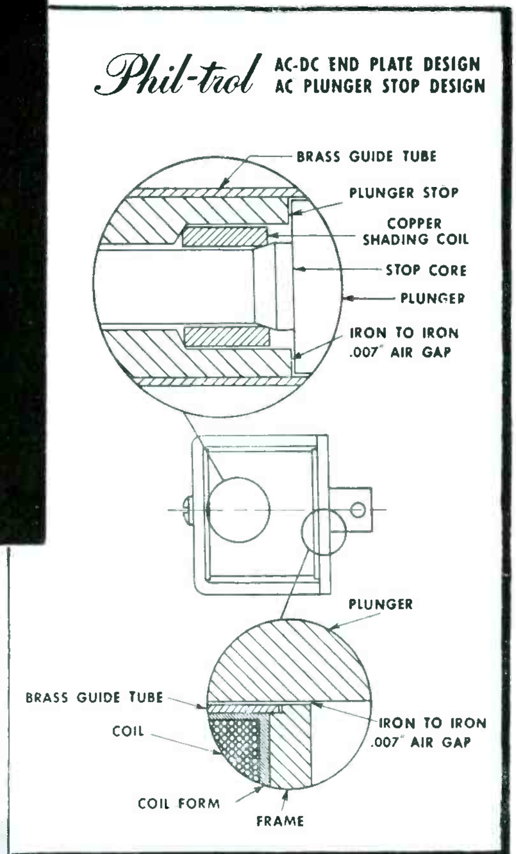
Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • TORONTO, CANADA

Phil-trol ACTUATORS

. . . Designed for POWER



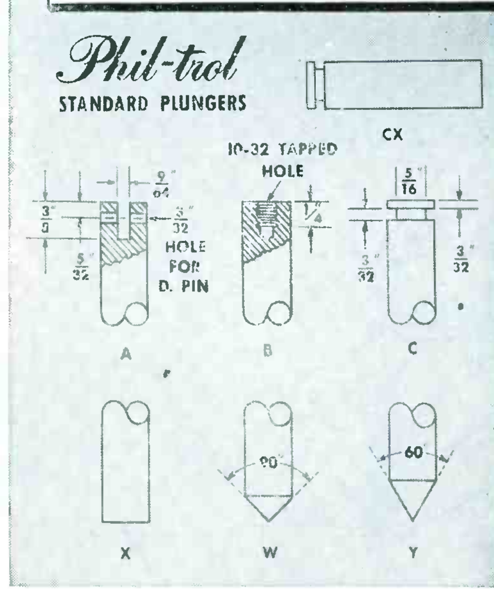
For maximum power, reliable operation and efficient performance, specify Phil-trol Actuators. Exclusive design features incorporated in one-piece solid frame construction make Phil-trol Actuators strong, durable units for a wide range of solenoid uses.

Outstanding construction features include: One-piece 1/8" iron frame, dovetailed and staked into end plate for a secure bond and extra strength; Plunger and plunger stops are made from specially processed steel and are available in three types of end shapes; Standard coils are fiber bobbins wound with enameled copper wire, and impregnated with insulating varnish; Entire frame and plunger stop are cadmium plated and plunger is chrome plated for smooth operation.

Five standard sized Phil-trol Actuators are available in either A. C. or D. C. desired voltage. Designed for "pull" application, they may be converted to "push" with but slight efficiency loss.

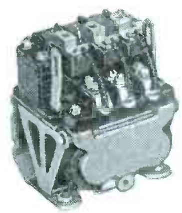
Phillips engineers, located in cities listed below, will be glad to assist you in determining solenoid requirements. Special Phil-trol Actuators are designed to specification.

Send for Phil-trol Actuator Bulletin



Phil-trol PRODUCTS

Relays, Actuators, Solenoids, Contactors, Starting Switches, Focus Coils, Ion Traps and Special Process Control Assemblies.



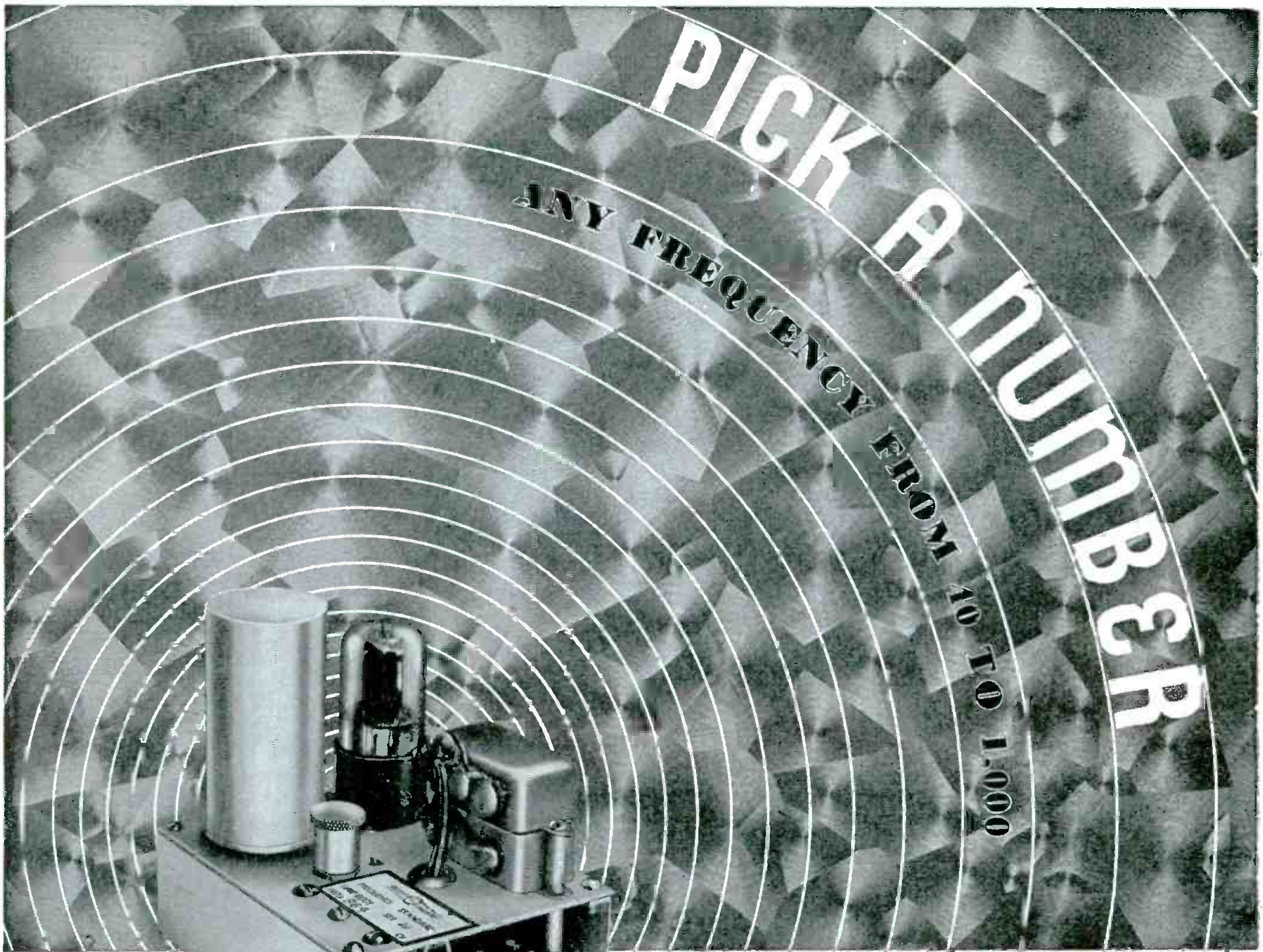
Type 27

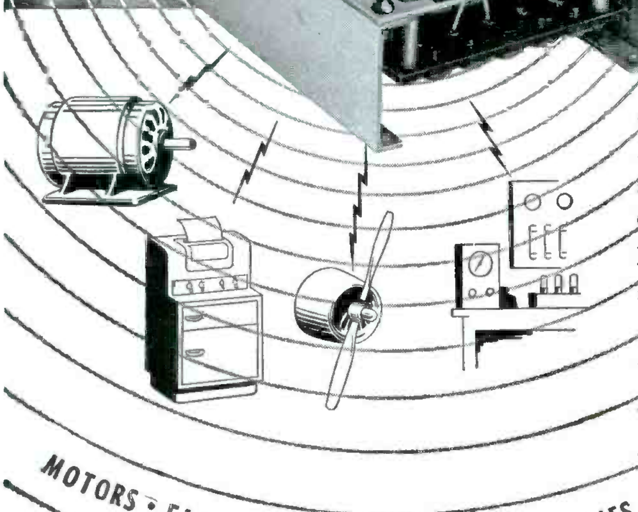
Phil-trol RELAYS:

There is a complete line of Phil-trol Relays, all engineered to the highest standards, for electronic and industrial control, signal and traffic control, radio, communication, aircraft and other applications. Send for new Relay Catalog.

PHILLIPS CONTROL CORPORATION • 612 N. MICHIGAN AVENUE • CHICAGO 11, ILLINOIS

PLANT: Joliet, Illinois • SALES OFFICES: New York, Boston, Philadelphia, Buffalo, Cleveland, Charlotte, St. Louis, Kansas City, Los Angeles, Toronto





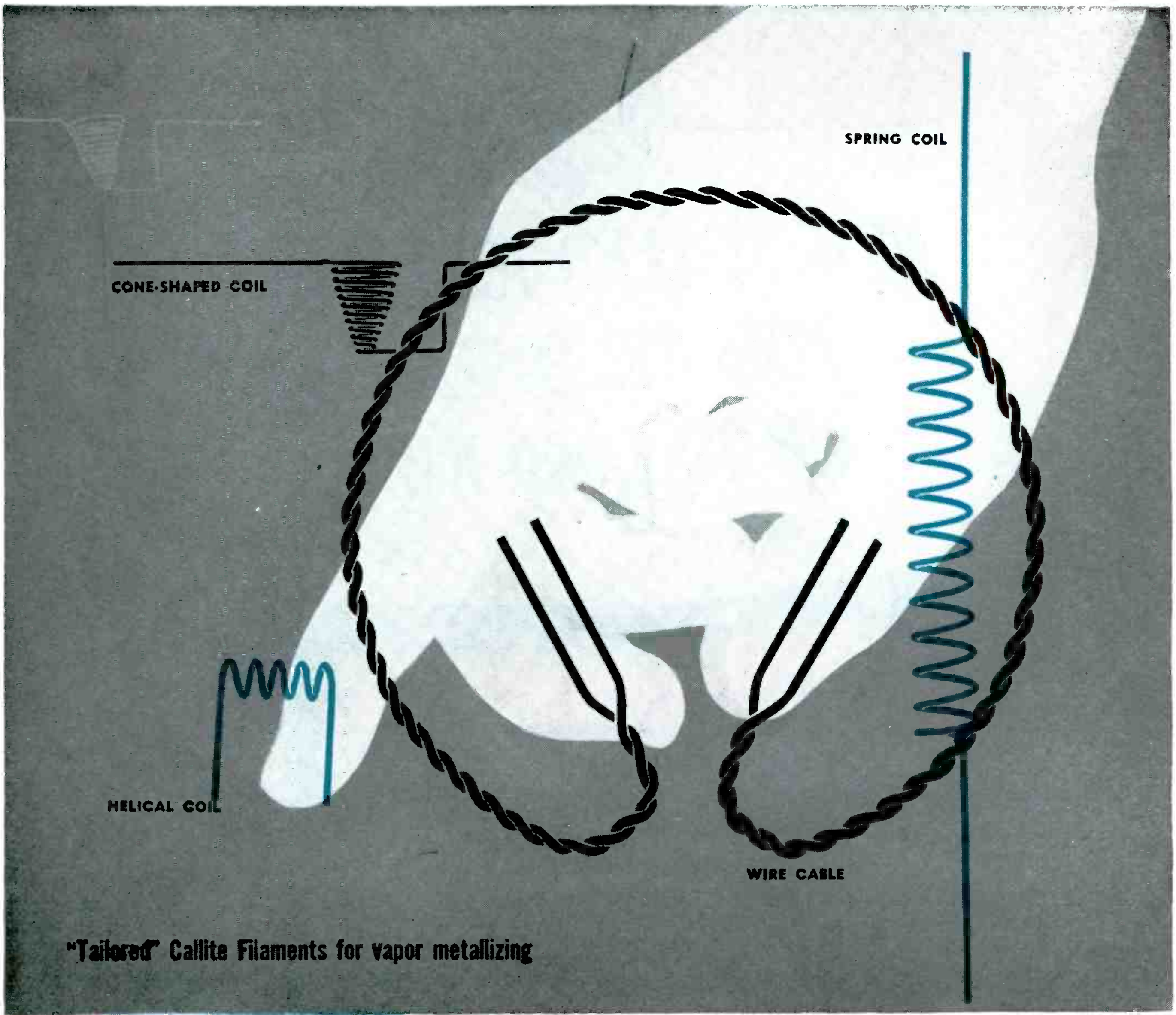
Pictured here is a tuning-fork frequency standard with accuracy guaranteed to one part per million per degree Centigrade. The fork is temperature-compensated and hermetically sealed against variations of barometric pressure. This standard, when combined with basic equipment, facilitates accurate speed and time control by mechanical, electrical, acoustical or optical means.

The unit is available separately or in conjunction with complete timing instruments. Our engineers are ready to cooperate on any problem.

American Time Products, Inc.

580 Fifth Avenue *New York 19, N. Y.*

OPERATING UNDER PATENTS OF THE WESTERN ELECTRIC COMPANY



another coating problem solved!

it's elementary...

when you use Callite heating elements to coat metals or plastics

Leading metallizers have discovered that Callite tungsten or molybdenum heating elements provide the simplest, quickest and most economical solution to their specific problem of coating materials by the vacuum evaporization process. Electrically heated, the filaments evaporate the coating metal — in pellets or wound on heater — and spread a smooth, uniform coat . . . often in a matter of seconds.

Let our many years of varied field experience help you, too, improve your metallizing operations. Skilled Callite engineers will gladly design special filaments — "tailor-made" to your specifications; to fit your current equipment; or to meet your production cost schedules. Prompt deliveries of all types. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago, Illinois; Cleveland, Ohio.

Callite

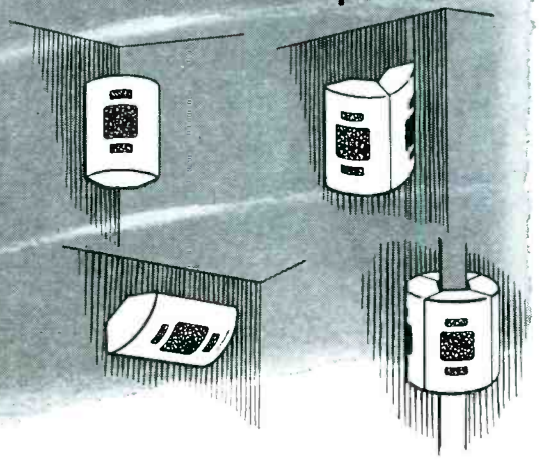
METALLURGY

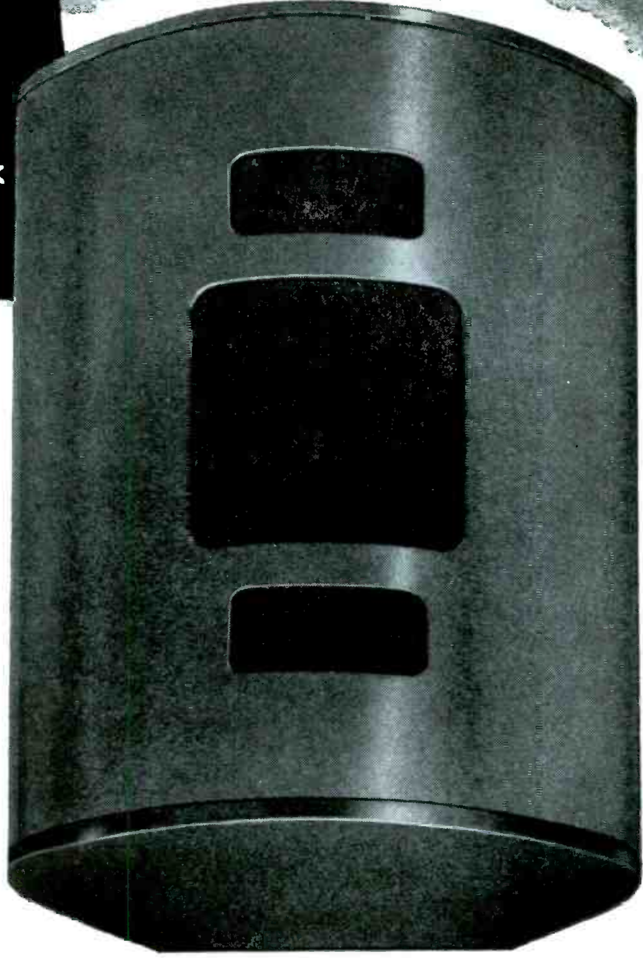
CALLITE TUNGSTEN CORPORATION CT

Tungsten, molybdenum, silver, platinum, palladium and alloys of these metals. Callifex Thermostatic Bi-Metals; Callinite Facing Material. Bulletins on request.

Jensen "SECTOR" CABINET WITH *Bass Reflex**

for 8-inch Speakers





They fit anywhere — in 90-degree corners — flat on walls — or in clusters to give wide-angle distribution. Perfectly adapted for nearly all interior sound installations, because of their economy, small size and, above all, the high quality performance of JENSEN speakers in Bass Reflex enclosures. Use with any JENSEN 8-inch speaker. Model P8-SH is recommended for high fidelity as required by many wired music installations.

Type H Sector Cabinets are built around a frame of solid wood with wood composition replacing the conventional plywood panels.

Model H-81 Sector Cabinet (ST-141) List Price $22.50

Finish is brown opaque lacquer although covering colors may be applied on the job if desirable to match environment. Size: Height 22½", width 17¾", depth 8½" Furnished with mounting brackets and screws.

JENSEN MANUFACTURING COMPANY
6607 South Laramie Avenue, Chicago 38
In Canada: Copper Wire Products, Ltd., 11 King St., W., Toronto

**Trade Mark Registered*

OTHER Jensen CABINETS

BASS REFLEX — PERI-DYNAMIC

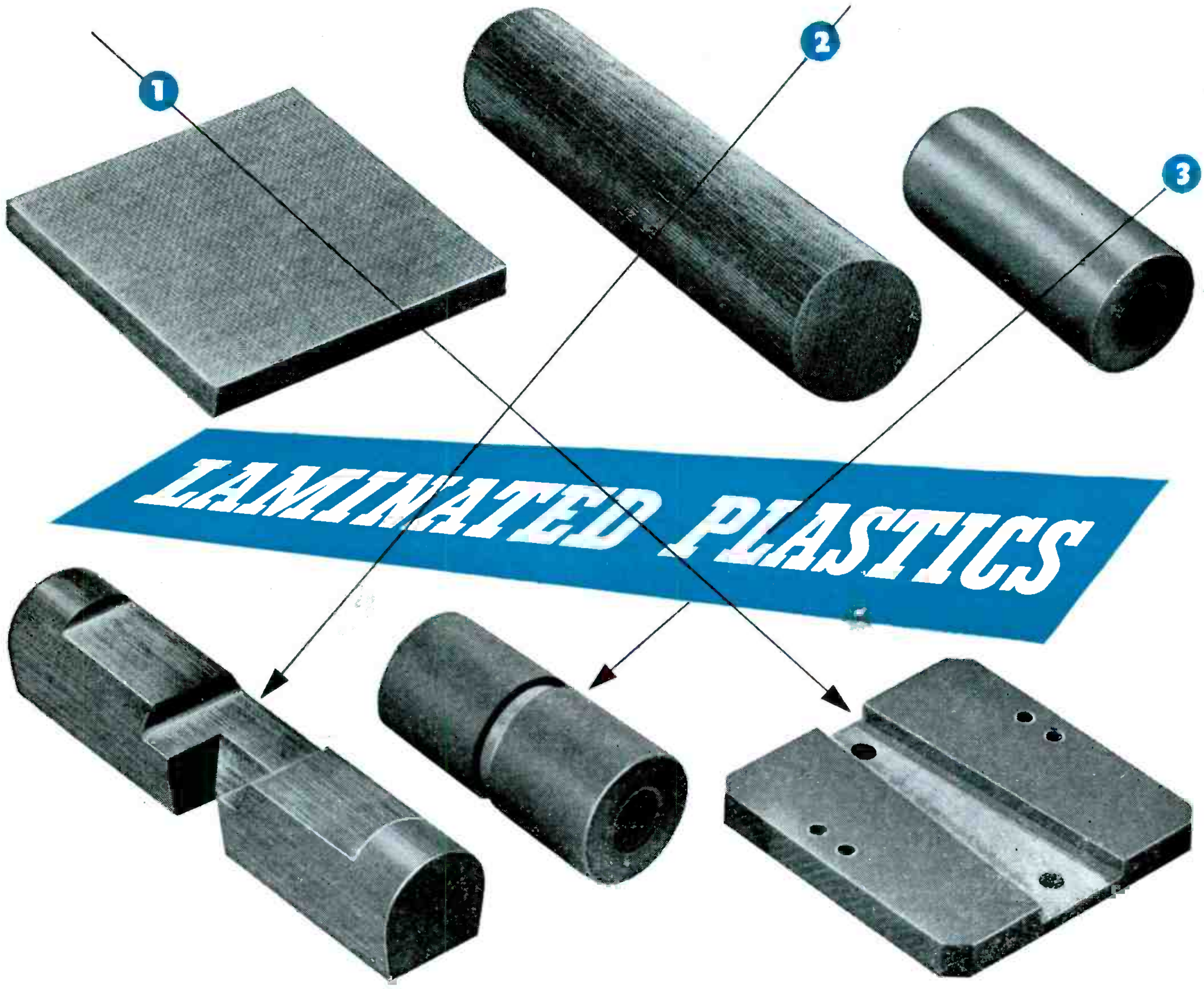
IMPERIAL TYPE D	UTILITY TYPE B	WALL TYPE J
D-151 (15-inch)	B-151 (15-inch)	J-61 (6-inch)
D-121 (12-inch)	B-121 (12-inch)	
	B-81 (8-inch)	

Jensen SPEAKERS WITH ALNICO 5

Jensen FINE ACOUSTIC EQUIPMENT

Designers and Manufacturers of Fine Acoustic Equipment


Sign of Transformer Reliability
KENYON
For over 20 years, the KENYON "K" has been a sign of transformer reliability. Ever since the cat's-whisker, crystal-set days, KENYON has pioneered high quality transformers. Skillful engineering, progressive design and sound construction have resulted in dependable, conservatively-rated transformers with an enviable record for minimum field rejections. Cut engineering and replacement costs. Improve products. Insure repeat business. Specify KENYON!
SEE US AT THE I.R.E. SHOW
Consult KENYON
About Your Transformer Problems
KENYON TRANSFORMER CO., Inc.
840 BARRY STREET
NEW YORK 59, N.Y.



Thousands of Fabricated Parts from Taylor's Sheets, Rods, Tubes

1 *Sawed, milled, and drilled piece, fabricated from fabric-base, Taylor Phenol Fibre sheet stock. Combines strength with good insulating qualities.*

2 *Part designed and machined using Taylor Phenol Fibre rod as the basic shape. Rods supplied either ground from sheet stock or molded.*

3 *Switch spacer, made from paper base grade of Taylor Phenol Fibre tubing. Fine machineability, dimensional stability, and electrical properties are characteristics of Taylor tubes. Supplied either rolled or molded.*

From sheets, rods, and tubes of Phenol Fibre or Vulcanized Fibre, Taylor makes thousands of different fabricated parts, turning them out by the millions and doing it quickly, accurately, and economically.

Almost every one of these parts is specially designed for a special purpose and calls for a laminated plastic with special characteristics. Their common feature is light weight with great strength. In addition, they have insulating, electrical, and dielectrical properties unequalled by any other material.

Having been in this business for more than fifty years, Taylor also has a stock of standard tools for turning out such things as plain washers and shoulder bushings in so many different sizes that the chances are good that the size *you* need is in stock and your fabricated part can therefore be made more quickly and more inexpensively.

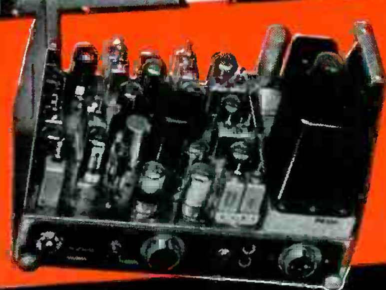
Whatever your problem, our engineers will gladly tell you, without obligation, exactly what Taylor Laminated Plastics can contribute to its solution. Write us today, sending sketch or blueprint.

TAYLOR FIBRE COMPANY

LAMINATED PLASTICS: PHENOL FIBRE • VULCANIZED FIBRE • Sheets, Rods, Tubes, and Fabricated Parts

NORRISTOWN, PENNSYLVANIA Offices in Principal Cities Pacific Coast Plant: **LA VERNE, CALIFORNIA**

note the New Look in Power Transformers



Typical Motorola FM two-way radiotelephone receiver utilizing Sealed in Steel Chicago Transformers.

With CT's Famous

Sealed in Steel Construction

The clean, streamlined appearance and compactness of CT's new *Sealed in Steel* construction contribute immeasurably to the trim, precision-like effect of any electronic equipment.

In addition, CT Transformers provide "steel wall" protection against atmospheric moisture, efficient magnetic and electro-static shielding, unsurpassed strength and rigidity to withstand shock and vibration, and unusual convenience of mounting.

Two base styles are available for most of the units in this catalog line, one with clearly identified solder lugs in a phenolic terminal board, the other with RMA color coded leads, stripped and tinned for easy soldering.

The design of these new power transformers assures maximum performance with minimum physical size and minimum temperature rise in accordance with RMA standards.

The wide range of carefully selected ratings achieves maximum flexibility of application, close matching with today's preferred types of tubes, and conformance with all industry standards.

Write direct for catalog illustrating, describing and listing the complete line, or contact your nearest radio parts jobber at once.

PLATE AND FILAMENT SUPPLY TRANSFORMERS

Primary 117 Volts, 50-60 Cycles

Catalog Number	HIGH VOLTAGE SECONDARY A.C. Volts	D.C. Ma.	D.C. Volts Output	FILAMENTS Rectifier Volts	Rectifier Amps.	No. 1 Volts	No. 1 Amps.	No. 2 Volts	No. 2 Amps.
For CAPACITOR INPUT SYSTEMS									
PC-55	270-0-270	55	260	5	2	6.3CT	2	......	
PC-70	335-0-335	70	320	5	2	6.3CT	3	......	
PC-85	330-0-330	85	320	5	2	6.3CT	3	......	
PC-105	345-0-345	105	320	5	2	6.3CT	3.5	......	
PC-120	375-0-375	120	380	5	3	6.3CT	4	......	
PC-150	370-0-370	150	390	5	3	6.3CT	4	6.3CT	1
PC-200	385-0-385	200	390	5	3	6.3CT	4.5	6.3CT	1
For REACTOR INPUT SYSTEMS									
PR-55	350-0-350	55	260	5	2	6.3CT	2	......	
PR-70	425-0-425	70	320	5	2	6.3CT	3	......	
PR-85	440-0-440	85	325	5	2	6.3CT	3	......	
PR-105	445-0-445	105	325	5	2	6.3CT	3.5	......	
PR-120	500-0-500	120	400	5	3	6.3CT	4	......	
PR-150	505-0-505	150	400	5	3	6.3CT	4	6.3CT	1
PR-200	520-0-520	200	410	5	3	6.3CT	4.5	6.3CT	1
PR-300	550-370-75-0-75-370-550	300	425	5	6	6.3CT	5	6.3CT	1

Also available in the *Sealed in Steel* constructions:

FILTER REACTORS with current ratings to match power transformers above.

FILAMENT TRANSFORMERS to meet a wide range of modern tube requirements.

AUDIO TRANSFORMERS—Input, Output, Driver, and Modulation—that provide uniformly high fidelity response in three frequency ranges: 30-15,000 cycles, 50-10,000 cycles, and 200-3,500 cycles.

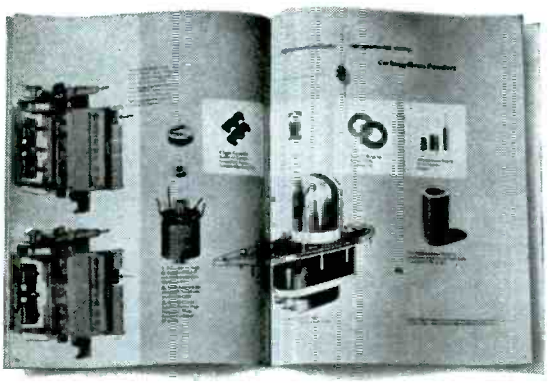
CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

3501 ADDISON STREET • CHICAGO 18, ILLINOIS

CHICAGO TRANSFORMER CTC

"What a lucky man I am to have this free G. A. & F. booklet! Now I know that SF Carbonyl Iron Powder is perfect for permeability tuning of the FM band. That it gives remarkably low loss and uniformity. What's more, this same SF powder is ideal for adjusting television circuits. Imagine!"



FREE! This easy-to-read booklet that can save money — *real* money — for every radio engineer and electronics manufacturer!

Ask your core manufacturer—he's an authority on the use of G.A.&F. Carbonyl Iron Powders.

*®

G.A.&F.

carbonyl iron powders

An Antara* Product of
General Aniline & Film Corporation

Clip this coupon—Mail it today!

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444 Madison Ave., New York 22, N. Y.
Please send me a free copy of:
☐ G. A. & F. Carbonyl Iron Powders ☐ Polectron* dielectrics

Name____________________

Address____________________

____

For Truly Fine Recording and Reproduction

THEY SPEAK FOR THEMSELVES

Professional Recordists Use—
Professional Recordists Recommend—

audiopoints*

THE NEWLY EXPANDED LINE of Audiopoints now covers the full range of recording and playback needs. There are Audiopoints that fully meet the requirements of the most exacting professional recordists. There are also Audiopoints which these engineers unhesitatingly recommend to the non-professional and the general public.

RECORDING AUDIOPOINTS

Sapphire #14. Long recognized by recording engineers as the best recording stylus obtainable. Manufactured to rigid specifications. Disc-tested on a recording machine just before packaging. List price **$7.25.**

Sapphire #202. A fine quality brass shank stylus, ideally suited for those recordists not requiring the super quality of Sapphire Audiopoint #14. List price **$5.25.**

Stellite #34. Favorite with many professional and non-professional recordists. Though moderately priced, it is the very best stellite stylus produced. List price **$1.75.**

Diamond-Lapped Steel #50. Most practical stylus for home recordists when "first cost" is important. Being diamond-lapped, it cuts a quiet, shiny groove. List price 3 for **$1.00.**

PLAYBACK AUDIOPOINTS

Sapphire #113. Materials, workmanship and design make this playback point the finest made for original recordings and vinyl transcriptions. For years the outstanding choice of professional recordists. List price **$6.50.**

"Red Circle" Sapphire #103. With straight dural shank and fine polished jewel point. Excellent for original recordings, vinyl pressings and phonograph records. List price **$2.00.**

"Red Circle" Sapphire #303. Bent dural shank sapphire needle that is tops for phonograph records. *For the first time a phonograph needle with a resharpening feature.* List price **$2.00.**

Steel Transcription Needle #151. The ideal all-purpose transcription needle for original recordings, vinyl pressings and phonograph records. Quality performance is assured since each point undergoes a shadowgraph test. List price **20** for **25¢.**

*Reg. U. S. Pat. Off.

RESHARPENING SERVICE

Established years ago, our resharpening service gives real economy in the use of Audiopoints #14, #202, #34, #113, #103 and #303.

Write for new dealer discounts and our folder "Audiopoints."

Audiopoints are a product of the manufacturers of Audiodiscs.

AUDIO DEVICES, INC., 444 Madison Ave., New York 22, N. Y.

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS

tronic applications. It costs little and mounts in places where a rectifier tube and socket won't fit. Tests prove that this new selenium rectifier will outlast several 117-volt rectifier tubes. Installation is easier too—only two soldering operations and a minimum of mounting hardware are required.

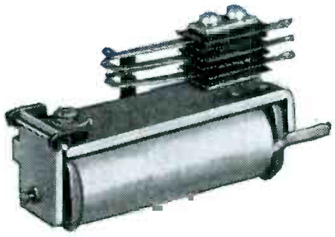
These rectifiers have an exceptionally high inverse-peak rating, and the inverse current is extremely low even with peak voltages up to 350 volts. At rated current output, the forward drop is five volts or less. Ratings are based on ambients of 50 to 60 C. Check Bulletin 21-127 for more information on this and other General Electric radio rectifiers.

NEW MACHINABLE PLASTIC FOR UHF INSULATION

A new arrival in the plastics insulator field is G-E No. 1422, which offers characteristics of advantage in the manufacture of ultra-high-frequency equipment, television, FM, radar, and radio sets, and many other electronic applications. Possessing a dielectric constant of 2.5 to 2.6 with a power factor of .0006 to .0009 at 3000 mc, G-E No. 1422 exhibits unusual heat resistance and excellent machinability.

Indicative of its machinability is the industrial production of r-f connector beads from G-E No. 1422 on automatic and semi-automatic screw machines. As a low-loss dielectric in the hands of the electric-equipment designer, it affords an excellent low-cost means of producing experimental models and small production quantities through the use of standard machine shop tools. Check coupon for technical report.

HANDLES 12 CIRCUITS SIMULTANEOUSLY



This new telephone-type relay is capable of handling as many as 12 circuits in a wide variety of contact combinations. Designed for multi-purpose use in industrial electronic apparatus, communications and signaling equipment, these devices have service lives measured in millions of operations. Working from five basic contact arrangements, combinations can be stacked to satisfy intricate circuit switching requirements. Silver, palladium, or tungsten contacts can be supplied; the choice depends on rating and life specifications.

More than 500 different coils are available, with ratings ranging from 1 to 250 volts, and 0.1 to 26,000 ohms. This varied selection of coil ratings makes it possible to match closely the coil voltage and resistance with the rating of the energizing circuits. Check Bulletin GEA-4859 for full details.

TO MEASURE TUBE LIFE

Now available for immediate delivery, General Electric Type KT time meters are ideal for inclusion in transmitters and other electronic equipment where knowledge of tube "on time" is important. They can record operating time in hours, tenths of hours, or minutes, and are built in four forms: round or square for panel mounting, portable with attached base, or for conduit mounting. Those designed for panel mounting are housed in small Textolite cases that harmonize with other panel devices.

Telechron motor drive assures an accurate record of tube operation over a long period of time. They can also be used on electronic production tools, such as resistance welders, to keep an accurate record of machine operating time. Researchers use them for measuring time intervals, verifying circuit operation, and life testing. Bulletins GEA-3299 and GEA-1574 have full details.

GENERAL ELECTRIC COMPANY, Section F-642-16
Apparatus Department, Schenectady 5, N. Y.

Please send me:

☐ GEA-2621 400-v D-c Capacitors
☐ GEA-3299 } Type KT Time Meter
☐ GEA-1574 }
☐ 21-127 Selenium Rectifier
☐ GEA-4859 Telephone-type Relay
☐ Report on G-E No. 1422 Plastic

NOTE: More data available in Sweets' File for Product Designers.

Name ....

Company ....

Address ....

City .... State ....

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RELAYS *by* GUARDIAN

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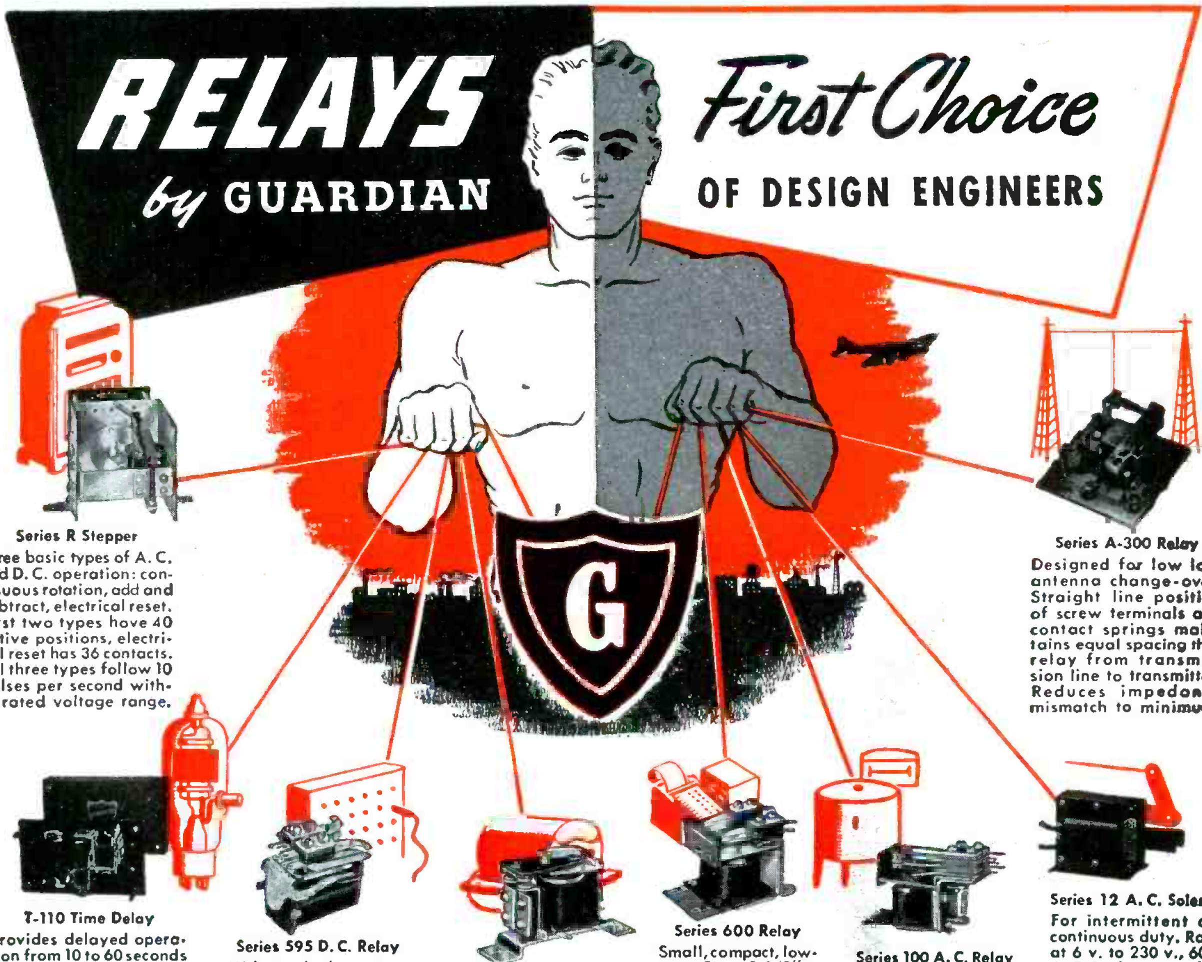

Series R Stepper
Three basic types of A. C. and D. C. operation: continuous rotation, add and subtract, electrical reset. First two types have 40 active positions, electrical reset has 36 contacts. All three types follow 10 pulses per second within rated voltage range.

Series A-300 Relay
Designed for low loss antenna change-over. Straight line position of screw terminals and contact springs maintains equal spacing thru relay from transmission line to transmitter. Reduces impedance mismatch to minimum.

T-110 Time Delay
Provides delayed operation from 10 to 60 seconds using a resistance wound bi-metal strip. In radio it prevents damage to rectifiers and tube filaments by retarding plate current until tubes are sufficiently heated. Used widely in industry to change circuits after a predetermined interval.

Series 595 D. C. Relay
Midget telephone type unusual for amount of power provided. Size only 1 7/16" x 1 3/8" x 1". Three outstanding features — frictionless pivot — proper copper-iron balance—capacity to carry up to 8 single pole, single throw contact combinations.

Series 220 A. C. Relay
Capable of breaking currents up to 20 amps at 230 v., 60 c., A. C., non-inductive load. Bakelite contact block tests 1500 v. break-down to ground. 5/16" dual contacts minimize arcing.

Series 600 Relay
Small, compact, low-cost. Size: 2 1/8" x 1 1/2" x 1 1/8". Contact combinations up to 4 P. D. T. Power consumption, 6 V. A. Max. cap., 8 amps, 3 v. to 230 v. A. C., or 3 v. to 110 v. D. C. Coil and contact assemblies interchangeable.

Series 100 A. C. Relay
Used successfully in automatic home washing machines. It is incorporated in many new household appliances now on drafting boards.

Series 12 A. C. Solenoid
For intermittent and continuous duty. Rated at 6 v. to 230 v., 60 c., A. C. Stroke ranges from 1/8" up to 7/8". Series 6 D. C. rated 6 v. to 230 v. Stroke 1/8" up to 2".

Faced with responsibilities for the design and successful performance of their companies' products, American design engineers are eagerly turning to Guardian Electric *first* for relays and complete control assemblies. They find at Guardian a vast wealth of application and performance data, an expert engineering staff with more than a decade of specialized experience solving the most complex and widely diversified control problems. Such experience offers design engineers an *extra bonus value* thru practical suggestions and valuable specific recommendations given without cost or any obligation. Should your design call for a "special" control, Guardian has probably built the self-same principle you seek into one of its large line of *basic* type units. When such a *basic* type unit becomes the "special" you need thru slight variations, the savings in time and money are substantial, you circumvent die costs and beat delivery schedules in the bargain! Should special engineering be required, our staff is at your disposal. Write — call on Guardian for these excellent controls designed by Guardian engineers *for* engineers. Expert advice is yours for the asking to help you design better products thru improved techniques which are now so vital to meet competition.

GUARDIAN G ELECTRIC
1625-C W. WALNUT STREET CHICAGO 12, ILLINOIS
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

1949 —

Can Be a Good Year Too

You can expect good business to run on well through 1948.

But old-time competition is close upon us.

And 1949 will be a critical year for all of us — making lower taxation imperative NOW.

These are the main conclusions drawn from a nation-wide survey of industry's plans for new plants and equipment which McGraw-Hill has just completed. Here are the major findings:

1. Capital expenditures in 1948 may be a little lower — but at the most only 8% lower — than in 1947.
2. In 1949 capital expenditures may decline. 1949 plans are still fluid. However, those which have been projected now show a falling off. (Washington planners, please note: Current official attempts to discourage capital expansion may turn out to be superfluous — or downright dangerous.)
3. Industry's initial postwar rebuilding will be 85% complete at the end of 1948. When this first wave of deferred maintenance and expansion is finished, American industry will have more than half again the capacity it had in 1939. This does not mean the end of needed capital expenditures. Business will need to invest much more. (President Truman sets an investment goal immediately ahead of $50 billion.) But it does mean that tough competition is returning fast.

• IF YOU WANT *full details of the McGraw-Hill survey of Capital Expenditures, which is summarized in this editorial, write to the Economics Department, McGraw-Hill Publishing Company, 330 West 42nd Street, New York 18, N.Y.*

These are solid facts, based on plans which are firmly made by a broad cross-section of American industry and which the McGraw-Hill survey revealed.

The greatest contribution of this survey is the information it supplies on business plans for the purchase of new plants and equipment. What business planned to do about such expenditures was by far the biggest unknown element in the 1948 outlook. For, if business planned to slash its outlays for plants and equipment this year, that fact alone could bring a sharp downturn in business.

In making this survey, McGraw-Hill researchers all over the nation personally interviewed top executives of companies selected to make up a scientific cross-section of industry. Each executive was asked to give, *not his opinion* about general business trends, but *factual details* about his company's plans for 1948. By adding together the plans of the companies interviewed, McGraw-Hill has secured, for the first time, a reliable picture of what business plans to do in the months ahead.

Here are plans for 1948 and 1949, as revealed by the survey:

1. Industry still needs more than a year to finish its initial postwar maintenance and rehabilitation program.

Among manufacturing industries, top executives report that 64% of their program for the immediate postwar period is now complete. According to present plans, 85% will be installed by the end of this year even though some manufacturing industries still have a long way to go. For instance, oil companies will complete only three-quarters of their presently planned expansion program by the end of 1948.

2. Business may spend less on new plants and equipment this year than the record $16.1 billion spent last year. But the decline

probably will be negligible and certainly will not be great enough to bring on a business recession.

At the time McGraw-Hill interviewed top executives, some companies had not yet approved their 1948 capital budgets. Under the extreme assumption that those particular companies will make *no* capital expenditures in 1948, industry's 1948 bill for new plants and equipment will run to $14.9 billion, or 8% below last year's record figure. Under the more realistic assumption that those companies will cut their capital investment only as much as the companies which had already drawn up their plans for 1948, industry's 1948 capital budget will run to almost $15.8 billion, a decline of only $300 million from 1947.

Thus the over-all conclusion of the McGraw-Hill survey is that capital expenditures by business will be only slightly lower this year than last.

3. Business executives will not slash their 1948 capital budgets unless they are convinced that a real slump is in the offing—and they are not convinced now.

Almost two-thirds of all manufacturing companies say they would not cut capital budgets sharply even if business activity declined 20%. What is more, even a 15-20% boost in wage rates would have little effect on projected capital budgets. If wages go up, 57% of manufacturing companies would not change their capital budgets, 26% would increase them, and 17% would cut them.

4. Most executives look for an increase in their company's sales this year.

More than half of all manufacturing companies are planning on a sales increase over last year of 10% or more. A third of them say sales will be about the same as in 1947. And fewer than 10% look for lower sales.

5. Manufacturing companies will finance much of their purchases of new plants and equipment in 1948 from funds set aside out of past or current earnings.

Utilities and railroads, on the other hand, must go to the securities markets or commercial banks to finance most capital expenditures.

Although manufacturing companies say they can finance this year's capital expenditures in large part from current profits and past savings, all evidence indicates that, to do so, they will use up most of the funds they earmarked during the war for this purpose. So in 1949, industry must go to the capital markets or to the commercial banks if it is to continue to spend for capital purposes. If the securities markets continue to lie in the doldrums, *as they will under present tax laws*, only companies with triple A credit ratings will be able to raise funds that way.

6. Purchases of new plants and equipment may fall off in 1949.

The McGraw-Hill survey collected all available evidence on plans for 1949 capital budgets. Fewer than 40% of all manufacturing companies now have definite plans for 1949. Of those that have plans, 45% intend to spend less than in 1948, 30% plan to spend the same amount, and a quarter expect to spend more. These preliminary decisions would seem to indicate that capital investment may fall off in 1949.

7. Industry's production capacity in 1949 will be far above prewar.

Manufacturing capacity will be more than 50% greater than in 1939 once the present wave of postwar building is complete. Almost a third of all manufacturing companies report that their capacity will be double or more than double the prewar figure. Thus, 1949 may see a huge increase in production of many things that now are hard to buy.

The last two points in this summary mean that 1949 will be a critical year. We must forestall a sudden drying up of capital expenditures in that year. We must be able also to absorb a great outpouring of production both of capital and consumer goods.

What will happen to business in 1949, therefore, will depend on how successful we are this year in dealing with such momentous problems as taxation, foreign aid and prices. But 1949 *can* be a good year too.

The next editorial in this series will discuss the pivotal problem of taxes.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 65TH OF A SERIES

Anyone can make accurate SOUND LEVEL TESTS...

...with this dependable, portable *Western Electric* Sound Level Meter

THIS instrument—available in a-c line or battery operated models—is small and light, simple to operate, ruggedly built, adaptable to many noise measuring problems. And it's modestly priced!

The Western Electric Sound Level Meter has built-in calibration circuits to permit rapid, accurate adjustment to A.S.A. standard reference levels. Negative feedback in the amplifier contributes to utmost stability.

The frequency range of this meter is 20 to 10,000 cps. It can be used alone—or in conjunction with an associated Filter Set which enables the meter to measure sound in selected frequency bands between 50 and 4800 cycles.

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BUSINESS BRIEFS

By W. W. MacDONALD

Buyers' Guide Issue idea hinted at on p 69, February, has now jelled. We are going to include a special editorial section giving the electrical, mechanical and other characteristics of materials important to designers of electronic equipment and the components used in such gear.

Included will be such things as *insulating materials, plastics, ceramics, glass, metals, magnetic materials, chemicals, gases, radioactive materials, crystals, acoustic materials,* and *finishes.*

The special issue will reach readers around the middle of June, between the times they receive the regular June and July numbers.

Take A Piece Of Paper, sandwich it between a thin sheet of Lucite and a similar sheet of celluloid. Place sandwich on insulated surface and rub hard with dry cloth. Flip sandwich over.

Remove top sheet. Dip small, pointed artist's brush in nonconducting dye. Hold tip of brush an inch above paper and write in the air. You will find that static electricity attracts the dye to the paper in a fine spray and that what you have written in the air appears on the paper, much as if it had been written with a pen.

Here's a principle that appears to have many important applications, particularly in the publishing and textile industries. We're on top of it, watching completion of a demonstration machine and awaiting erection of a pilot plant. When these are ready there'll be technical details in our feature pages, probably sometime this summer.

Tea Would Taste Better in restaurants if the water used to make it was brought to precisely the right temperature during preparation. But it is hard to maintain water at this temperature with existing equipment.

The Tea Association thinks the problem might be solved by designing 10 or 15-cup commercial units employing electronic heating to bring water up to the proper temperature in a matter of seconds. We ourselves suspect that electrical rather than electronic heating might provide the answer, but if any of you out there feel differently and want to take a fling at the job, write committee chairman George N. Wicc at the National Urn Bag Company, 3408 Northern Boulevard, Long Island City 1, N. Y.

FCC Licenses, at the end of 1947, were as follows:

Broadcast Stations	
A-M	1,962
F-M	1,010
Remote Pickup	590
TV (exp.)	91
TV	73
Educational	40
International	37
Other	31
	3,834
Non-Broadcast Stations	
Amateur	75,000
Aeronautical	20,818
Marine	14,254
Public Safety	4,653
Land Transportation	2,447
Industrial	2,028
Miscellaneous	1,307
	120,507

Licensed radio operators were listed as follows:

Commercial	341,000
Amateur	81,000
Special Aircraft	61,999
	483,999

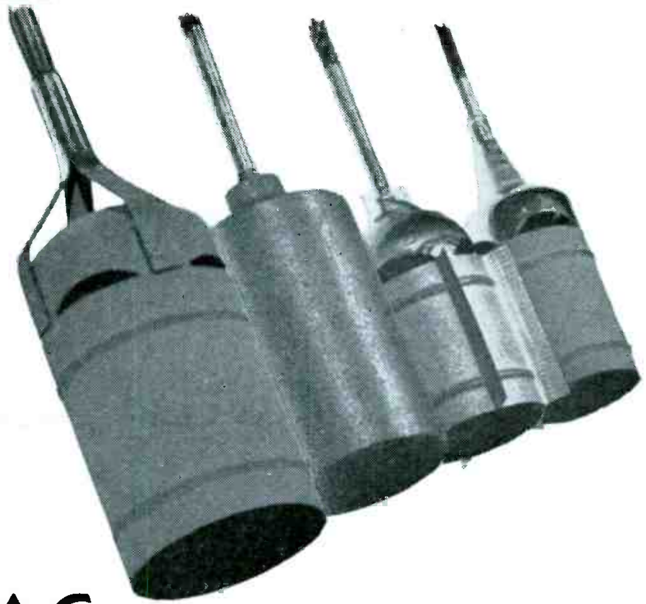
Personal And Business interests clash when we spend a quiet evening at home listening to f-m. On the one hand, the chief attraction of the service for us is freedom from announcements. On the other, we keep wondering how long this lovely music can play on, like Muzak, without advertising support.

We hope the programs stay as they are. And we hope the stations begin to make money. A spot for a Jekyll and Hyde, if we ever saw one.

If There Is Any Doubt in your mind about the speed with which f-m receivers are being sold watch the rooftops in towns that have stations when passing through by car, bus, or train.

The number of dipole-reflector rigs we spotted on a run to St.

there IS a difference.



PYROVAC the new Eimac plate material makes a better vacuum tube anode . . . on all counts.

1. **LIFE . . .** Tubes with tantalum plates formerly giving 3000 hours of service, now, with Pyrovac plates operate in excess of 15,000 hours . . . a 400 percent increase.

2. **OVERLOADS . . .** With Pyrovac plate, 65 watt tubes have dissipated 900 watts—a 1280 percent momentary overload—without indication that the eventual life of the tubes or their characteristics were affected. In normal service these tubes are still going strong. Excessive plate dissipation due to tuning procedure and circuit failure normally won't mean the loss of your tube.

3. **MECHANICAL CHARACTERISTICS . . .** Pyrovac is easily welded, enabling rugged shock-resistant mounting. It is a "black body" radiator and possesses excellent characteristics as an electrical conductor.

4. **COSTS . . .** Pyrovac plates in Eimac tubes cost you no more, yet since they enable longer life you actually get more for your vacuum-tube-dollar.

5. **PROVEN IN SERVICE . . .** Pyrovac is the result of millions of hours of life tests. The universal acceptance of the 4-125A and the 4-250A in all fields of electronic endeavor can, in part, be attributed to Pyrovac for contributing overload resistance, life, and a general ability to "take it."

THESE ARE THE TUBES WITH PYROVAC PLATES

EIMAC TUBE TYPES	PLATE DISSIPATION watts
TETRODES	
4-65A	65
4-125A	125
4-250A	250
4-400A	400
4-1000A	1000
TRIODES	
25T	25
3C24	25
35T	50
35TG	50
75TH	75
75TL	75
100TH	100
100TL	100
152TH	150
152TL	150
250TH	250
250TL	250
304TH	300
304TL	300
450TH	450
450TL	450
750TL	750
1000T	1000
1500T	1500
2000T	2000

EITEL-McCULLOUGH, Inc.
193 San Mateo Ave., San Bruno, California

Export Agents: Frazar & Hansen 301 Clay St., San Francisco, Calif.

Louis a short time ago was reminiscent of the early a-m days, when enthusiasts put up skywires resembling everything from umbrellas to pawnshop balls.

Receiver Production by RMA members in 1947 is estimated at 17,695,677 units. Breakdown by months:

January	1,564,171
February	1,379,966
March	1,377,269
April	1,759,723
May	1,316,373
June	1,213,142
July	1,155,456
August	1,265,835
September	1,339,980
October	2,002,303
November	1,615,541
December	1,705,918

Included in the figures are 3,029,637 auto radios, and 178,571 television sets. Some 72 percent of all home radio receivers made were table models, 13 percent consoles, and 15 percent portables.

In addition to the radio and television receivers tabulated above, members made 291,410 phonographs and 224,945 record players.

Projection Television is about to get another shot in the arm, the needle being wielded this time by designers up at the North American Philips lab.

Nearly ready for sale to tele set manufacturers, in more or less packaged form, is an extremely compact unit comprising a stubby c-r tube having a high-intensity screen just a little larger than two inches in diameter, an optical system, and a mirror that shoots the picture up to any conventional translucent screen. A high-voltage power supply using fewer than the usual number of tubes is also involved.

A detailed technical description of the system is in preparation and will soon appear in ELECTRONICS.

Associate Editor Zeluff has an idea worthwhile passing along. He thinks lots of people who have television sets with small screens will soon want larger pictures, largely so that more can watch. So, how about auxiliary cathode-ray tube units that can be attached to such sets and used simultaneously some place else in the same room? And, if and when they become available at reasonable cost, auxiliary units with larger screens?

Hotel installations using the central receiver and remote cathode-ray tube system are already being made. Why not apply the idea to homes?

Transmitter Equipment Sales by RMA members exceeded $97,000,000 during the first half of 1947.

Makers of broadcast transmitting and studio equipment shipped $9,253,358 worth. A-m transmitter sales totalled $2,319,006, f-m transmitter sales $1,820,633. A-m and f-m studio equipment sales went to $2,205,382. Antenna equipment for both types of broadcast service brought in $433,767. Television station equipment of all kinds totalled $1,354,633.

General communications equipment sales totalled $2,589,468 for vhf equipment and $746,902 for medium frequency. Aviation radio gear went for $4,061,072. Marine transmitting equipment sales were $1,677,703. Sales of piezoelectric quartz crystals hit $456,137, of which $315,169 worth went to equipment manufacturers.

The U. S. Government received delivery of $78,347,341 worth of gear in the first half of 1947.

Test Equipment can be made smaller and lighter by using miniature tubes, batteries and component parts. Some instruments hitherto limited by size and weight to laboratory use could be made sufficiently compact for field applications, thus broadening their market.

An Indian Radio Company has ordered 100,000 two-tube sets produced by the Sargrove method. In case you've forgotten, that's the method employed to turn out the machine-made radio appearing on the cover of ELECTRONICS for February.

One Way To Find Time: Studying in his cell from books furnished by his mother, a Cranston, R. I. man is said to have become an electronic expert while serving a 35-year sentence for the second degree murder of his fiance.

MALLORY ORIGINATED ELKONITE* METALS—

ELKONITE

and only Mallory has the years of experience with their complex fabrication

ELKONITE is the registered trade mark for a series of metals originated by Mallory which derive their effectiveness from the skillful compounding that Mallory has developed through many, many years of pioneering in the field of powder metallurgy.

Elkonite metal proved so dependable under the most severe conditions that it quickly became standard on most heavy duty circuit interrupting equipment. It also proved indispensable in the field of resistance welding and in countless applications requiring its particular characteristics.

The success of Elkonite metal is so well established that the trade mark has been mistakenly applied to materials that are sold with the implication that they will match the performance of true Elkonite metal.

Mallory has made true Elkonite metals for years. Only Mallory can guarantee the correct formulation that gives hardness, high electrical conductivity, resistance to mechanical wear and to sticking and erosion by arcing—the qualities that have made the word Elkonite a symbol of dependability.

ONLY MALLORY MAKES AND SELLS GENUINE ELKONITE METAL

*Reg. U. S. Pat. Off.

P. R. MALLORY & CO. Inc.

MALLORY ELECTRICAL CONTACTS & CONTACT ASSEMBLIES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

CROSS TALK

▶ **ALEX** . . . Out near the end of Long Island stand several monuments to one of the grand figures of electronics. Here are antennas the like of which the younger generation of experts has never seen. They are a mile long and 400 feet high. They operate in the region of 15 kc and they get their power, several hundred kilowatts of it, from huge generators rotating at high speed.

The genial figure who has thus created his own monument is E.F.W. Alexanderson, just retired after 45 years with General Electric. "Alex" not only produced the alternators which bear his name but had much to do with the multiple-tuned antennas which launch the energy into the ether. His contributions to electronics, however, are not confined to dot-and-dash techniques. The industry still remembers with awe television demonstrations in Schenectady where his giant scanners made possible theater-size images. Industrial electronics, too, has felt his handiwork. And above all, Alex has the human touch, so often missing in those who deal primarily with machines—and big machines at that.

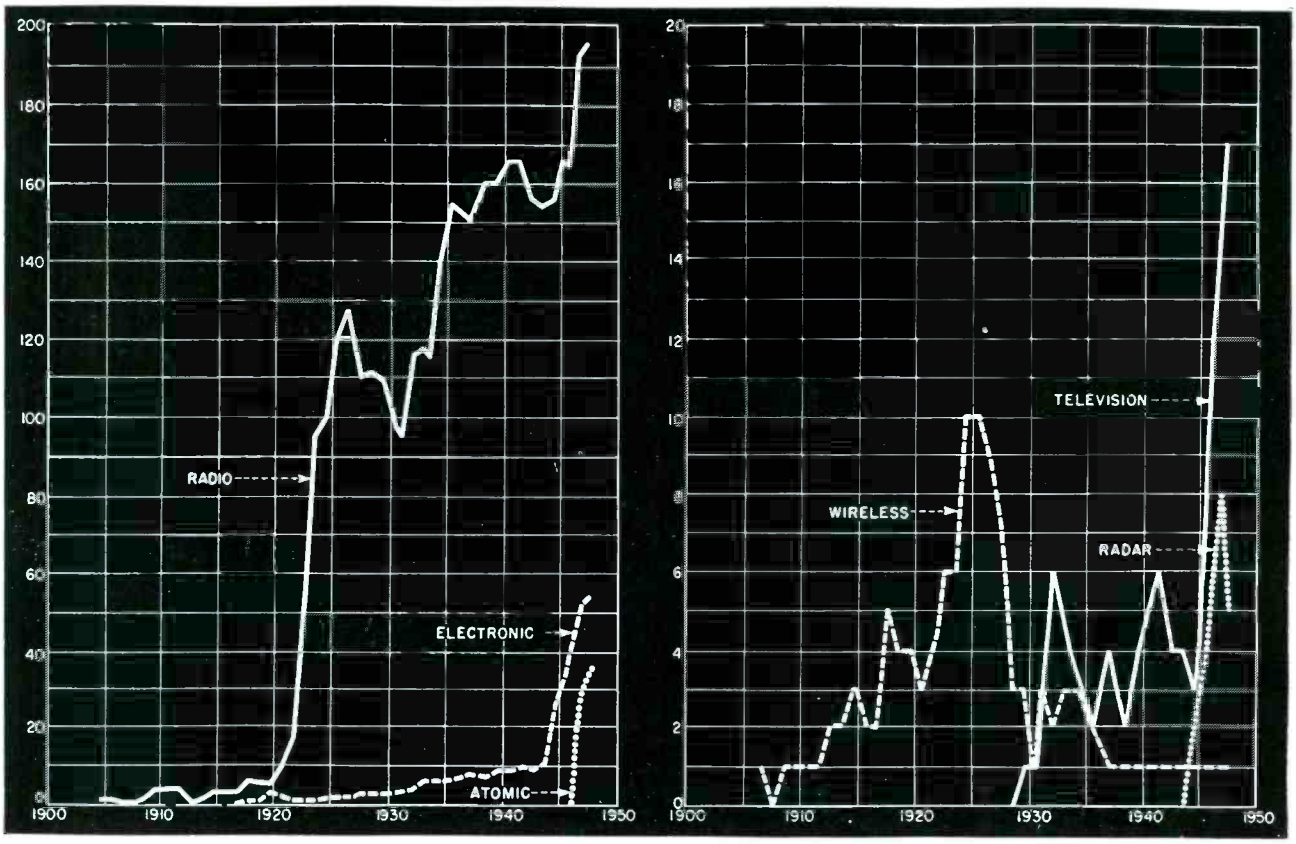
▶ **STANDARDS** . . . Recent changes in two basic physical standards remind us that arbitrarily defined units of measurement are subject to alteration. From W. F. Meggers of the National Bureau of Standards comes news that a new and better standard of length is available. It is a spectrum line, of green color, produced by mercury 198. This isotope of mercury does not occur in nature, but is produced by neutron bombardment of gold. The wavelength of this line is, according to Dr. Meggers, superior to the long-established standard red line in the spectrum of cadmium, and far easier to reproduce than the standard meter bar now preserved in Paris. So nuclear technology provides a new standard, measurable to an accuracy of one part in 100,000,000.

The other change is less exciting, but perhaps of equal practical importance. Effective this year, the standard ohm becomes about 1/20th of a percent smaller than formerly. The formerly used international ohm was 1.000495 absolute ohm. The absolute ohm is the newly defined standard. The practical effect is that precision resistors, whose tolerance is 0.1 percent or better, must be made to the new standard. For all other practical purposes, we are glad to report, we may cleave to the obsolete (non-absolute) ohm.

▶ **OVERSUPPLY** . . . While busily engaged in trying to control the inflationary aspect of our feast-and-famine economy, we may lose sight of a similar oscillation in the supply of electrical engineers. Through a now-recognized defect in the draft policy of the last war, we virtually stopped production of young engineers for nearly five years. Meanwhile we vastly enhanced the attraction of the electrical industry, particularly the electronics part of it, by introducing radar and similar wonders to vast numbers of soldiers and sailors. So students, largely G.I.'s, have since flocked to the electrical departments of colleges throughout the land. The committee on manpower of the American Society for Engineering Education has surveyed this rush and sounds a warning. By 1949, there will be an oversupply of electrical engineers, by 1950 an "exceedingly high" oversupply, or so the A.S.E.E. experts claim. Perhaps so. But in 1948 we still have a shortage of young men, as well as experienced men. If the products of electrical science continue to command an increasingly large portion of the national income, as they have since prewar years, our industry will absorb all the good men offered.

▶ **MICROSCOPE** . . . The electron microscope has climbed in magnifying power to 300,000 diameters and, like telescopes of new power, is revealing hitherto unknown worlds. The latest adventure has been reported at Philadelphia by Dr. James Hillier, speaking before the Electron Microscope Society of America. Microscope pictures taken at the RCA Princeton Laboratories show viruses attacking bacteria and destroying them. Both virus and bacteria were killed by the passage of the electron beam in the microscope, but they preserved their relative positions at the instant of exposure and so showed, in successive pictures, the advance of the attack. This direct insight is of the greatest importance in studying the nature of virus diseases. A new double electron lens did the trick, revealing bodies only one four-hundred-millionth of an inch in diameter.

NEW WORDS



When a new technical word having popular appeal is publicized into the language, businessmen frequently ride on its coat tail and incorporate the word into the names of their firms. Sometimes these firms are engaged in the field so intimated, sometimes not

THE NAMES of new advances in science are often employed in connection with business ventures. Their use as part of company names tells an interesting story.

The trend is easily traced by an examination of telephone directories of past years. Such a search of New York (Manhattan) telephone directories since 1904 reveals the growth and sometimes the decline of several words in our field. It also discloses the extent of their popular appeal over the years.

The words chosen for this study were *Radio*, *Wireless*, *Electronic* (including *Electron* and *Electronics*), *Television*, *Radar* and *Atomic*. The 1904 starting date was chosen as directories back to that date were conveniently available. This date also pretty well antecedes the common use of most of the words.

The number of listings in the telephone directory is plotted in the accompanying chart. (Note that the fluctuations do not follow at all closely the boom of the late twenties or the depression of the thirties.)

Radio

Strangely enough, the word *radio* appears two years before the word *wireless*.

In 1904 and 1905 there was a single entry, the Radio Chemical Company. The next two years showed no use but in 1908 it reappeared, one listing being a radio telephone company. In 1910 a radio wireless station was listed. In 1912 the word disappeared, but it returned the following year. By 1917 there was a total of six in use, but none of them were really applicable to the science of radio as we know this very popular word today.

The Radio Corporation of America showed up in 1920, and in 1931 the completion of Radio City swelled the list considerably. The period of most rapid growth was between 1919 and 1924, when the number of mentions increased from five to 100. Use of the word is now pushing the 200 mark.

The publicity value of the word *radio* caused it to be used in connection with many enterprises such as awnings, grills, picture frames, meat shops, slippers, neckwear, and wet wash.

The term *radionic* has not so far made a great deal of progress.

Wireless

The word *wireless* first made real news in this country as a result of the reception of Marconi trans-

COME . . . . . and GO

By W. C. WHITE
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atlantic signals on December 12, 1901. However, it did not appear in the New York telephone directory until 1906. It was not represented in 1907, which year incidentally was the only one covered by this survey that yielded no entry of any of the words chosen.

It is rather prophetic of the early era of wireless that the first entry in 1906 was for the Wireless Securities Exchange, which proved to be short-lived, at least under that title.

The word *wireless* was back again in 1908 with the well-remembered and relatively long-lived Wireless Specialty Apparatus Company.

Another big boost in the news value of the word occurred in connection with the wreck of the S.S. Republic, in 1909, and to an even greater extent as a result of the Titanic disaster in 1912. However, its use in connection with business enterprises did not seem to be immediately affected. The number of appearances in the telephone directory reached a maximum in 1924 and 1925 with 10 entries.

As in the case of the word *radio*, many of the listings were not really connected with the science.

By 1937 the listings were down to one entry, and this one and only entry has remained up to the present. It is for a printing company. Incidentally, in 1926 there was a Wireless Radio Corporation in Brooklyn.

Electronic

Although none of the words stemming from *electron* appeared until 1917, the word *elektron* was listed in 1904 and 1905, applied to an elevator company. The word *electron* appeared first in 1917 in connection with a chemical company. The number of entries varied slightly but never reached over four until after 1932.

The word *electronic* first showed up in 1926 and *electronics* in 1930 in connection with this publication. The magazine remained the sole representative of this form of the word in the telephone directories until 1944.

For some reason not entirely evident, the three words based on *electron* have been applied appropriately to a much greater extent than *radio* or *wireless*. A rapid increase occurred between 1943, with 11 entries, and the latter part of 1946, with 52 entries. Use apparently is still on the increase.

Television

The word first was used in the telephone directory in 1929, in connection with a television-radio shop. There was an increase from a single entry in 1930 to six entries in 1931. Then it varied back and forth between these limits until 1944, when it started a rapid and continuous increase, reaching 17 in the latest issue.

As in the case of *electronic*, listings under television are largely connected with the actual industry.

Radar

The word *radar* made its first appearance in 1944 with two entries, one a paint and one a novelty company. It appears to have reached a maximum of eight mentions in 1946, none of them having any apparent connection with the science. Typical firms listed dealt in blouses, novelties, restaurant supplies, paints, and slippers.

The use of this word in the telephone directory will probably decrease and may well disappear after a few years.

Atomic

The 1945 fall directory was probably well along in preparation when the atom bomb was dropped over Hiroshima so there were no listings containing the word *atomic* in that issue. But in the next issue, in the spring of 1946, it appeared 19 times. None, of course, were directly applicable to the scientific development.

The great popular appeal of the word is indicated by the fact that it showed more listings in the issue of its first appearance than any of the other words did after a growth of ten years. The listings showed activity in handbags, pleating, rainwear, and surgical supplies. By the 1946 fall issue, the number had grown to 30 and added lines were neckwear, undergarments, podiatry, art studios, food, and jewelry.

By the fall of 1947, the number had grown to 35. One appropriate entry did appear then, the Atomic Energy Commission.

Nucleonic

To date the word *nucleonic* has not appeared. It offers a wonderful opportunity if you are going into neckwear, novelties, etc.

You may have the field to yourself for at least one issue of the Manhattan directory if you start now.*

* ED. NOTE. You will *not*. See "*Nucleonics*," a McGraw-Hill Publication.

REPEAT PERFORMANCE

THE EDITORS almost let this article slip through their fingers. So unusual was the theme, and so light the treatment, that it seemed not to fit a serious technical publication.

BUT a good story will not die. The editors re-read it, and again enjoyed it. Why keep it from readers? Editors can get too serious. So here it is.

BILL WHITE, by the way, is not only a charter subscriber to ELECTRONICS but is a charter contributor as well. An article appeared under his signature in our first issue, back in April 1930

Electronic Preservation of Food

Experiments indicate that foods of many varieties can be preserved over long periods, without alteration in appearance or taste, by exposing them in their sealed containers to ultra-short-time pulsed cathode rays from a capacitron. Sterilization of drugs without decrease in potency is also possible

By WOLFGANG HUBER*
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Electronized Chemicals Corp.
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THE IMPORTANCE of electrons moving within evacuated tubes has been amply demonstrated. By contrast, comparatively little has been done with electrons released from the confinement of tubes, particularly in the field of food preservation.

In 1894 Lenard[1] brought cathode rays out through a window in the wall of a tube. But the cathode-ray tube remained a low-voltage, low-current device until 1926 when Coolidge[2] developed a tube capable of operation at several ma and up to 350 kv. With this type, electron beams of sufficient intensity to permit practical experimentation with chemical and biological objects were obtained.

Still higher electron velocities were obtained by the subsequent development of cascaded cathode-ray tubes. Many investigators[3] used this method to expose a wide variety of materials of inorganic as well as organic origin to the action of electrons. The results of the biological experiments were not very encouraging, however. Micro-organisms within the penetration range were killed, but irradiated products showed pronounced changes in taste, odor and appearance.

HEATLESS

Energy developed by the capacitron is cold energy. Thus limitation of micro-organism and enzyme activity may be accomplished while food is in any physical state . . . frozen, raw, partly or fully cooked

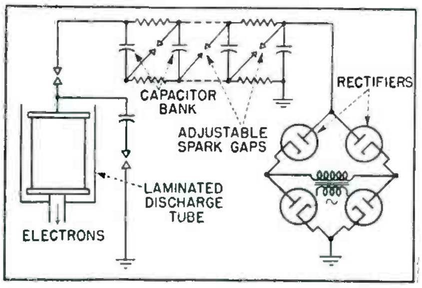


FIG. 1—Basic circuit of the electronic impulse generator

Capacitron Development

Biological and medical experiments undertaken by Brasch and Lange[4] in cooperation with Beck and Haelberstaedter opened new possibilities. These men used a capacitron, an apparatus which produces high voltages and great electron intensities during ultra-short-time periods. It was indicated that the release of high intensities during ultra-short-time periods killed micro-organisms in much the same way as continuous current-voltage generators but without radically changing taste, odor or appearance.

Initial experiments were carried out by the utilization of voltage produced by lightning.[5] This source of voltage was obviously unreliable and further progress was intimately connected with the development of an impulse generator developed by E. Marx[6] and shown in Fig. 1. A number of capacitors are charged in parallel, through resistors, from a rectifier unit. Discharge of the capacitors in series is accomplished by means of gaps which spark over at predetermined voltages.

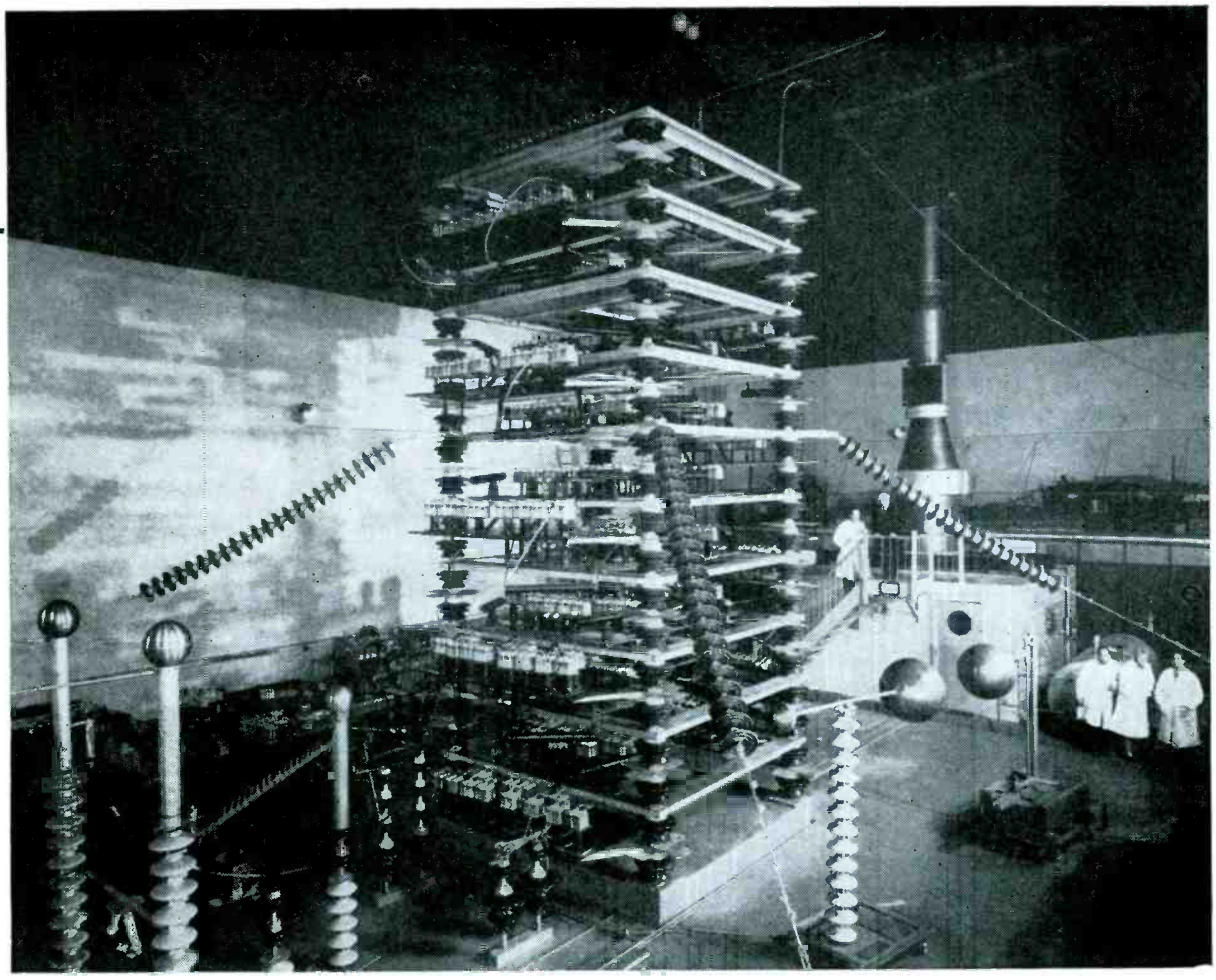
The availability of impulses of several million volts from a generator now made it imperative to develop discharge tubes that would handle these voltages continuously and without breakdown. Brasch and Lange[7] determined that the breakdown voltage depended not only on the status of the vacuum and the construction of the electrodes but also upon the type and structure of the wall of the discharge tube. Breakdown troubles were reduced by lamination of the tube wall and by increase in the lengths of surfaces which were prone to cause gliding discharges. This led in 1930 to the development of the so-called laminated tube illustrated in Fig. 2. It consists of alternate stainless steel or nickel, insulating resin, and rubber discs.

In order to avoid excessive bombardment of the walls with electrons it is important to construct the tube in such a way that the relation of length to width is not materially in excess of 8 to 1. In large capacitrons the ratio may be as low as 2 to 1. To avoid flashovers the tube is immersed in oil.

Practical Design

Experimental work by A. Brasch and the author[8] has so far been carried on with the experimental capacitron pictured in these pages. Line voltage is transformed to 100,000 volts and converted into d-c by a set of rectifier tubes. Induction coils used in lieu of resistances permit a capacitor-bank charging fre-

* From a paper presented before the 1947 National Electronics Conference in Chicago.



Experimental capacitron used in the tests

quency of 50 to 100 times per minute. The generator itself consists of capacitors arranged in 30 banks of 100,000 volts each, thus giving a peak output voltage of 3,000,000.

The intensity of each individual impulse is of the order of thousands of amperes and the release time of the order of 10^{-6} second. The electrons reach the open through a window device which consists of a grill supporting a thin metal foil. Foils of beryllium alloys, which have the best strength and ductility characteristics, are not yet available. Therefore, we are at present using 0.05-mm foil of a hard aluminum alloy. The efficiency of the device, as compared with other corpuscular accelerators, is relatively high. According to calorimetric determinations, about 35 percent of the surge generator intensity is converted into electrons.

The simplicity of capacitron design permits the attainment of practically unlimited voltages and intensities, particularly if the entire surge generator together with the discharge tube is immersed in a liquid insulating material contained in a grounded tank. The general design of such a unit, which will be a prototype for commercial uses, is shown in Fig. 3. In this unit, the capacitor banks and the discharge tube are immersed in oil in a submerged concrete pool, with only the pumping equipment, the exit window and the conveyor belt above ground in a separate concrete housing. The spark gaps are hermetically sealed in compressed gas and the beam of electrons is bent around by a system of magnets to facilitate

Table I—Penetration Range of Electrons in Water

Velocity*	Accel. Pot. (kv)	Max. Range (mm)	High Intensity Range†	Depth of Max. Intensity (mm)
0.55	100	0.03	......	.....
0.70	204	0.83	......	.....
0.78	300	1.40	......	.....
0.80	340	1.60	......	.....
0.90	662	2.46	......	.....
0.91	1,000	5.20	......	.....
0.97	1,600	7.70	0– 2.7	1.3
0.985	2,400	12.50	0– 4.5	3.0
0.993	4,000	21.00	0– 7.5	6–7
0.998	8,000	42.00	0–14.0	10–12
0.999	12,000	62.00	0–22.0	16–18

*Expressed as fraction of velocity of light
†Higher than at surface

the use of conventional conveyor equipment and to eliminate x-rays.

The penetration range of electrons depends on the accelerating voltage and the density of the target. Table I illustrates this, using water as a target, as well as the fact that electrons exercise more intensity at a certain depth than on the surface. The latter effect is due to the phenomenon that with increasing electron speed scattering will be predominantly in the forward direction. This is of considerable practical importance, since it avoids unduly high energy absorption in any container wall.

Penetration in water with 5,000,000 volts is about 25 mm. After electrons pass through the discharge-tube air exerts a bushing effect upon them. In 5 inches distance from the window, for example, an area of at least 380-mm diameter is covered. With a penetration range of 25 mm it is thus possible to process with one impulse 2.83 liters of one particular material. If we assume an average discharge frequency of only 30 impulses per minute this would be equivalent to a capacity of 85 liters per minute and about 5,100 liters, or 5.5 tons, per hour.

Table II indicates the nature of changes in several substances when subjected to continuous radiation and, by comparison, to ultra-short-time radiation. Using ultra-short-time impulses with intensities far above maximum continuous radiation values recommended in the literature, we note no formation of vitamin D in ergosterol. Our interpretation of this fact is that the first step in the photoactivation of ergosterol, namely, the isomerization of the angular methyl group on C-10, has a reaction time considerably in excess of 10^{-6} second.

Preservation of Foods

Table III illustrates the effectiveness with which foods are preserved by means of capacitron radiation. For example, slices of raw beef, veal and pork were put into thin-walled glass containers which were sealed off under air and exposed for four impulses. The energies applied were far in excess of the minimum sterilization dose.

Tests for sterility were made directly after irradiation and at the end of the storage period, which was in some few instances coincident with perceptible change in appearance but in most cases arbitrary. Experiments are continuing, so it is difficult to estimate the extent of ultimate storage stability for many samples. In the protein series, for example, we feel that we are nowhere near the limit.

Table II—Comparison of Continuous and Ultra-Short-Time Radiation

Substance	Continuous Radiation	Effect	Capacitron Impulses of 10^{-6} Sec
Ergosterol	u-v, α, β	vitamin-D formation	no change
Casein, Egg Albumen	β, γ	decomposition, oxidation	no change
Butane, Heptane	α, β	H_2, CH_4 evolution, polymerization	no change
Styrene	u-v, α, β	polymerization	no change
Castor, Linseed, Tung Oil	u-v, β	polymerization, change of ref. index, iodine no. and color	development of slight flowery odor
Acetone	β	condensation, gas formation	no change
Hemoglobin	u-v, α	inhomogenization, low molecular breakdown products	small % of methemoglobin
Rubber Plant	β	discoloration, drying, latex formation	no change

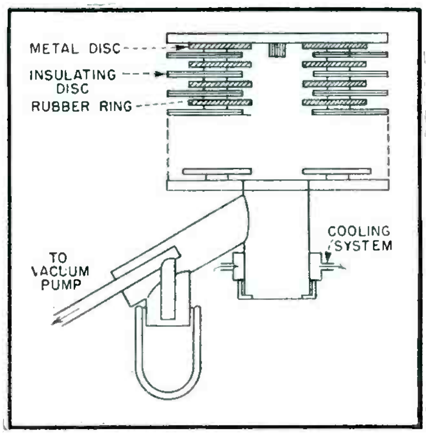


FIG. 2—Laminated discharge tube used in the system

Boiled ham showed decomposition after 63 days, whereas raw fat pork exhibited no change after 207 days. This had us puzzled until we found that the discrepancy was due to differences in packing. The boiled ham samples were packed in double bags of 0.004-inch polyethylene foil, considered ideal because of its low density, and heat-sealed. Decomposition of the sample started around the areas closest to the sealed edges, indicating need for a foolproof, fully airtight plastic container.

Ultra-short-time impulses do not always eliminate all side effects. In the case of butter as well as other products containing butter fat a definite taste change occurs which cannot be classified as any of the previously known taste changes. We call this change irradiated taste. It can be considerably reduced by critical variation of the irradiation conditions, and also by prolonged storage. In the case of cream cheese, irradiated taste completely disappeared after 66 days of storage at room temperature in the original tin-foil wrapper.

Considering the most common use of castor oil, it was rather amusing to find that under radiation this household standby developed a fragrant odor much like that of daisies.

Table III also illustrates the behavior of capacitronized vegetables. The days of storage for the products in plastic containers are somewhat deceiving, since these samples were opened regardless of appearance when we discovered the unsuitability of heat-sealed polyethylene bags for our purpose.

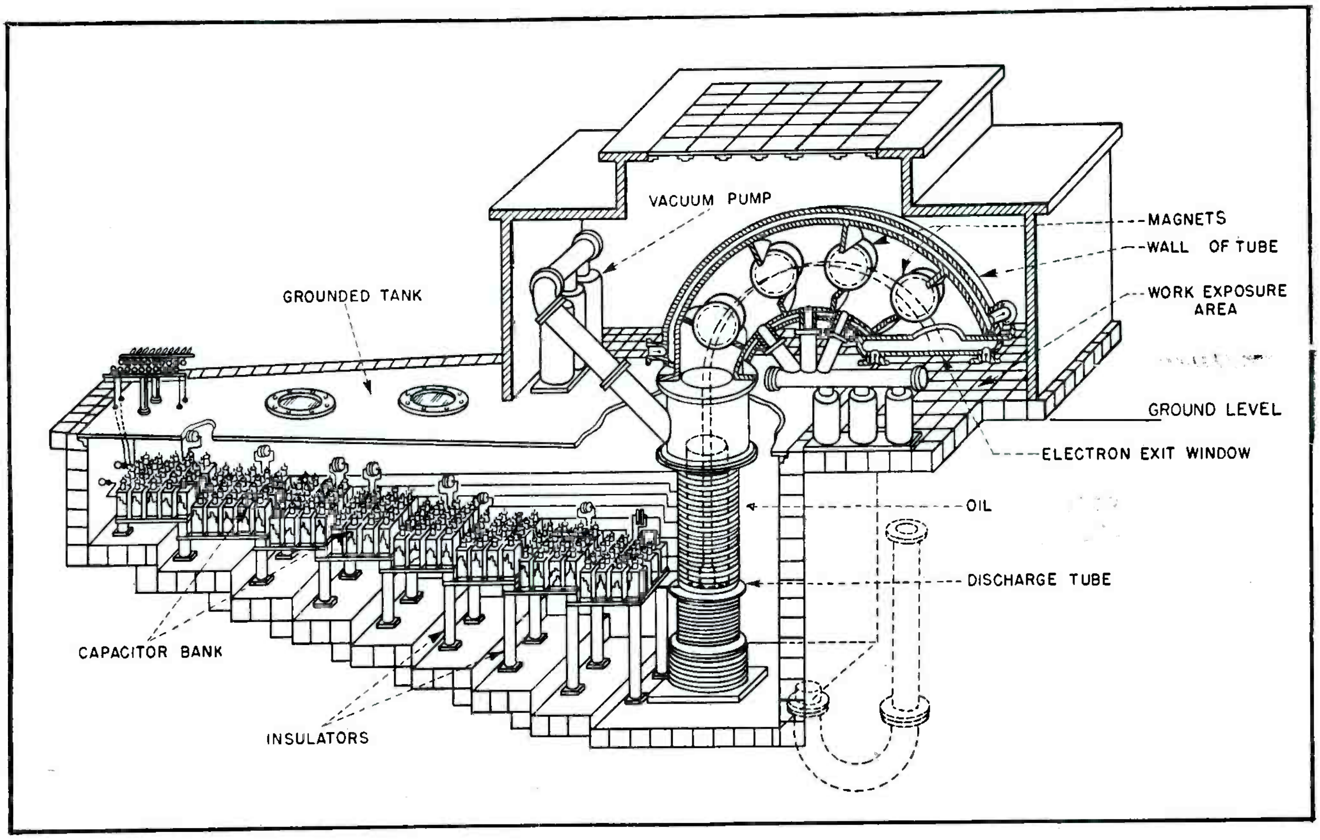


FIG. 3—Prototype of a commercial capacitron

By contrast with the color of substances of animal origin, some plant dyes were found to be much less stable under our conditions of storage. Bleaching is not a radiation effect but develops slowly on storage. It can be reduced by storage away from light. On the other hand, attempts to preserve lettuce have so far been a failure, with the detrimental effects undoubtedly due to irradiation. We do not yet know why.

The color of all except one of the fruits so far tested was well preserved after radiation. The notable exception is strawberries. Indications are that special treatment and storage conditions as well as more rigidly controlled impulse dosages may overcome the undesirable effects.

Surface Sterilization of Foods

All the experiments discussed so far were undertaken for the purpose of studying the maximum extent of preservation obtainable with penetrating electrons of ultra-short-time duration. If, however, only a moderate extension of shelf life is needed then the capacitron can be readily utilized for a process which we have called surface sterilization. In this procedure the irradiation conditions are adjusted in such a way that the electrons penetrate just through the surface of the foodstuff.

We have found that the elimination of micro-organisms from the surface affords a considerable extension of the life of fresh food products, particularly of those that have a rather thick or tough skin, such as apples, peaches, melons, corn, nuts and eggs. That this should be so seems logical if one remembers that except for insect infestations the surface is the main portal of entry for micro-organisms.

We have been able to preserve fruits such as melons, peaches, pears and corn on the cob, wrapped in plastic envelopes, over periods of several weeks at room temperature. Controls kept under identical conditions started to decay after several days.

Another interesting application of the capacitron is the preservation of partly or wholly dehydrated foodstuffs, particularly when the dehydration has been achieved by freeze-drying. And this discussion of preservation of foods would not be complete without mentioning commodities which serve in one way or another as raw materials, intermediates or additives in the preparation of finished food products. These highly diversified products include grains such as wheat, corn and rice, as well as the corresponding flours, beans, nuts, spices, plant extracts, protein fractions and many others. We have achieved preservation of these commodities by elimination of micro-organisms of all types as well as infestations caused by insects, insect eggs or larvae.

Before concluding the discussion of food preservation, I would like to say a few words about capacitron preservation in relation to preservation by refrigeration, particularly by deep freezing. We do not hold the opinion that preservation with penetrating electrons of ultra-short-time duration will be a potential antagonist to deep-freezing techniques. Quite the contrary, we feel that the process can offer great advantages to the processor of frozen foodstuffs. The capacitron offers a means for heatless sterilization and enzyme inhibition. To this, refrigeration can add preservation of color and texture. In addition, and this is probably even more important, capacitronized frozen products can be kept without loss at about 10 F for very long periods of time, thus providing considerable reduction of freezing costs and elimination of many of the headaches of transport.

Sterilization of Drugs

The last topic of this discussion deals with the sterilization of drugs. Some of the results are illustrated in Table IV.

It can be seen that vitamins such as thiamin, riboflavin, pyridoxine, niacin, and pantothenic acid either alone or in mixture are readily sterilized without loss in potency, even with large impulse dosages. Similar data was obtained when testing fat-soluble vitamins, such as vitamin A and vitamin D. The same also holds true for hormones, and even such a mixture of complicated protein molecules as pituitary hormone can be readily sterilized without any loss in potency. Another remarkable result is the radiation stability of antibiotics such as penicillin and streptomycin. They withstand even higher impulse dosage than those given in the table without any loss of antibiotic activity.

To illustrate in this table the sterilization of individual enzyme preparations as well as their sensitivity to penetrating electrons of ultra-short-time duration, I have selected three examples, namely, hyaluronidase, clarase, and trypsin. Two facts are outstanding. First, the margin between sterility dose and activity loss, although rather narrow, is still wide enough to achieve sterilization with little or no potency loss. Second, there are appreciable individual differences in enzyme sensitivity to capacitron radiation.

The sensitivity of individual enzymes as well as isolated enzyme systems to penetrating electrons of ultra-short-time duration is at present under more detailed investigation.

Summary and Acknowledgments

Summarizing the salient features of penetrating electrons from a capacitron as they apply to heatless

Table III—Effects of Capacitron Radiation on Foods

Food	Impulses (10^{-6} Sec)	Storage Conditions* Temp (°C)	Storage Conditions* Time (days)	Appearance, Taste, Odor	Untreated Sample Decay (days)	Container
MEATS, FISH, EGGS						
Beef	4	room	264	unchanged, raw and fried	2	glass
Veal	4	room	238	unchanged, raw and fried	3	glass
Pork, fat	4	room	207	unchanged, no rancidity	2	glass
Flounder, filet	4	room	127	unchanged, no rancidity	1	glass
Roast Beef, red	4	room	94	unchanged except for darkening of color	2	plastic
Ham, boiled	4	room	63	fair, slight decomposition	2	plastic
Bacon, smoked	6	room	156	unchanged, no rancidity	6	aluminum
Chicken a la King	6	+4	74	unchanged	4	plastic
Hamburger	4	+4	83	unchanged	5	plastic
Eggs, pigeon	4	room	194	unchanged	18	cardboard
FATS and OILS						
Butter	5	room	97	preserved, but off taste; no rancidity	3	glass
Margarine	4	room	79	preserved, but off taste; no rancidity	..	glass
Lard	4	room	182	unchanged, no rancidity	8	glass
Olive Oil	6	room	204	unchanged	10	glass
Cream Cheese	2	room	66	unchanged; off-taste after irradiation disappeared in storage	4	tinfoil
Camembert	4	room	82	preserved, ripening process arrested; taste more like cheddar	2	tinfoil
VEGETABLES						
Peas	6	room	184	unchanged, except for slight bleaching	5	glass
Beans, cut	6	room	184	unchanged, except for some bleaching	6	glass
Carrots, diced	6	room	147	considerable bleaching, some loss of texture	5	glass
Potatoes, diced	4	room	64	unchanged, except for some browning	4	plastic
Lima Beans	6	room	227	unchanged	5	glass
Cabbage, diced	4	room	234	unchanged	9	glass
Broccoli, diced	4	room	42	unchanged, except for some bleaching	2	plastic
Spinach, chopped	4	room	83	unchanged, except for some bleaching	3	plastic
Mushrooms	4	room	33	unchanged, except browning of stem and slight loss of texture	1	plastic
Lettuce	3	room	2	soggy, flat tasting and considerable bleaching	1	plastic
Cauliflower, diced	4	room	234	unchanged, slight yellow discoloration	6	glass

*In air and light.

FRUITS						
Food	Impulses (10^{-6} Sec)	Storage Conditions*		Appearance, Taste, Odor	Untreated Sample Decay (days)	Container
		Temp (°C)	Time (days)			
Pineapple, sliced	4	room	94	unchanged	4	plastic
Coconut, sliced	4	room	86	unchanged	3	plastic
Peaches, sliced	4	room	83	well preserved, but slight loss in texture and some browning	1	glass
Apples, sliced	4	room	101	unchanged, except for some browning	2	glass
Blueberries	4	room	65	unchanged, except for slight loss in texture	2	plastic
Raspberries	4	room	69	unchanged, except for slight loss in texture	2	plastic
Strawberries	4	room	41	preserved, but marked loss in texture and color	1	plastic
Cherries, sweet	4	room	64	unchanged	2	plastic
Orange Juice	4	room	128	preserved, but some loss of aroma and sweetness	1	glass
Orange-Grapefruit Juice	4	room	129	unchanged	1	glass
Grapefruit Juice	4	room	134	unchanged	2	glass

*In air and light.

Table IV—Capacitron Sterilization of Drugs

Drug	Impulses (10^{-6} Sec)	Contamination	Potency		Container
			Untreated	Treated	
Thiamine HCl	2–4	unknown	4.6 mg/cc	4.4 mg/cc	glass
Protein Hydrolysate	2	GNB, GPC	....	....	aluminum
Penicillin-Na	3	B. subtilis fungi spores	220,000 U	220,000 U	glass
Streptomycin-H_2SO_4	4	B. subtilis	100,000 U	100,000 U	glass
Testosteron	4	B. subtilis	100%	100%	glass
Prolactane	4	....	100%	110%	glass
Pituitary Hormone	2	unknown	3800 I. U.	4000 I. U.	plastic
Hyaluronidase	2	unknown	100%	97%	plastic
Clarase	2	unknown	100%	87%	aluminum
Trypsin	2	unknown	100%	100%	aluminum
Yeast	2–4	B. subtilis	....	....	plastic
Riboflavin	....	....	0.07mg/gm	0.07mg/gm	....
Pyridoxine	....	....	0.04mg/gm	0.04mg/gm	....
Pantothenic Acid	....	....	0.10mg/gm	0.10mg/gm	....
Niacin	....	....	0.35mg/gm	0.35mg/gm	....

preservation and sterilization:

While the energy is cold energy it is of very considerable intensity. The use of such cold energy makes it possible to treat products at temperatures well below freezing and in any physical state—raw, partly or fully cooked.

The application of high intensities for ultra-short-times accomplishes the selective elimination of micro-organisms and enzyme activity which, under such conditions, in many cases runs ahead of undesirable side reactions.

Highly accelerated electrons penetrate to a considerable depth, depending upon the voltage. Furthermore, they release more energy underneath the surface than on the surface. These characteristics permit the treatment of ready-packed items without breakage of the container and with minimum energy loss within the wall of the container, provided the density and the wall thickness of the container materials are kept within reasonable limits.

High accelerating voltages, necessary for the preservation of bulky materials, will not give rise to nuclear reactions, thus eliminating the danger of artificial radioactivity.

The possibility of large-volume processing, due to the high discharge rate and good efficiency, make commercial application of the capacitron feasible and attractive in many fields.

The author gratefully acknowledges the assistance rendered by the staff of Electronized Chemicals Corporation in carrying out this work. In addition, he is indebted to Alexander Astrack Jr., who conducted many of the food experiments.

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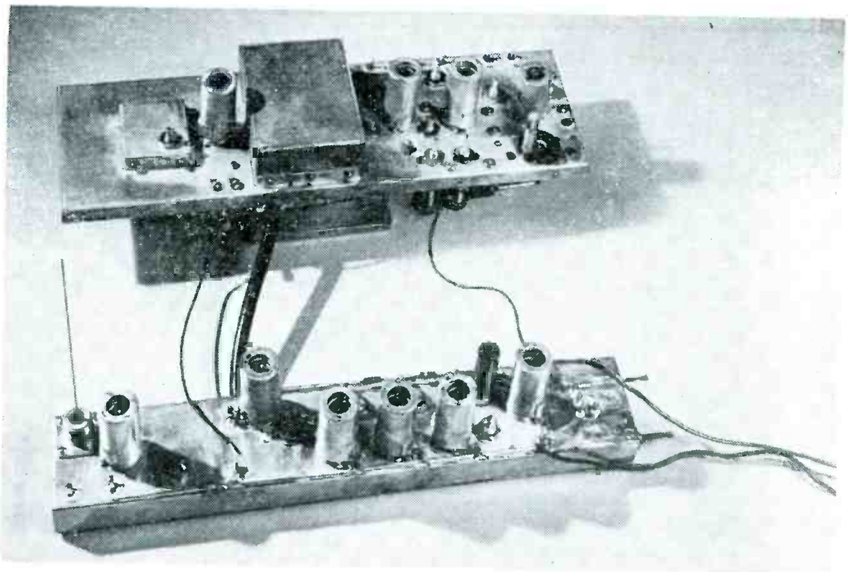
Part II of a Series



Transmitter and receiver for 465 megacycles. The quarter-wave receiving antenna is at the lower left. Local oscillator power for the receiver (bottom) is taken from the transmitter (top)

RECEIVER for the

A RECEIVER operating in the 460–470 mc band is ultimately limited in sensitivity by the thermal noise associated with the antenna resistance and circuit components, and the shot noise due to the tubes. A satisfactory receiver for the Citizens Service should limit on noise and have a good noise figure.

Figure 1 shows the block diagram upon which the present design was based. The preamplifier was used in the interest of improved noise figure, but also improves image rejection and reduces local oscillator radiation. The following assumptions were made:

(1) 10-db gain in the preamplifier.

(2) Unity power gain in the converter.

(3) 250-kc effective bandwidth to receive the 200-kc channel width allowed by FCC specifications. This allows for the $\pm$ 0.02 percent tolerance for class-A operation and $\pm$ 25-kc deviation of the carrier.

(4) 10-db noise figure.

(5) 10,000-ohm converter plate load.

The available thermal noise power is 4.1×10^{-21} watt per cycle per second.[1] For our bandwidth, the thermal noise power is 1.025×10^{-15} watt. On the assumption of 10-db preamplifier gain, 10-db noise figure, and unity power gain in the converter, the noise voltage across the 10,000-ohm converter plate load is 32 microvolts.

This noise must be amplified to the 1-volt level in three i-f stages. The required gain is 31,200 overall or 31.5 per stage. This gain is readily obtained at 15 megacycles using tubes of the 6AU6 type.

Typical operation for the 6AU6 is as follows: $E_b = E_{c2} = 100$ volts, $E_{c1} = -1$ volt, $I_b = 5.2$ ma, $I_{c2} = 2.0$ ma., $G_m = 3{,}900$ μmho. Using these parameters, the load resistance for a gain of 31.5 is 8,090 ohms.

Four tuned circuits enter the bandwidth considerations. These are the converter plate tuned circuit and the three i-f amplifier tuned circuits. The converter plate tuned circuit will be considerably broadened by the plate resistance of the 6J4 converter and the last i-f tuned circuit by the loading action of the limiters. From these considerations, only the first two i-f amplifier tuned circuits determine the total bandwidth.

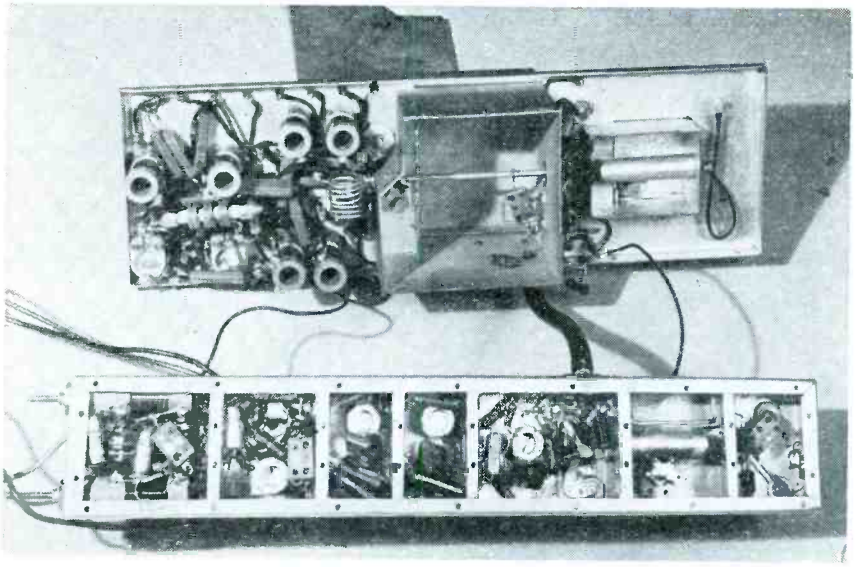
For two single-tuned circuits, the bandwidth factor for 3-db down is 0.64, making the bandwidth per stage 390 kc.[2] This requires a circuit Q of 38 and a capacitance of 50 $\mu\mu$f per stage for the desired bandwidth and gain.

Circuit Details

Limiting is accomplished by two 1N35 germanium diodes biased at 0.5 volt. The limiter clips both positive and negative peaks exceeding 0.5 volt. This circuit is about equivalent to two stages of conventional limiting.

The limited signal then is fed into another 6AU6 i-f amplifier which drives a Foster-Seeley discriminator employing 1N35's as detectors. An inverse frequency network is included for reception of a phase-modulated carrier.

Figure 1 shows the complete



Underview of transmitter and receiver, showing coupling to transmitter doubler cavity resonator for receiver local-oscillator power. The two coil forms at left of the receiver (bottom) form the discriminator transformer

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Citizens Radio Service

Circuit operation and construction details for a 465-megacycle superheterodyne receiver for operation in conjunction with the transmitter described in November 1947 ELECTRONICS. Grounded-grid input, cavity resonators, and crystals in limiter and discriminator aid in design of a small-size unit for portable operation

block diagram of the receiver and Fig. 2 is the schematic diagram, without the audio system. The received signal is fed in the receiver from the antenna coaxial transmission line to the input jack, J_1. The input is tuned by L_1 a short length of transmission line, and the tube input capacitance. No tuning adjustment is required as the Q of the input circuit is extremely low due to the low driving impedance of the 6J4 grounded-grid amplifier V_1.

Impedance matching is accomplished by tapping down the line,

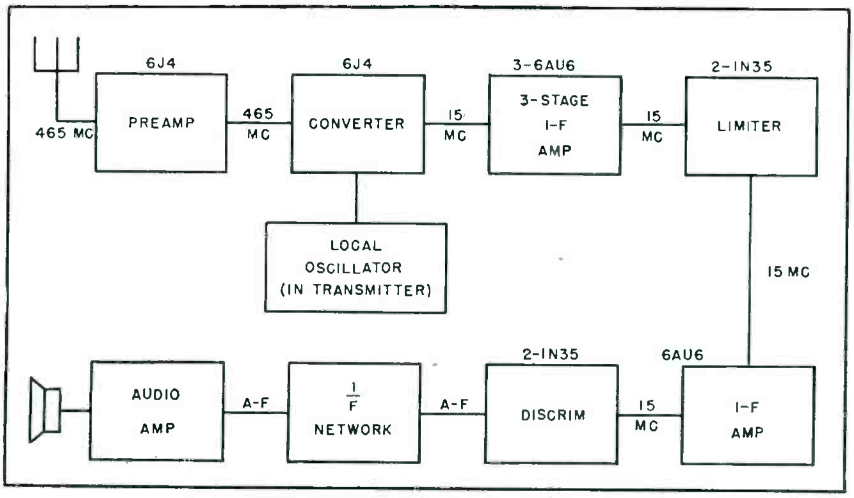
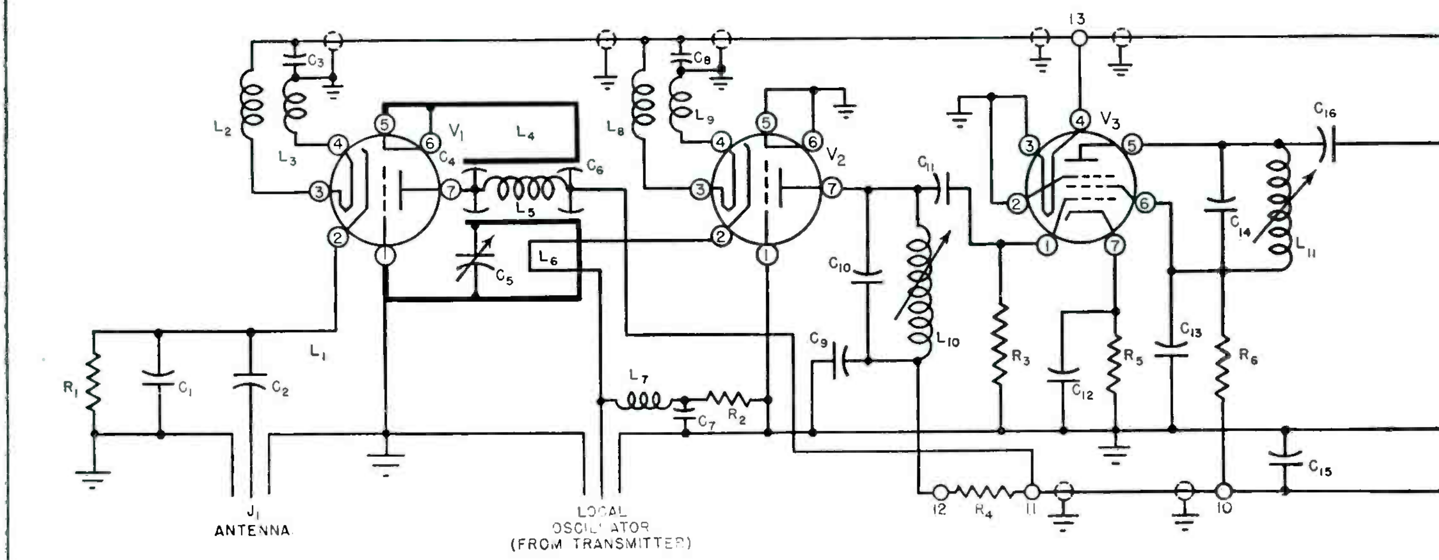


FIG. 1—Block diagram of the receiver. Power supply and a-f circuits are separate from the chassis illustrated in the accompanying photographs

* The equipment described was produced by Mr. Hollis as an independent consultant to the McGraw-Hill Publishing Company. For a full account of ELECTRONICS Citizens Radio Project, see p 80 of the November 1947 issue.



R_1, R_{14}, R_{16}–100, 1/2 w, Allen-Bradley
R_2–390, 1/2 w, Allen-Bradley
R_3, R_{15}, R_{24}–470,000, 1/2 w, Allen-Bradley
R_4–1,000, 1/2 w, Allen-Bradley
R_5, R_8, R_{11}, R_{18}–130, 1/2 w, Allen-Bradley
R_6, R_9, R_{12}, R_{19}–7,500, 1/2 w, Allen-Bradley
R_7, R_{10}, R_{17}, R_{20}–50, 1/2 w, Allen-Bradley
R_{13}–30,000, 1 w, Allen-Bradley
R_{21}–22,000, 1/2 w, Allen-Bradley
R_{22}, R_{23}–100,000, 1/2 w, Allen-Bradley

C_1, C_3, C_4, C_6, C_7, C_8, C_{37}–1,000 $\mu\mu$f, Erie button mica, Type 370BB
C_2–10 $\mu\mu$f, silvered mica
C_5–3-15 $\mu\mu$f, E. F. Johnson, type 160–107
C_9, C_{12}, C_{13}, C_{15}, C_{17}, C_{18}, C_{20}, C_{22}, C_{23}, C_{24}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{33}–5 $\mu\mu$f, Centralab Type D6–502
C_{10}, C_{14}, C_{19}–36 $\mu\mu$f, silvered mica
C_{11}, C_{16}, C_{21}, C_{26}, C_{32}–430 $\mu\mu$f, silvered mica
C_{25}–20 $\mu\mu$f, silvered mica
C_{34}–3 $\mu\mu$f, silvered mica
C_{35}, C_{36}–100 $\mu\mu$f, silvered mica

FIG. 2—Detailed circuit of the receiver showing values of compo-

L_1. Capacitor C_2 is provided for d-c blocking when used with an antenna or signal generator having a d-c return.

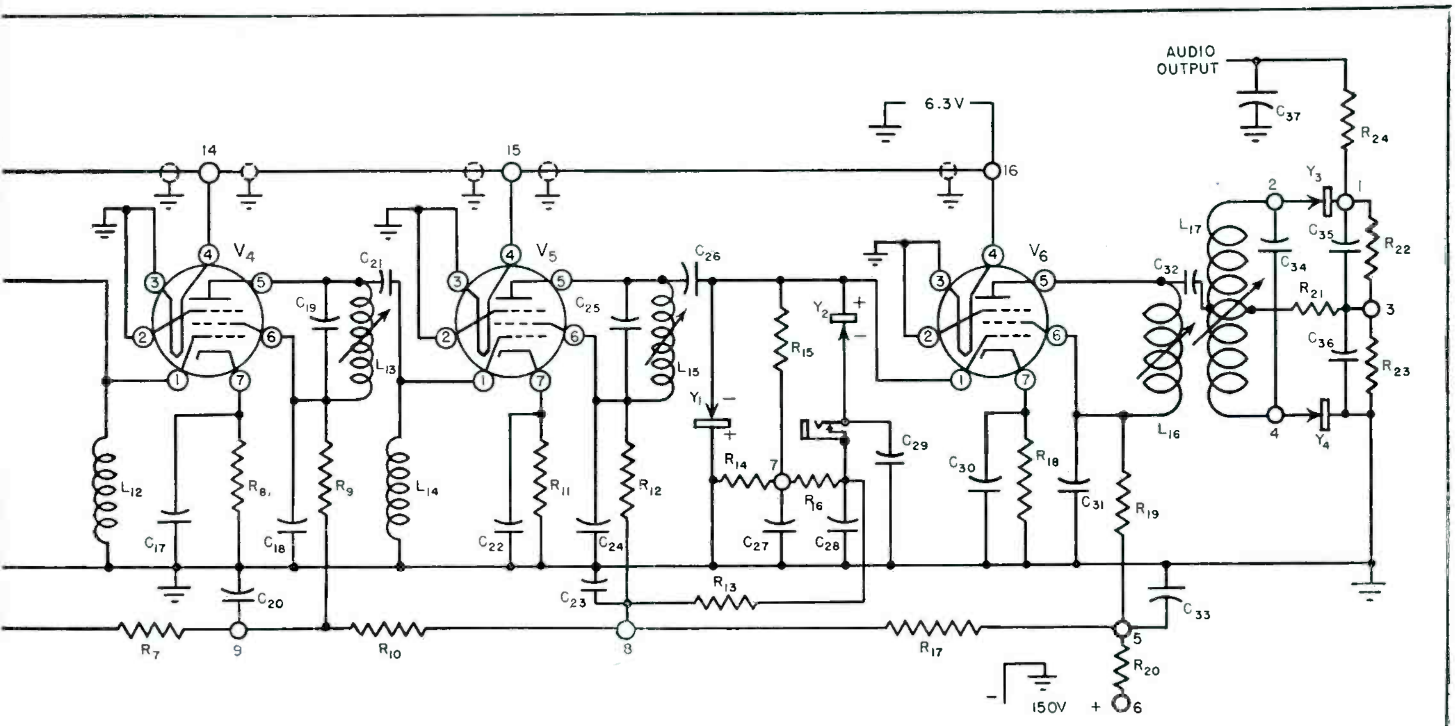
The plate resonator circuit for the grounded grid preamplifier consists of L_4 and C_5. These constitute a resonator similar to that used in the transmitter and shunt fed through L_5, C_4, and C_5. Grid bias is supplied by R_1, bypassed by C_1. Chokes L_2 and L_3, bypassed to ground by C_3, place the filament at cathode potential.

The converter, V_2, is another 6J4 operated with grounded grid. The amplified signal is inductively coupled from the preamplifier plate resonator through coupling loop L_6. Local oscillator power is fed in series with the amplified signal. The oscillator voltage is developed across self-resonant choke, L_7. Grid bias is developed across R_2 bypassed by C_7. Local-oscillator power is fed in at half frequency (225 mc) and doubling is accomplished in the converter.

The intermediate frequency of 15 mc is developed in the plate resonant circuit, L_{10}, C_{10}. Plate decoupling is accomplished by R_4, C_9. The i-f signal is coupled into the grid of the first i-f amplifier, V_3 through C_{11}, R_3. Tube V_3 is a 6AU6 operating as a normal pentode amplifier. The amplified i-f signal is developed across L_{11}, C_{14}. Plate decoupling is accomplished by R_6 C_{13}; grid bias is developed across R_5 bypassed by C_{12}. Coupling to the second i-f stage is through C_{16}, L_{12}. The second and third i-f stages, V_4 and V_5 are identical with the first. Inductors L_{12} and L_{14} are self-resonant grid chokes employed to provide zero audio gain to overcome a troublesome audio oscillation due to feedback through the plate decoupling networks.

The signal level in the third i-f plate circuit L_{15}, C_{25} is sufficient for limiting. The limiter is coupled through C_{26} and R_{15}, and consists of two 1N35 diodes oppositely biased to 0.5 volt through the voltage drop across R_{14} and R_{15}, bypassed by C_{27} and C_{28} respectively. A dropping resistor R_{13} limits the current to 5 ma. A closed circuit jack is used for limiter current monitoring; C_{29} bypasses it to ground.

The fourth i-f amplifier, V_6, is



L_1, L_4, L_6–see text
L_2, L_3, L_5, L_8, L_9–12 turns No. 22 enamelled, close-wound on 1/2-watt Allen-Bradley resistor, 100,000 or larger. dipped in Glyptal
L_7–15½ turns No. 22 enamelled, close-wound on 1-watt Allen-Bradley resistor, 100,000 or larger, dipped in Glyptal
L_{10}, L_{11}, L_{13}, L_{15},–16 turns, No. 30, heavy Formvar, close-wound on Millen form No. 69041
L_{12}, L_{14}–100 turns, No. 34 heavy Formex close-wound on Stackpole G-Y core, 0.25 x 7/8″, coated with Glyptal
L_{16}–24 turns, No. 22 enamelled, close-wound on National XR-50 form
L_{17}–Bifilar winding, each winding 10 turns No. 26 heavy Formvar, double spaced
Feed-through terminals 1 to 16–Vitro-seal Corp. Terminal No. 1901-9-L-HT
J_1–UG-58/U r-f jack
J_2–Closed-circuit phone jack
V_1, V_2–6J4
V_3, V_4, V_5, V_6–6AU6
Y_1, Y_2, Y_3, Y_4–IN35 crystal

nents. At current net prices, the cost of parts is approximately $40

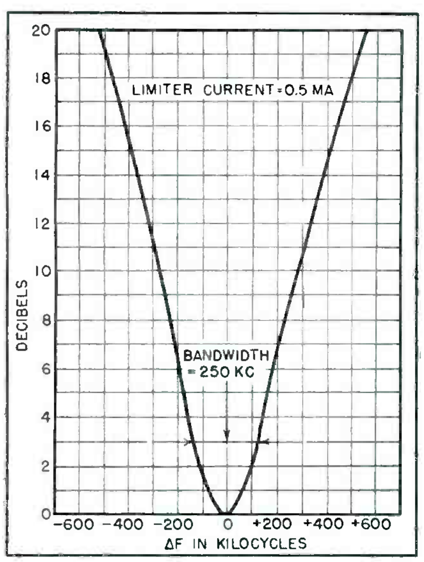


FIG. 3—Bandpass characteristic of the receiver i-f stages

driven by limited voltage. The output voltage is developed across L_{16}. This output voltage drives a Foster-Seeley discriminator consisting of L_{17}, C_{35}, Y_3, Y_4, R_{22}, R_{23}, C_{36}, C_{37}, and coupling elements C_{34} and R_{21}. Units Y_3 and Y_4 are 1N35 diode detectors. Opposing output voltages are developed across R_{22} and R_{23}. An inverse frequency network for reception of a phase-modulated carrier is formed by R_{24} and C_{37}.

Plate decoupling between stages is accomplished through R_{17}, C_{23}, R_{10}, C_{20}, R_7, C_{16}, and R_4, C_9. The filter formed by R_{20}, and C_{33} effectively decouples any resonance in the plate supply.

As shown in the photographs the receiver chassis measures only 12¾ × 2¼ inches. All tubes and components are miniature. Each stage is individually shielded and the preamplifier plate resonator is built into the chassis. All i-f coils are slug-tuned and accessible for tuning from the top of the chassis, except for the discriminator coils which are accessible from the rear.

Performance

The assumed preamplifier and converter gain were not achieved. For the optimum adjustment of the r-f portion of the receiver, there are at least four interacting parameters to adjust. These are (1) output loop size, L_6, which directly affects (2) the tap position on L_1, and (3) local-oscillator drive power, a function of (4) the converter cathode resistor, R_2.

Another difficult-to-determine parameter is the impedance reflected at the signal frequency by the local oscillator across the choke coil, L_7. The length of transmission line (5 inches) was chosen so that under assumed maximum limits of terminating loop inductance (tap on first doubler resonator), the input impedance at 465 mc would be a short circuit or a capacitive reactance. As choke L_7 presents a capacitive reactance at 465 mc, an inductive reactance presented at input to coaxial cable could produce resonance and absorb much signal power.

The r-f stages were adjusted in the following manner: A Measurements Corp. model 84 signal generator was connected through a coaxial cable to the input jack J_1. and an 0-1 milliammeter plugged into J_2. A loop size was chosen for L_6 and the local oscillator adjusted to produce a computed bias of 5.8 volts across R_2. With sufficient output voltage from the signal generator to produce limiter current, the preamplifier tuning adjustment, C_5, was adjusted for maximum limiter current. The local oscillator tuning was then adjusted for maximum limiter current. Several tap positions were then tried and the signal generator level for minimum detectable limiter current noted. This process was repeated for other loop sizes for L_6. This process admittedly adjusts for maximum gain, not signal to noise ratio.

A loop size of 1⅝ by ⅜ inch made of No. 14 tinned copper wire for L_6 was determined as a reasonably good adjustment. For this size loop, the antenna was tapped directly to the cathode terminal of V_1. A bias voltage of 3.5 volts across R_2 was optimum and a detectable limiter current was observed from an input of 10 microvolts. An image rejection of 30 decibels was observed. A bench-to-bench talking test using a bread-board version of the transmitter described in the November issue of ELECTRONICS showed highly intelligible reception.

With no i-f regeneration, the gain was insufficient to obtain limiter current on noise. It was found, however, that the receiver was critical as to the grounding of the shield cover. The receiver is normally quite stable, but at times it was possible to obtain a slight amount of regeneration which brought the noise up to a readable level. Under these conditions, assuming no decrease in i-f bandwidth, the noise figure measured 20 decibels above theoretical.

Figure 3 shows the i-f bandpass characteristic. This was measured by feeding an i-f signal in at the local oscillator input. Under this condition, the converter stage operates as an i-f amplifier. This has a minor effect due to differences in the plate resistance between converter and amplifier operation. For this measurement, the limiter current was maintained constant at 0.5 ma. The ratio of input voltage expressed in decibels is plotted against deviation from the center frequency. The bandwidth for 3-db down is 250 kc, the objective.

Figure 4 shows the limiter characteristic. Output voltage as measured across R_{23} is plotted against limiter current. It is seen that effective limiting occurs above 0.1-ma limiter current. Increasing limiter current to 1.0 ma produces only 3.3-db more in output.

Figure 5 shows the discriminator characteristic taken at 0.5 ma of limiter current. The characteristic is essentially linear over ± 100 kilocycles. The slope at resonance is 0.08 volt per kilocycle, producing 2 volts peak for 25-kilocycle deviation, which is sufficient to drive a low-power audio amplifier.

Constructional Details

Figure 6 shows chassis details. The chassis is constructed entirely of 1/32-inch sheet brass. Each stage is enclosed within its own shield formed by partitions soft-soldered into the chassis. Each partition has a cut-out to clear the tube socket. The preamplifier plate resonator is formed by two partitions, into one of which a 1⅝-inch length of ½ inch × 1/32-inch wall brass tubing is soldered.

A shield cover of 1/32-inch sheet brass is securely fastened to the chassis with 3–48 screws. Two screws are used in each partition to produce a complete electrical shield between each stage. The chassis and cover are cadmium plated to resist corrosion.

Button mica capacitors and feed-through terminals are soft-soldered into the plated chassis. Units C_4 L_5 and C_6 are then assembled into the center conductor of the resonator. Capacitor C_5 is mounted

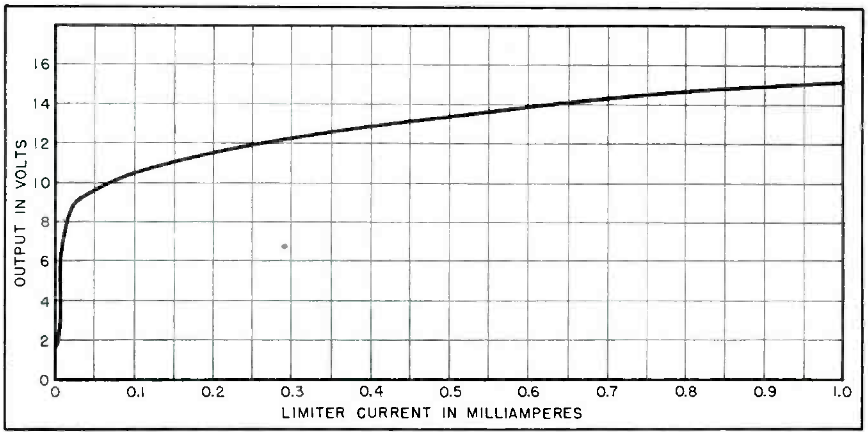


FIG. 4—Output voltage across R_{23} in the discriminator load circuit (Fig. 2) plotted against limiter current

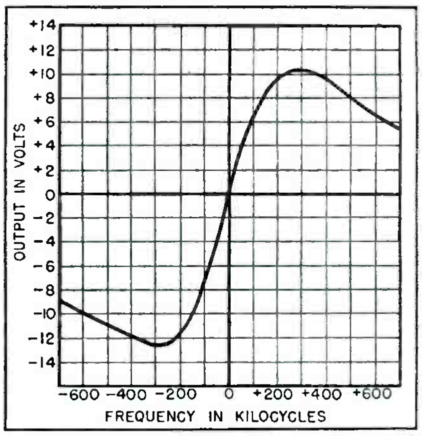
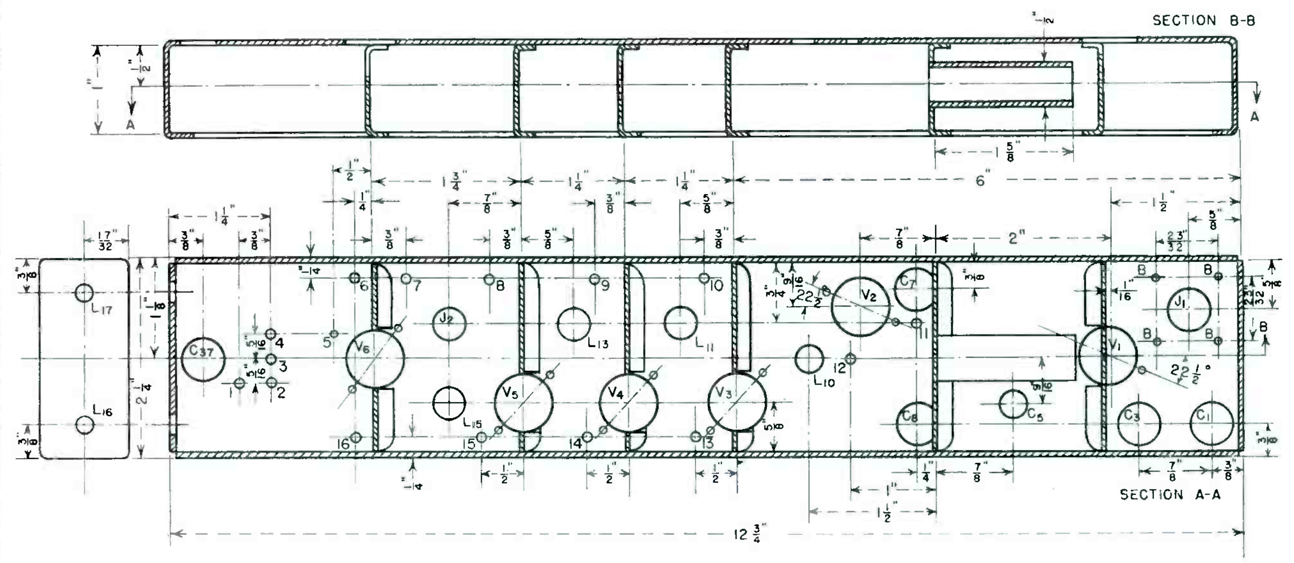


FIG. 5—Discriminator characteristic when limiter current is 0.5 milliampere



HOLE SPECS:
Jack J_1–9/16″ hole
Connector hole B–#31 drill
Holes 1 to 16–3/16″ drill
Capacitors C_1, C_3, C_8, C_7, C_{37}–29/64″ hole
Capacitor C_5, coil L_{16}, L_{17}–1/4″ hole
Coils L_{10}, L_{11}, L_{13}, L_{15},–5/16″ hole
Jack J_2–3/8″ hole
Tube sockets V_1 to V_6–21/32″ hole, #3 drill spaced 7/8″

FIG. 6—Mechanical details of receiver chassis, including those of shield partitions. Section A-A at the right is the plate resonator of the r-f preamplifier stage

on the chassis and the uprights soldered to the center conductor. Coil L_1 is a length of No. 14 tinned copper bus wire spanning the cathode terminal of V_1 and the terminal on C_1. It is spaced about ¼ inch above the chassis.

The components should next be mounted and the receiver wired in the normal manner. All grounds are made to the same point within each stage; for example, C_{12}, C_{13}, C_{15}, and L_{12} are all grounded to the same point as terminals No. 2 and No. 3 on the tube socket for V_3, grounded to shield partition.

The secondary winding of the discriminator transformer, L_{17}, consists of two interlaced windings spaced one wire diameter. One set of opposite ends of the winding are tied together to form the center tap. The other set of opposite ends feed the 1N35 crystal diodes. This construction automatically permits the tuning slug to affect both windings nearly equally, thus maintaining an approximate inductance balance.

All shielded filament and plate leads are covered by copper-shielded wire, Precision Tube Co., No. 22 Lenz Aeroglas, in 0.101 OD by 0.009 wall tubing.

A signal generator tuned to 15 mc is connected to the local oscillator cable. Care must be taken to carefully shield this lead. A 0–1 ma meter is plugged into J_2. Coils L_{10}, L_{11}, L_{13}, and L_{15} are tuned for maximum meter current. A high resistance d-c voltmeter is next connected from terminal No. 3 to ground and L_{16} tuned for maximum deflection. The voltmeter lead is then moved from terminal No. 3 to No. 1 and L_{17} adjusted for a null. This completes the i-f alignment.

A signal generator is next connected through a coaxial cable to the input jack, J_1. Local oscillator power at 225-mc (4,166.667-kilocycle crystal) is fed in through the local oscillator coaxial cable by tapping the center conductor of the cavity resonator of the first doubler stage of the transmitter through a 10-$\mu\mu$f. mica capacitor, see Fig. 2.

The local oscillator power is adjusted to produce 3.5 volts across R_2 by adjusting the tap position or tuning of the first doubler of the transmitter.

One possible improvement, requiring no circuit change, is a reduction in the resistance of R_2. The value of 390 ohms was computed on the basis of maximum second harmonic space current at a d-c cathode current of 15 ma. An optimum bias voltage of 3.5 corresponding to 9-ma cathode current was observed. This indicates increased conversion transconductance could be achieved by reducing the value of R_2, staying within maximum plate dissipation (2.25 watts) of the 6J4.

Another relatively simple improvement would be to change the 6J4 converter into a 15-mc grounded-grid amplifier. The input impedance would present approximately the optimum load for a silicon crystal converter which could be incorporated into the preamplifier resonator.

Acknowledgments

The author wishes to thank Herbert Hardy for his assistance in the mechanical construction of the chassis. Thanks are also due Gilman Andrews for his suggestions and criticisms during the design and test of the receiver.

References

(1) H. T. Friis, Noise Figure of Radio Receivers, *Proc IRE*, Vol. 32, No. 7, p 419, July 1944.
(2) C. E. Dean, Bandwidth Factors for Cascade Tuned Circuits, ELECTRONICS, July 1941.

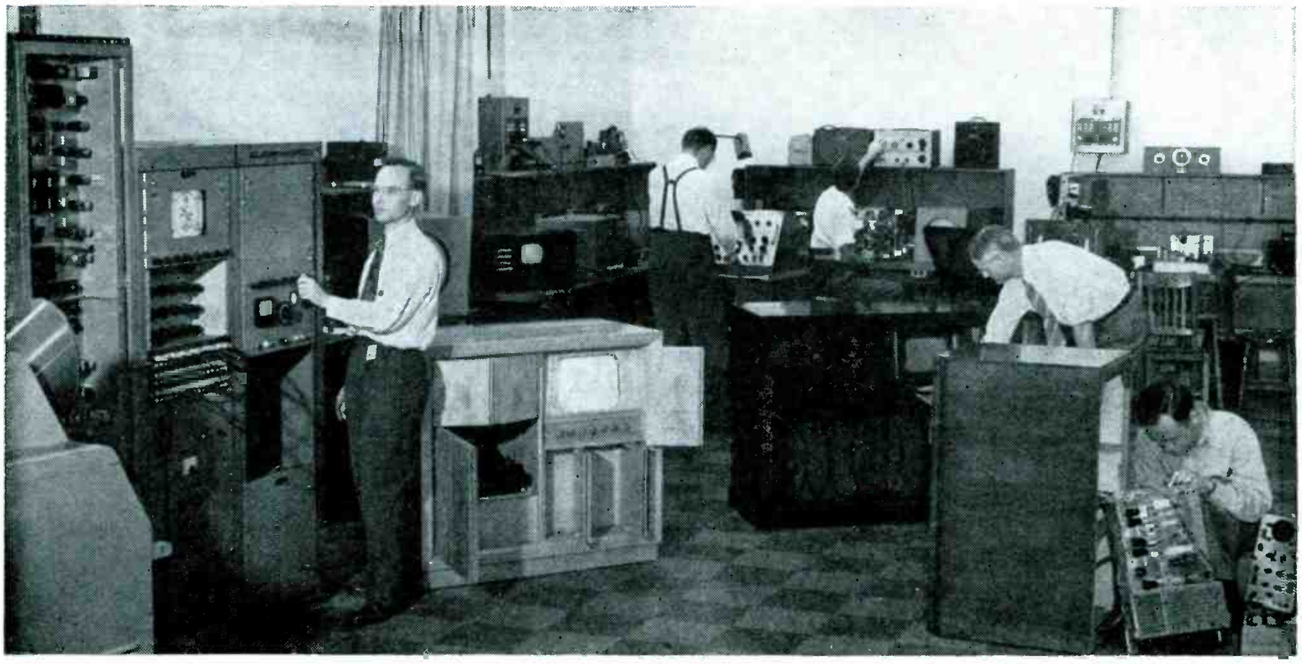


FIG. 1—In this view of the laboratory, the central test equipment racks illustrated in Fig. 2 appear at left. The line-isolation amplifiers are mounted on the walls

Television Receiver Laboratory

Design of test facilities, shielding, and filtering for a development laboratory. An oscilloscope adapter, line-isolating amplifiers, safety boxes for c-r tubes and the construction of the shielded room are among the features

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IN THIS PLANT, the television receiver development program is carried out in part in the general laboratory area, with the main activity taking place in a special receiver room, a small camera room, two shielded rooms, and an adjacent space with impedance-measuring lines suitable for use at 40 mc to 250 mc.

The main television room is shown in Fig. 1. In addition to a number of 7, 10 and 15-inch direct-view receivers and one 10-inch indirectly-viewed experimental receiver, one 15 and two 10-inch diameter cathode-ray tubes may be seen on the benches in safety boxes. These are plywood boxes with sloping fronts, having a safety-glass window the full size of the tube screen. They are provided with readily adjustable deflection-yoke and focus-coil mounts.

In one safety box, a second focus coil and deflection yoke have been mounted remote from those around the neck of the tube. By switching from one set of coils to the other (with brightness control turned down to avoid burning a spot on the screen) the undeflected, unfocused spot can be conveniently observed. This is of interest in studying asymmetry of the spot or proper adjustment of the ion-trap magnet. Connections to a receiver chassis can be made by using either binding posts or a multiple-pin connector mounted on the side of the box. The front section of the box is hinged and held

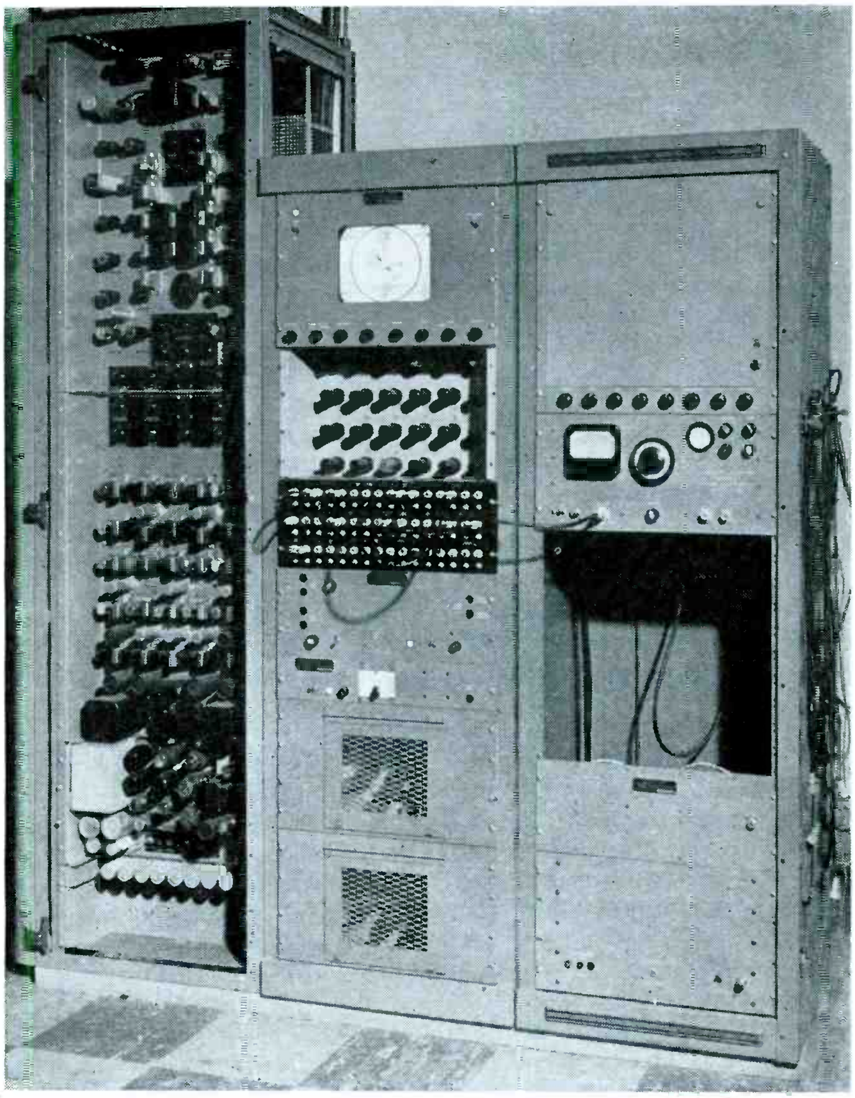

FIG. 2—Central receiver test equipment. The rack at left contains the sync generator. In the center rack are the laboratory picture monitor, distribution and line amplifiers, a linearity test generator, and picture monitor and monoscope camera power supplies. The right-hand rack mounts the monoscope, a transmitter, a noise generator, and line-isolation amplifier power supply

in place by convenient snap catches to facilitate changing tubes.

Curtains are provided for darkening one end of the room without affecting the rest of the laboratory. Fluorescent ceiling units provide over 20 foot-candles of illumination. Lights behind the curtains can be turned off separately, and, if desired, an incandescent unit in that area can be adjusted from its maximum light output to any lower brightness by means of a Variac.

Test Instruments

The first essential equipment of a television laboratory is a television synchronizing generator, preferably one complying with RMA standards[1]. The second major requirement is a dependable source of picture signals such as those obtained from a monoscope or other test pattern which remains fixed while adjustments are made and which can always be used to observe the geometric distortion, resolution, contrast, focus and general quality of the received picture.

An electrical bar or grating pattern generator is needed to accurately and rapidly adjust sweep linearity. The pattern generator signals provide a grating of horizontal and vertical bars accurately spaced in time. Thus their distances apart on the picture screen show the sweep speed averaged over each time interval between bars. The pattern can be chosen so as to produce squares when the aspect ratio is correct and then the linearity and amplitude of the sweeps can be quickly adjusted.

A monoscope camera (such as the one at the top of the right hand rack in Fig. 2) generally includes an amplifier which mixes blanking signals with the picture signal. Either its output or that of some other camera or picture signal source is then put into a line amplifier where sync pulses are added to produce a standard RMA[2] composite picture signal. This composite video signal should then be monitored by a laboratory picture monitor and a waveform monitor. For complete receiver testing, a laboratory television transmitter is necessary if locally broadcast picture signals are not available.

A noise generator to provide a known and controllable amount of various types of noise, such as thermal noise, but more particularly impulse noise similar to ignition noise, is also needed to permit study of noise limiting and sync interference and other important receiver characteristics.

In Fig. 2, the RMA sync generator occupies the left-hand rack. Its outputs are made available both on the central racks and at seven line-isolation amplifiers mounted in boxes on the wall above the benches at convenient locations around the laboratory. These locations are connected through RG 59/U coaxial lines to the central racks. The coaxials and d-c power connections for each line-isolation amplifier are run in ducts mounted along the walls near the ceiling with branches down to each box. From each box two coaxial cables run directly to the central jack panel shown at the center of Fig. 2. Signals can be sent from any part of the room to any other location by making a suitable connection at the jack panel. This saves time and avoids having lines remain on the floor.

The picture on the monitor at top center of Fig. 2 is not retouched. The actual picture resolution and contrast as viewed directly are excellent, even with the room brightly lighted. An aluminized 10-inch cathode-ray tube is used at about 14 kilovolts, giving about 200 foot-lamberts brightness in the highlights. A neutral density filter in the safety glass over the tube has only 40-percent light transmission. The ambient room illumination is thus attenuated before it strikes the screen. Thus the picture still looks bright and the contrast is not appreciably impaired when the room is fully lighted.

A small broadband scope near the racks is used as a waveform monitor and doubles as a test oscillograph. However, it is desirable to have a rack-mounted waveform monitor which is always available when needed.

The test transmitter shown on the right-hand rack in Fig. 2 is crystal controlled for the desired channel. The output stage uses a grid-modulated 832A tube with a 2-inch c-r monitor directly connected to the plate coil. A balanced mutual-inductance type attenuator is used, giving a continuously adjustable output from 100,000 to 1 microvolt with a direct-reading dial. This balanced output appears on two coaxial jacks, at an impedance level of 50 ohms to ground from either side, or 100 ohms from side to side. This is very convenient in receiver testing.

Line-Isolation Amplifiers

The line-isolation amplifiers shown in the schematic of Fig. 3 have five type 6J6 tubes, one for each of the five independent circuits. Both plate and cathode-coupled outputs (either polarity of the applied signal) are available at coaxial jacks on the front of the box. The first three circuits are intended for pulse signals such as sync, blanking, camera driving, and the last two for composite picture signals or camera output signals. Slightly different circuit values were used for convenience.

The polarity of the input signals on the first and last circuits are black negative so the output jacks are marked − on the cathode and + on the plate to indicate the output signal polarity. The middle three circuit jacks are marked with the + on the cathode and − on the plate to indicate whether the output is the same or the opposite polarity from the applied input.

The maximum output level is about 0.5 volt peak-to-peak if compression is to be avoided. This level is often insufficient, but a few booster amplifiers used on the bench as needed have been found satisfactory. Other engineers may prefer to use more distribution amplifiers whose outputs can be patched from central racks to any location desired. This line-isolation amplifier system provides a multiplicity of outputs always available at each location. Larger output tubes were not used because the total B current drain of the isolation amplifiers would become excessive.

The coaxial line to the amplifiers is looped into one after another, the amplifier inputs being simply bridged across the line except at the last amplifier, where the line must be accurately terminated to avoid reflections which may become serious if there is an appreciable mismatch. A small coaxial cable of the length used here has about 3-db loss at 5 mc. The output of the amplifiers is practically flat to beyond 5 mc except for the line loss, which is not serious since the phase response is excellent.

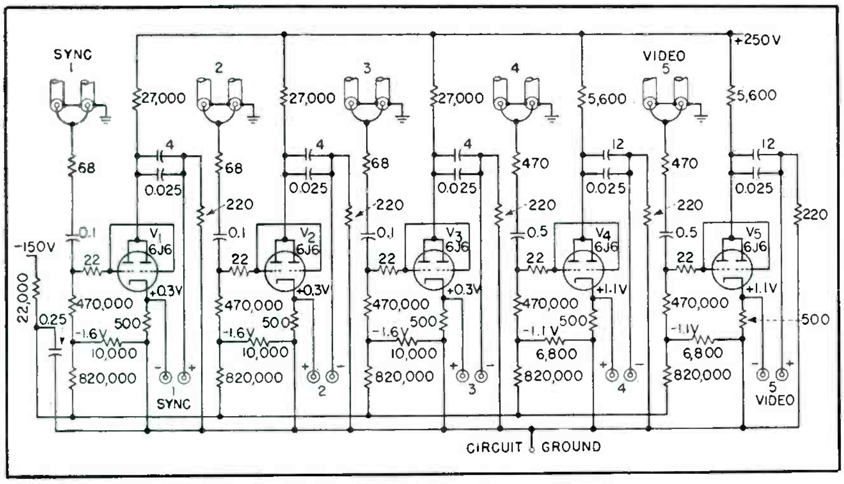

FIG. 3—Circuit of line-isolation amplifier

Oscilloscope Adapter

An oscilloscope adapter is shown in Fig. 1 on the rear bench at the left-hand side. It may be conveniently used with any broad-band oscilloscope to increase its utility in television development work. Its schematic diagram is shown in Fig. 4. The adapter is used to supply a 60-cycle calibrating voltage to the input probe to compare in amplitude with the signal under test, and to supply a variable sweep voltage to provide sufficient sweep velocity to view only a few lines of a television signal. This is also adjustable in phase; any desired portion of the signal may be expanded for close examination. The unit also provides a double trace on the oscilloscope at a 30-cycle rate for study of the interlace of a television signal, and provides a broadband (6-mc) video mixing amplifier with two inputs.

The sweep-voltage waveform is a trapezoid, produced from a 60-cycle sine wave which is adjustable in phase over about 360 degrees. The slope or velocity may be varied to allow only a few lines of a television signal to be viewed if desired. Blanking for the oscilloscope is produced by differentiating the sweep to avoid bright spots on the screen where the beam would otherwise dwell during the time between the fast sweep intervals.

In using the unit, compression of the positive trace may occur due to nonlinearity in the amplifier if the trace separation is widened too far. The phase shifter is quite satisfactory but an autosyn resolver would give even more constant output amplitude and make it possible to adjust the phase continuously in any direction. The present arrangement is limited to 360 degrees and has a slight variation in amplitude with phase.

Shielded Rooms

The screen rooms are somewhat unusual in that hardware cloth with $\frac{1}{4}$-inch mesh is used for both the inner and outer screens on the usual wooden 2 × 4 frames. The relatively open mesh permits excellent interior illumination by

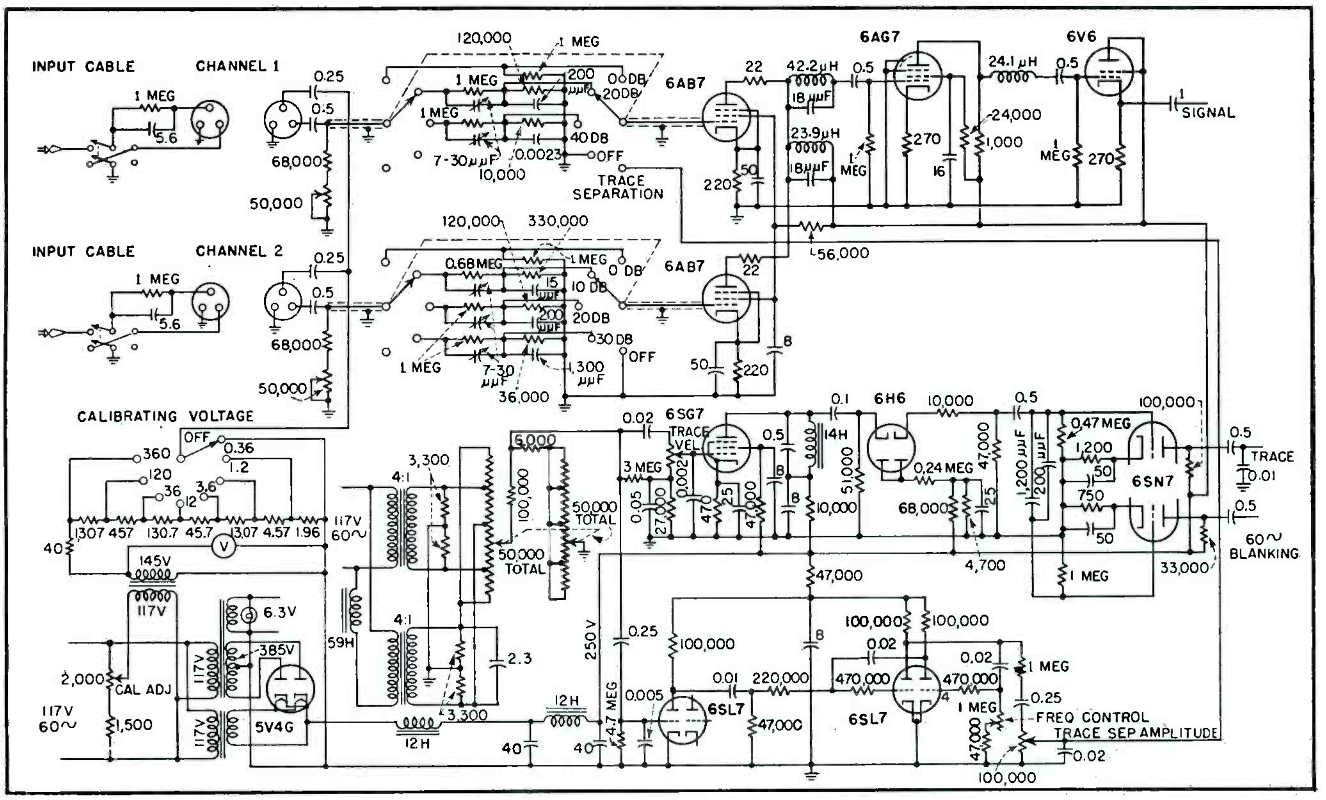

FIG. 4—Circuit of oscilloscope adapter

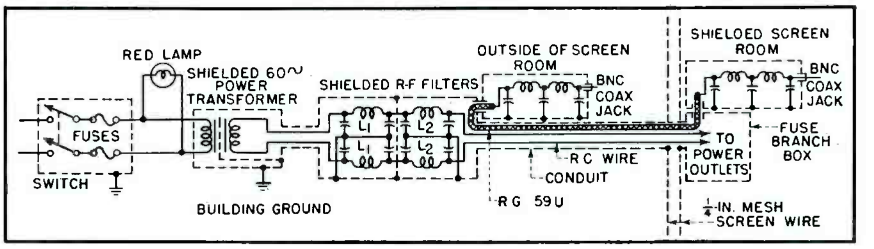

FIG. 5—Power line and video input filters for the shielded room

fluorescent light fixtures suspended just over the enclosure, thus eliminating any radio interference due to them and not loading the special filtered power circuit to the room. The open mesh also permits a free circulation of fresh air from an anemostat over the screen room.

The galvanized steel wires of the hardware cloth are bonded at every intersection, and it is believed that the efficiency of the screen in eliminating radio interference will be higher over a period of years than for a fine mesh copper screen, which is likely to corrode in time and cause poor contact between wires.

In constructing the rooms, care was exercised to solder all joints in the hardware cloth. Joints around the door between the screen on the door and that on the main frame are doubly sealed by bronze weather-stripping on both the door and the frame, on both the inner and outer sides. No connection anywhere between the inner and outer screens was permitted except for the single conduit which carries power wires and coaxial cable circuits.

A schematic of the filters for one of the screen rooms is shown in Fig. 5. With this arrangement the screen room provides more than 70-db attenuation anywhere within the room with respect to a signal level measured just outside the room, throughout the frequency range from 20 to 250 mc.

The main power fuse and switch box for each room is mounted outside the door, with a red lamp to indicate when the power is on. The 60-cycle shielded transformer and all the wiring are enclosed in metal boxes or conduit. A motor-driven voltage regulator supplies a constant 117 volts.

The two r-f filter sections are made resonant at widely different frequencies, and seem to be quite effective throughout the spectrum. Chokes L_1 and L_2 in the r-f filters are multiple-layer solenoids wound with large rectangular wire to avoid heating and keep the line voltage drop low.

Two coaxial lines into the screen room (only one is shown in the schematic) have 15-mc low-pass filters in small boxes on both the outside and the inside of the room. Thus any video signals (including color picture signals) can be transmitted without distortion of the signal and without any interference being introduced into the screen room at present television i-f or carrier frequencies.

The author wishes to acknowledge the contributions made by many engineers and technicians associated with him, particularly those of W. B. Wilkens and J. E. Mackenzie, and the encouragement and assistance of A. C. Omberg, chief research engineer.

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Airborne Engine Analyzer

Electronic instrumentation for aircraft engine trouble shooting insures greater safety and efficiency of operation. Special circuits provide cathode-ray display of ignition and vibration patterns regardless of engine speed

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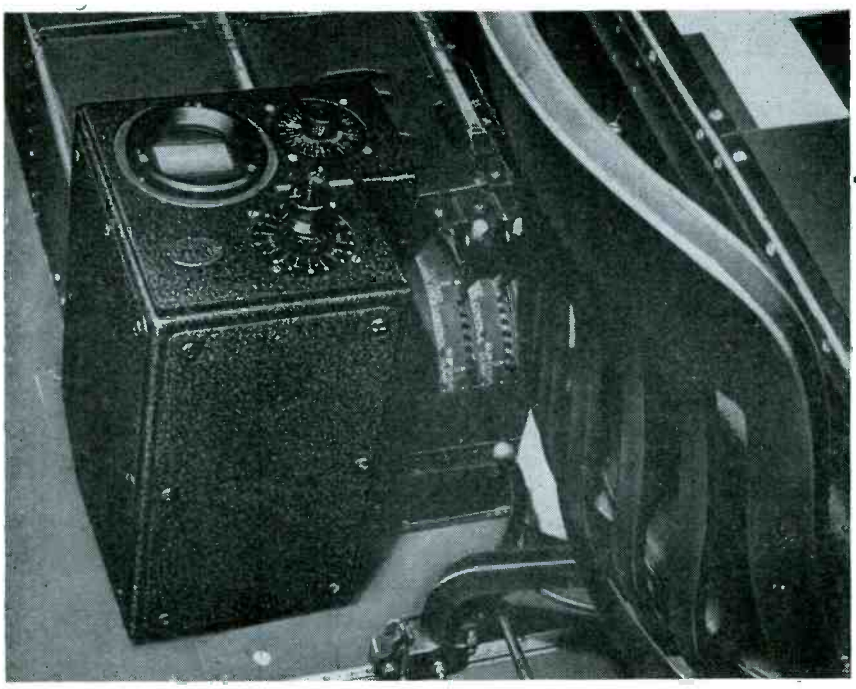

Engine analyzer installed in plane at rear of pilot's seat near flight engineer's desk

ALTHOUGH many engine malfunctions are not serious enough to prevent aircraft from flying, present-day commercial practice requires that all engines on even multi-engine ships be in as nearly perfect condition as possible before the plane is permitted to take off.

As a result of these high standards of maintenance, and because no easy, accurate, and rapid method has been devised to enable maintenance crews to quickly locate engine malfunctions, airlines have often found it necessary to withhold an aircraft from active service for many hours and even days because one or more causes of engine irregularities could not be located.

Estimates of the loss in revenue to an airline caused by the grounding of a large ship range as high as $37,000 per day.[1] Although in some cases this constitutes merely a paper loss it is none the less true that the dollar loss caused by an aircraft being grounded is considerable, and when added to the passenger ill-will invariably incurred when flights are delayed or cancelled the situation becomes of considerable importance to any first-class airline.

The importance of the problem has been recognized for some time, and much work has been done in the development of methods designed to expedite maintenance work to the utmost.

Functions Performed

The two principal functions of the engine analyzer[2] are: the location and identification of engine ignition system malfunctions such as fouled plugs, faulty magneto capacitors, and grounded high-tension leads; and the location and identification of what might be termed vibration faults, such as detonation, incorrect valve clearances, and valve bounce. Records show that approximately 50 percent of all engine faults are caused by ignition troubles alone.[3]

It should be noted that the engine analyzer is installed as a permanent part of the aircraft's flight equipment and consequently is available not only to the maintenance crews while the ship is on the ground, but is also constantly available to the flight engineer so that he can check the power plant whenever he has an opportunity or whenever he believes a fault is developing. Experience has shown that checks made during actual flight often reveal faults not detectable by ground test methods.

Ignition Check

To understand how ignition faults are revealed it is necessary to discuss the operation of a typical aircraft-engine ignition system.

Without considering the details involved, we can state that at the instant the magneto breaker points are opened by the engine-driven magneto cam mechanism, a high value of magnetic flux has been built up in the iron core structure of the magneto by the action of the magneto's permanent magnet rotor. Then as the breaker points separate, this magnetic field suddenly collapses, generating a very high voltage in the secondary winding of the magneto which is connected to the

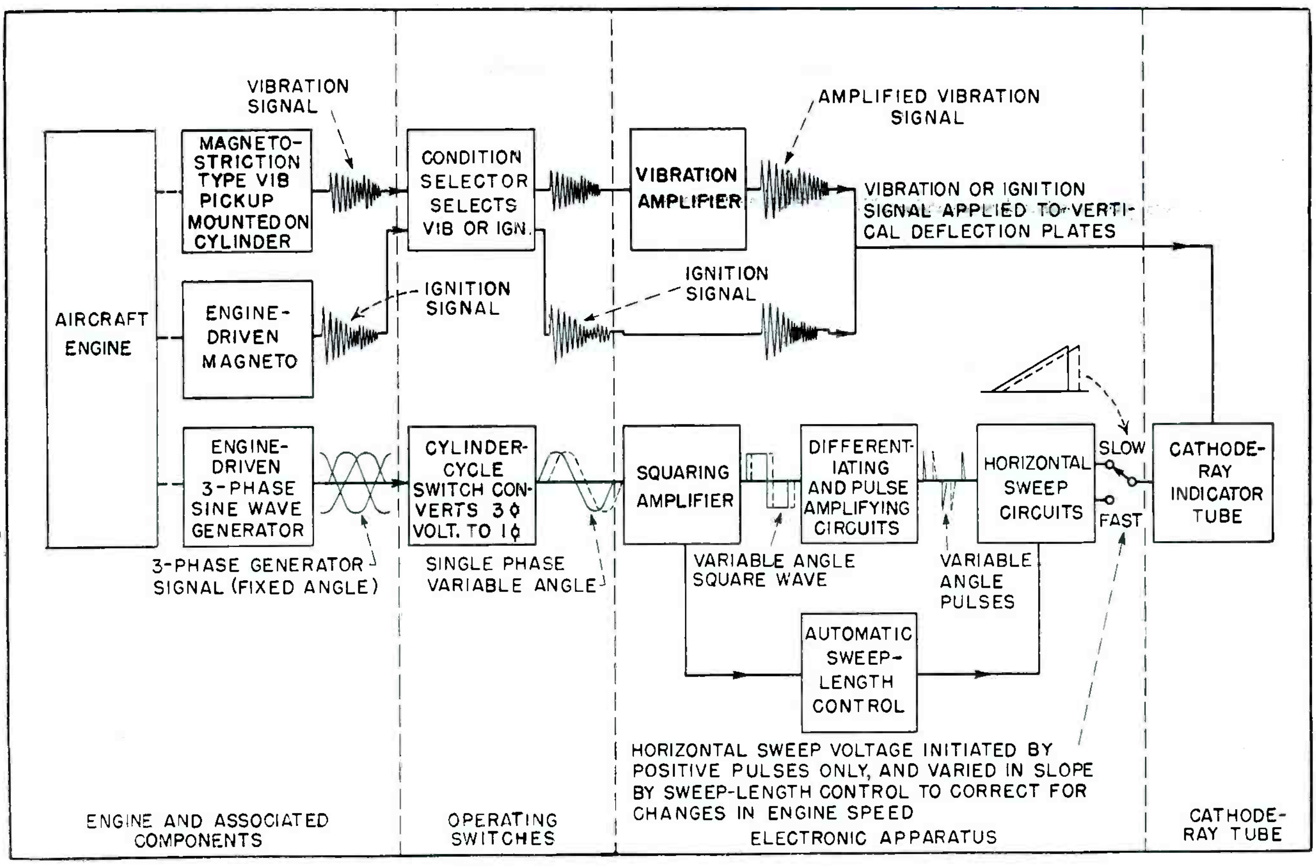

FIG. 2—Block diagram of engine analyzer

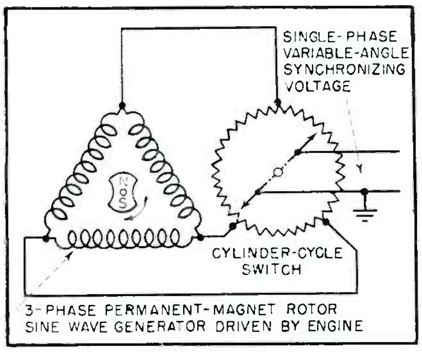

FIG. 1—Simplified circuit diagram of synchronizing voltage generator

spark plugs through the distributor. It is this voltage that fires the spark plugs.

During the time that the breaker points are open and the spark discharge is taking place the engine analyzer makes its analysis of conditions existing in the ignition system. The spark discharge sets into motion a highly oscillatory circuit. This circuit comprises the resistance and inductance of the magneto primary as well as the primary capacitance located in parallel with the breaker points. The circuit also includes the resistance, inductance and stray capacitance of the secondary circuit, including the effect of ionization in the spark-plug gap, and the breakdown and extinction voltages of the plug. The characteristics of the oscillation will be determined by these quantities and it follows that if one of them, say the secondary resistance, should change from its normal value to some higher or lower value, then the resulting oscillation would suffer a change in one or more of its characteristics such as its frequency, or rate of damping.

It has been found that in ignition systems nearly all of the common malfunctions are accompanied by some significant change in one or more of the electrical parameters constituting the oscillatory circuit. Consequently, it is necessary only to establish the oscillation characteristics occurring in a completely normal engine, and then to establish, similarly, the characteristics produced by the various ignition malfunctions. The effect of the malfunctions upon the oscillation characteristics have been studied by building in various faults such as fouled plugs on a test engine.

Breaker-Point Voltage

In order to study the oscillations, it is necessary to specify a method of measuring them. In the engine analyzer this is done by measuring the voltage appearing across the breaker points during the time they are open, and the actual evaluation of the characteristics is made visually by observing the resulting ignition patterns on a cathode-ray type indicator. The voltage across the breaker points is chosen because it rarely exceeds 200 volts.

It should be noted that an isolating resistor of several thousand ohms value is placed between one of the magneto breaker points (the other breaker point being grounded in a normal engine installation) and the analyzer. This resistor prevents any short circuit or ground condition that might occur inside the analyzer from affecting the operation of the magneto.

Analysis of vibration faults requires use of a magnetostriction-type vibration pickup. The essential parts of this device are a small permanent magnet surrounded by a winding of many turns of copper wire, and a suitable housing to contain the magnet and coil. One end of the winding is connected to the case of the pickup which is subsequently grounded, while the other end is brought out by means of a helical spring connector and shielded cable arrangement. The entire unit is mounted on the outside of the cylinder, the threaded pickup stud being located in a hole tapped into the thermocouple boss. The stud does not go through the cylinder wall into the cylinder itself, but extends a short distance into the mounting boss.

As the engine operates, vibrations are set up in the cylinder walls; these vibrations in turn cause the entire magnetostriction pickup to vibrate since it is attached to the cylinder. The vibrations set up in the pickup produce stresses in the permanent magnet, and since this magnet is made of a highly magnetostrictive metal, these stresses cause the magnetic flux of the magnet to vary in intensity, inducing a voltage in the winding surrounding the magnet. This voltage is equal in frequency to the frequency of the vibration, and proportional in amplitude to the amplitude of the vibration. Consequently, by its strategic location on the engine cylinder, the pickup is able to produce a voltage which is characteristic of cylinder vibrations caused by detonation and valve bounce.

Sweep Requirements

To understand the operation of the analyzer it should be noted that there are two voltages that must be displayed on a cathode-ray tube screen. These are the voltage from the magneto breaker points, and the voltage from the vibration pickup. Each of these signals is applied to the vertical deflection circuit of the cathode-ray tube. This leaves only the horizontal circuit of the cathode-ray tube to be considered.

In order to examine either the ignition or vibration voltages, it is clear that the patterns formed by these voltages must appear stationary on the cathode-ray tube.

Each complete pattern for a given cylinder, whether it be due to ignition or vibration, occurs once during each cycle of engine events. The initiation of the horizontal sweep of the cathode-ray tube is synchronized with the rotation of the engine. As the engine rotates through one complete cycle of events (two revolutions) the horizontal sweep is initiated, and the pattern appears stationary. Furthermore, if the sweep speed is such that during two revolutions of the engine the electron spot moves from the left to the right side of the tube, then it is clear that the ignition patterns for all the cylinders will appear one after the other along the tube face.

The patterns will begin at the left with the pattern for the cylinder whose firing corresponds to the angular position of the crankshaft at the instant of initiation of the sweep. That ignition patterns for all the cylinders will appear on the screen is seen from the fact that in two revolutions of the engine the magneto breaker points must open a number of times exactly equal to the number of cylinders. One vibration pattern for one cylinder will occupy the entire length of the trace, since one complete vibration pattern requires two engine revolutions for its completion.

Figure 1 shows the circuit used in generating the signal which is ultimately used for initiating the sweep in proper synchronism with the engine. The generator is a small 3-phase permanent magnet alternator that is connected to one of the engine's auxiliary tachometer drives. The alternator is wound as a two-pole machine and hence delivers one complete cycle of alternating voltage per revolution of its rotor. Since the tachometer drive operates at half the engine speed, the frequency of the resulting 3-phase voltage in cycles per second is numerically equal to half the speed of the engine in revolutions per second. This 3-phase voltage is applied as shown to a continuous resistor wound uniformly in a circular configuration. The continuous resistor is arranged so that it is contacted at two points 180 degrees apart by two contact arms. These contacts are insulated from each other electrically but are arranged so that they can be rotated around the continuous resistor as a single unit, one arm always remaining 180 degrees from the other.

Phasing Control

It can be shown that with an arrangement of this sort a single-phase voltage will appear across the two contact arms, the frequency of this voltage being equal to that of the 3-phase voltage and the phase angle with respect to the 3-phase voltage being dependent only upon the angular position of the two contact arms on the continuous resistor.

The contact arms are attached to a shaft equipped with a detent mechanism so arranged that as the shaft is rotated by means of a knob the contact arms are moved around the circular resistor in discrete steps. A dial used in connection with the knob is inscribed with numbers spaced over the 360-degree travel of the knob, one number for each cylinder. The numbers of the cylinders appear around the dial in the sequence of the particular engine's firing order. By turning the knob from one cylinder number to the next, the phase angle of the single-phase voltage across the contact arms is shifted with respect to the 3-phase generator voltage, or what is the same, with respect to the angular position of the crankshaft, by an amount equal to the number of crankshaft degrees between the occurrence of an event in one cylinder and the occurrence of the same event in the next cylinder.

The circular resistor, the contact arms, and the knob and dial arrangement are assembled as one unit known as the cylinder-cycle switch. For a given setting of the cylinder-cycle switch, the phase angle of the single-phase voltage with respect to the crankshaft will remain fixed regardless of variations in engine speed. This requirement obviously must be met in the present application, and represents the principal reason for using this type of circuit rather than one of many possible arrangements in which the phase shift would be dependent not only upon the setting of one or more circuit parameters, but would also be a function of the varying frequency supplied by the generator as engine speed varies.

Block Diagram

The block diagram of Fig. 2 shows the complete operation of the analyzer.

Three signals entering the analyzer from the engine are the vibration, ignition, and 3-phase generator voltages. The vibration and ignition signals go into the condition-selector switch, where either one or the other is chosen by the operator. If ignition is selected, the signal is passed to the vertical deflection circuit of the cathode-ray tube. Since the amplitude of the voltage appearing across the breaker points is sufficient to produce ample deflection when applied directly to the cathode-ray tube, no amplification of the ignition signal is necessary. If the vibration signal is selected, it is passed through the vibration amplifier and then to the cathode-ray tube. Amplification is necessary because the normal output of the vibration pickup is only a small fraction of a volt.

The single-phase sine wave developed from the 3-phase generator enters a squaring amplifier followed by a differentiating and amplifying circuit that converts the square waves into one positive and one negative pulse each cycle. The positive pulses are used to trigger the horizontal sweep circuit once each cycle, or once for every two revolutions of the engine. These pulses trigger a conventional sawtooth sweep voltage that is applied to the horizontal circuit of the cathode-ray tube. In actual operation the generator is mounted on the engine in such a position relative to the angular position of the tachometer drive shaft that the resulting pulses derived from the cylinder-cycle switch and pulse-forming circuits will trigger the horizontal sweep at exactly the instant the magneto breaker points open to fire, say, the number one cylinder if the cylinder-cycle switch is set to that cylinder. In a like manner, setting the cylinder-cycle switch to any other cylinder will shift the position of the pulse in one direction or the other by the amount necessary to cause initiation of the sweep to occur just as the breaker points open to fire that cylinder.

Having achieved the ability to initiate the sweep just as the desired ignition pattern is beginning to form, the sweep circuit has two adjustments such that instead of causing the electron spot merely to move across the tube face in two revolutions of the engine it will also move much more rapidly. Thus instead of seeing the ignition patterns for all the cylinders one after another, only the pattern of the cylinder being examined will be visible; but now the pattern will be greatly expanded horizontally (and may, indeed, be made to occupy the entire width of the tube face) thus facilitating analysis. The fast sweep is used mostly for ignition analysis where it is desired to expand the patterns considerably, while the slow sweep is used mainly for vibration analysis where it is more desirable to view the pattern for the entire cycle of cylinder events as one pattern rather than to have it broken up into a number of expanded sections. The slow

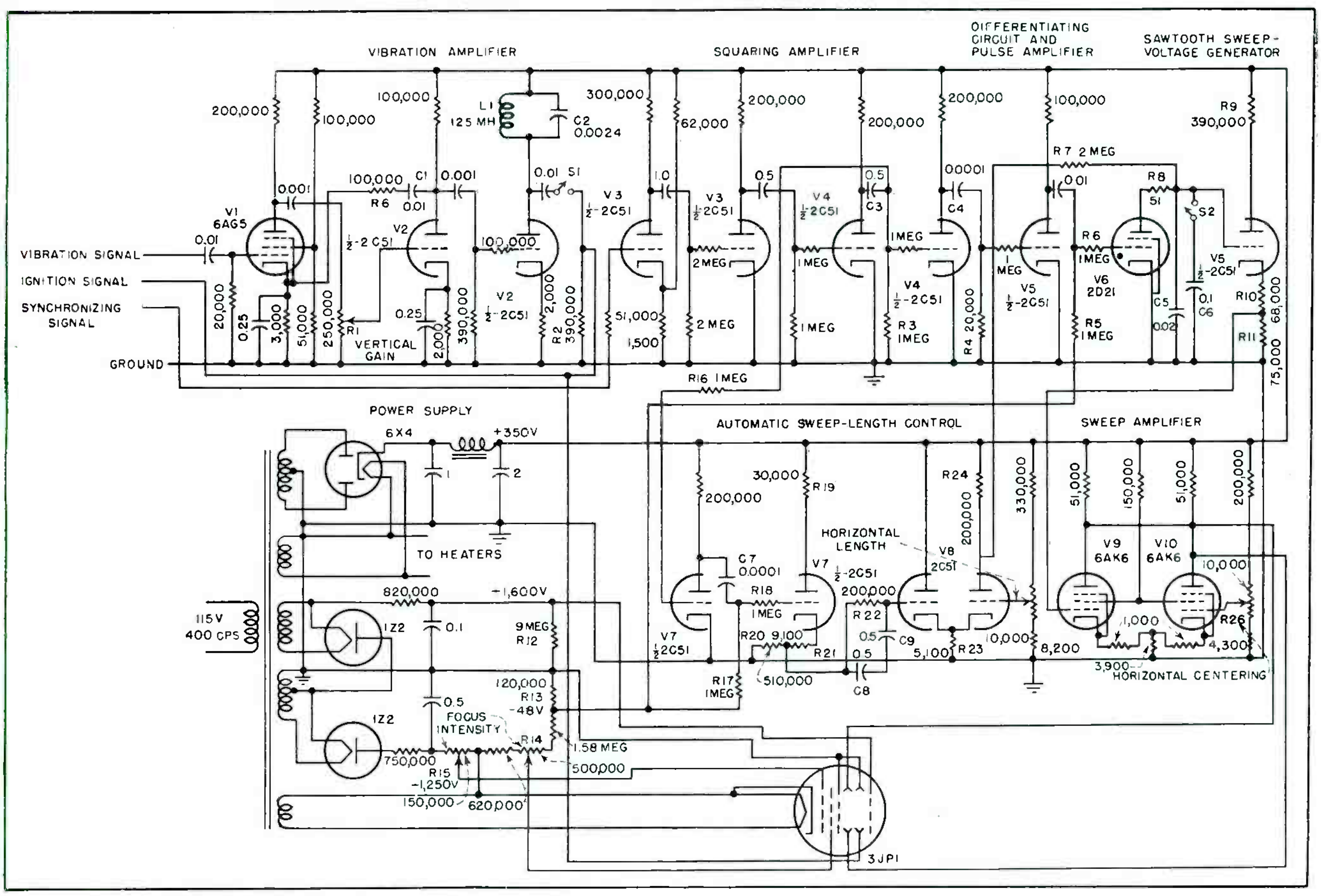

FIG. 3—Diagram of engine analyzer circuits. Value of capacitor C_5 is varied for different engines

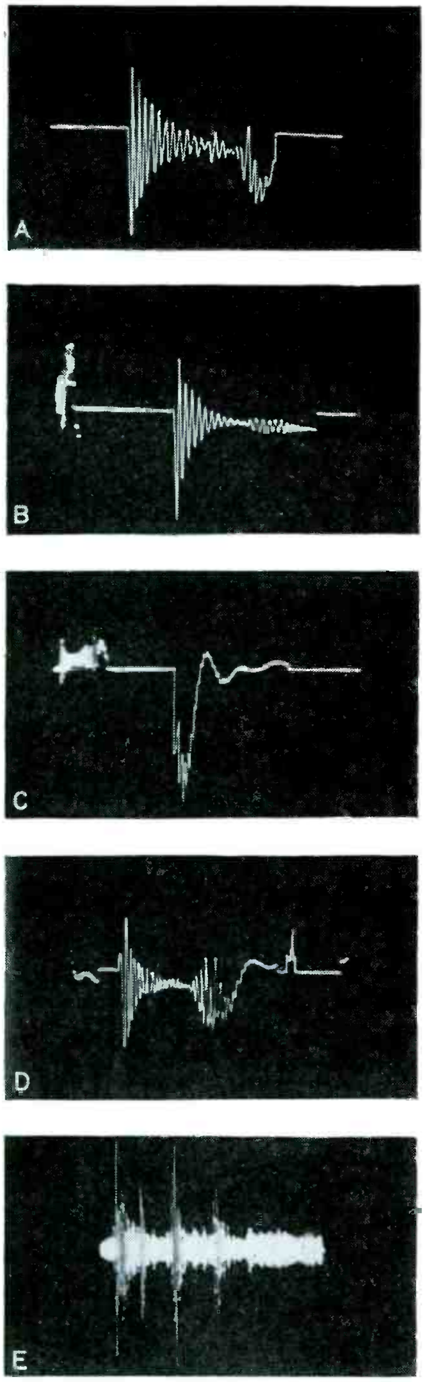

FIG. 4—Typical ignition patterns for (A) normal conditions, (B) fouled plug, (C) open secondary, (D) magneto breaker-point bounce, and (E) vibration pattern of a normal cylinder

sweep setting consequently provides a sweep requiring two revolutions of the engine for its completion.

If the sweep speed is maintained constant at either the fast or slow value the length of the horizontal trace will decrease as the engine speed increases. This effect results from the time between initiation of successive sweeps being inversely proportional to engine speed. For example, a 3-inch trace at 1,000 rpm would shrink to 1-inch length at 3,000 rpm. To remedy this condition an automatic sweep-length control is included. In effect this circuit measures the speed of the engine by measuring the frequency of the 3-phase generator voltage and adjusts the sweep speed accordingly. As the engine speed increases the sweep speed increases correspondingly to maintain the length of the patterns constant.

Electronic Circuits

A simplified diagram of the electronic apparatus used in the engine analyzer is shown in Fig. 3. All the electronic circuits with the exception of the cathode-ray tube, which is located remotely are contained in one box measuring approximately 8 × 10 × 9 inches.

The vibration signal is amplified by tubes V_1 and V_2. The amplified signal appearing across R_2 is then applied directly to one of the vertical deflection plates of the cathode-ray tube, the other plate being grounded. The amplifier is entirely conventional except for the circuit consisting of inductance L_1 and capacitor C_2. This circuit is tuned to resonate at about 10,000 cycles, causing the amplifier to peak at this frequency. It has been found that the cylinder vibrations associated with detonation and valve events occur in the band of frequencies lying between 5,000 and 15,000 cycles. The gain is adjustable from zero to approximately 10,000 by means of R_1. Feedback between the first and second stages is provided by R_6 and C_1. The switch S_1 is provided to disconnect the amplifier from the upper end of R_2 when the analyzer is used for ignition analysis; this is necessary since the ignition signal entering the electronic unit is conducted to the cathode-ray tube by the same circuit used for the vibration signal. In the actual analyzer this switch takes the form of a small relay which is operated by the condition-selector switch.

Considering now the single-phase variable-angle sine wave coming from the cylinder-cycle switch and entering the electronic apparatus, the voltage is amplified in the first section of V_3 and subsequently converted into a square wave by the second section of V_3 and by the two sections of V_4 which follow. Capacitor C_4 and resistor R_4 serve to differentiate the square waves, producing positive and negative pulses. These pulses are amplified by the first section of V_5, resulting in positive pulses of approximately 50 microseconds in duration and 150 volts in magnitude, and also negative pulses that serve no useful purpose. The positive pulses are used to fire the thyratron V_6 and are applied to its control grid through R_5 and R_6. One end of R_5 is returned to R_{13} as shown. A potential of about 48 volts is developed across R_{13} and serves as the negative bias which maintains the thyratron in a nonconducting condition until a positive firing pulse arrives.

Sweep Length Control

The first section of V_7 is supplied with square waves from V_4, the frequency of these square waves being equal to the frequency of the 3-phase generator. The square waves are amplified by the first section of V_7 and then differentiated by C_7 and R_{17}. The resulting pulses, both positive and negative, are applied to the grid of the second section of V_7. Since one end of R_{17} is connected to R_{13}, the grid of the second section of V_7 is biased well beyond cutoff except when a positive pulse arrives. Since the positive pulses are about 150 volts in magnitude, the second section of V_7 is forced to conduct fully during the time the pulses are applied. This current flow through V_7 charges the combination of C_8 and R_{20} to a voltage the average of which is determined by the frequency of the pulses. Resistor R_{22} and capacitor C_9 serve to filter the voltage appearing across R_{20}, resulting in a smooth d-c voltage that is almost exactly proportional to the frequency of the pulses, or in other words, proportional to engine rpm. The time constant of this filter is about two seconds. The values R_{19} and R_{21} are so proportioned as to prevent the voltage between the cathode and heater of V_7 from exceeding 100 volts, which is the limit specified by the tube manufacturer. With this arrangement it has been found that the d-c voltage appearing across C_9 is virtually independent of variations in the tube characteristics.

The purpose of tube V_8 is to amplify the voltage appearing across C_9. By properly choosing the values of the components used with V_7 and V_8, it has been possible to make the voltage at the plate of the second section of V_8 almost exactly proportional to engine speed over a range of speeds from 1,000 to 3,000 rpm, and it is this voltage that controls the sweep length. This effect is accomplished as follows: the voltage at the plate of V_8 is applied through R_7 to capacitors C_5 and C_6. Assuming these capacitors to be uncharged at the start, they will charge through R_7 in the usual exponential manner. The voltage appearing across C_5 and C_6 is applied to the cathode-follower circuit of the second section of V_5. The output of this cathode follower is used to drive the sweep amplifier consisting of tubes V_9 and V_{10}, the plates of which are connected to the horizontal deflection plates of the cathode-ray tube. Two capacitors C_5 and C_6, provide the fast and slow sweep speeds mentioned above. When the fast sweep is desired only C_5 is used, whereas when the slow speed is needed, switch S_2 is closed, adding C_6. The velocity of the sweeps is inversely proportional to the value of capacitance in the circuit. Because only the linear initial portion of the exponential charging characteristic is required to effect the complete sweep from left to right, the sweep speed is nearly uniform and proportional to the voltage appearing at the plate of the second section of V_8, which in turn is proportional to engine speed. Thus the sweep speed is proportional to engine speed and, since the time for one sweep is inversely proportional to engine speed, it follows that the trace length will remain constant even though the speed of the power plant varies.

As the capacitors charge and the sweep reaches the end of its travel, the engine completes the two revolutions started at the time the sweep was initiated, and the thyratron V_6 is fired by the pulse discussed earlier. The thyratron discharges C_5 and C_6 through current-limiting resistor R_8 and the process of charging repeats; thus a linear sawtooth sweep voltage is generated. Since it is desirable to be able to adjust manually the actual length of the sweep that is to be maintained by the automatic control, resistor R_{25} is provided. By adjusting the potential of the grid of the second section of V_8 at some convenient engine speed, the plate voltage of that tube is set to give the desired length at that speed, after which the automatic action compensates for higher or lower speeds.

Horizontal centering of the entire trace is accomplished by adjusting R_{26}.

It should be noted that the components comprising the sawtooth generator, cathode follower and sweep amplifier were chosen so that: (1) the minimum voltage ever appearing on C_5 and C_6 at the end of the sweep would be sufficient to insure reliable firing of the thyratron when the pulse arrives; (2) the maximum voltage ever appearing on C_5 and C_6 would not cause excessive current to flow through the thyratron; (3) the maximum energy ever appearing on C_5 and C_6 would be low enough that it could be dissipated by V_6 and R_8 in a time that is very short compared to the shortest sweep time; (4) the sweep voltage applied to the cathode-ray tube would be linear under all conditions; (5) the maximum voltage between the cathodes and heaters of V_5, V_9 and V_{10} would never exceed 100 volts; and (6) the maximum ratings of all components would not be exceeded under any condition.

The power supply used in this apparatus is conventional.

The focus and intensity of the cathode-ray tube are adjusted by R_{14} and R_{15} respectively.

Typical Results

The results obtained by use of the engine analyzer can best be shown by means of photographs of the cathode-ray screen while the analyzer was in operation.

Figure 4 (A through E) shows ignition patterns as they appear under various engine conditions. Space does not permit a detailed discussion of each photograph; however it has been possible to explain nearly all the patterns in terms of the electrical parameters of the ignition system. These photographs apply to a high-tension system, and while the corresponding patterns for a low-tension system are somewhat different in form, they too can be analyzed and used in the identification of faults. While only photographs showing normal ignition, fouled plug, open secondary, and breaker-point bounce have been included, numerous other patterns are available showing such conditions as shorted secondary, large plug gap, small plug gap, shorted primary capacitor, no combustion, and magneto mistiming. Breaker-point bounce, (Fig. 4D) shows a pattern almost exactly like the one for normal ignition, except for the sharp pip near the end of the trace indicating that the points bounced open at that time after closing an instant earlier.

Figure 4E shows a typical normal cylinder vibration pattern. It will be noted that there are four distinct points at which the vibration rises to values considerably higher than the rest of the pattern. Counting from the left, these points represent (1) the closing of the exhaust valve; (2) the injection of the fuel; (3) closing of the intake valve; and (4) vibration due to combustion. When any of these cylinder events become abnormal, the particular portions of the pattern change greatly in magnitude. Thus when a cylinder detonates (knocks) the combustion portion of the pattern increases in height considerably. With a little practice, one can distinguish at a glance nearly any vibration abnormality.

Acknowledgment

The author wishes to acknowledge the helpful suggestions given him in the writing of this paper by J. W. Wheeler and R. W. Brown of the Engineering and Publicity departments, respectively, of the Sperry Gyroscope Co., and to thank Charles Plate of the Sperry Design department for his work in preparing the illustrations.

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Space-Charge Tetrode Amplifiers

Performance of developmental space-charge audio output tetrodes is compared with that of 6K6 pentodes, 6V6 beam pentodes, and 45 triodes in push-pull output stages of high-quality amplifiers. Developmental tubes not only outperform other types, but also require less costly components and simpler circuits

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In the August 1947 issue of Electronics W. S. Brian described a space-charge grid power output tube that he had developed. In cooperation with Brian, a number of tests were made in which the performance of these tubes in a high-quality amplifier was compared with that of some standard tubes. It is the purpose of this article to report the results of these tests.

An amplifier was constructed in which provision was made for changing the output tubes, everything else remaining the same. Four sets of output tubes were tested—the 6K6 as representative of a pentode, the 6V6 as a beam tetrode, the 45 as a triode, and the new space-charge tubes under discussion. The 6V6 and the 45 were used, rather than the 6L6 and 2A3, because their power capacity is of the same order as that of the space-charge tubes available.

The standard type tubes were quite well matched; the space-charge tubes were quite badly mismatched, one tube having about twice the power output of the other. This circumstance was accidental, having arisen from the fact that two tubes of the better type were not available among the experimental models constructed. Therefore, the results for the space-charge tubes, while significant, are by no means optimum.

The nominal rating of the space-charge tubes used was 2 watts per tube. Since these tubes are operated strictly as class-A amplifiers, the push-pull amplifier was rated at 4 watts. The 6V6 tubes are rated in the tube manuals at 14 watts under the conditions used in these tests, 6K6's at 9.8 watts, and the 45's at 12 watts. In these experiments, even when allowance was made for the losses in the output transformer, the pentodes and beam power tubes failed to deliver rated power.

Measurements were made on all four amplifiers of both harmonic and intermodulation distortion versus power output. The optimum load resistance was first determined experimentally and that value used for the measurements. In the case of the three standard tubes, the load resistance thus determined agreed very closely with the published values. The push-pull, space-charge-tube amplifier gave the greatest power at the lowest distortion with a plate-to-plate load of 20,000 ohms.

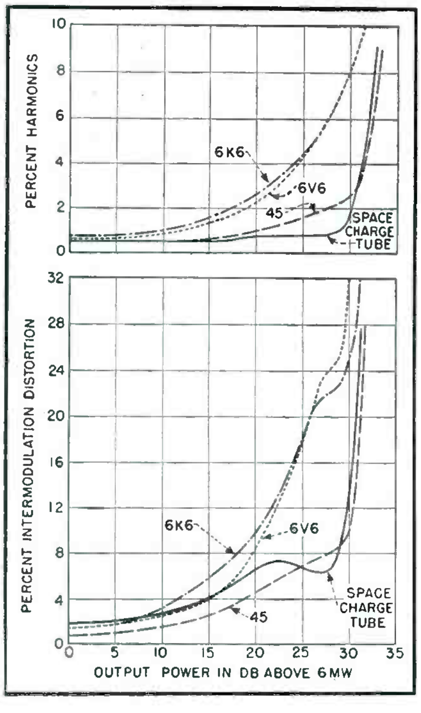


FIG. 1—Harmonic and intermodulation distortion versus output for resistive load

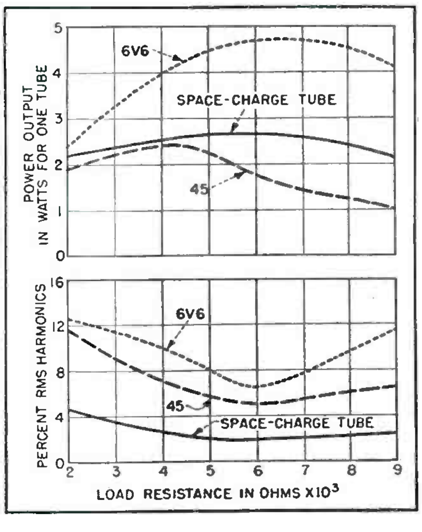
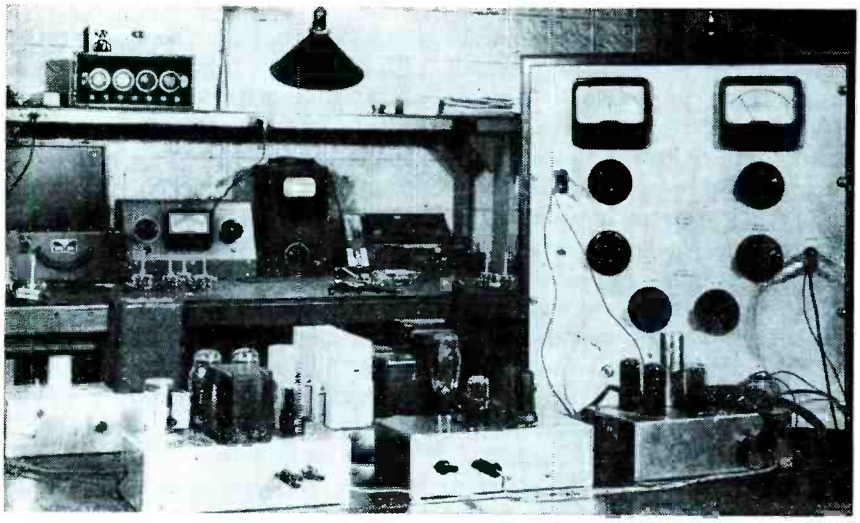


FIG. 2—Power output and harmonics show less variation for space-charge tubes



Three amplifiers undergoing comparison tests

Harmonic distortion was measured at 300 cycles by means of the high-pass filter method. The filter used to remove the fundamental had an attenuation of 60 db at 300 cycles, and less than 1 db at 600 cycles and above. The harmonic content was indicated on a vacuum-tube voltmeter reading rms volts. No attempt was made to analyze the harmonic content of the output waveform. Since the filter and vacuum-tube voltmeter were both flat to well above 20kc, it was assumed that all significant harmonics were included in the summation.

Intermodulation was measured on a Pickering Model 502 Intermodulation Distortion Meter. In this instrument, measurements are made at 100 and 7,000 cycles, with the low-frequency signal 12 db above the high-frequency signal. The percent intermodulation is specified as the degree of modulation of the 7-kc carrier after the low frequency has been filtered out.

It is felt by some engineers that harmonic distortion and intermodulation distortion measurements give essentially the same results, and therefore that there is no point in making both measurements. It is true that with a complete wave analysis and hours of laborious computation the intermodulation in an amplifier can be predicted. A simple harmonic distortion measurement, however, cannot indicate anything about the intermodulation, since the latter is dependent on the order as well as the magnitude of the harmonics.

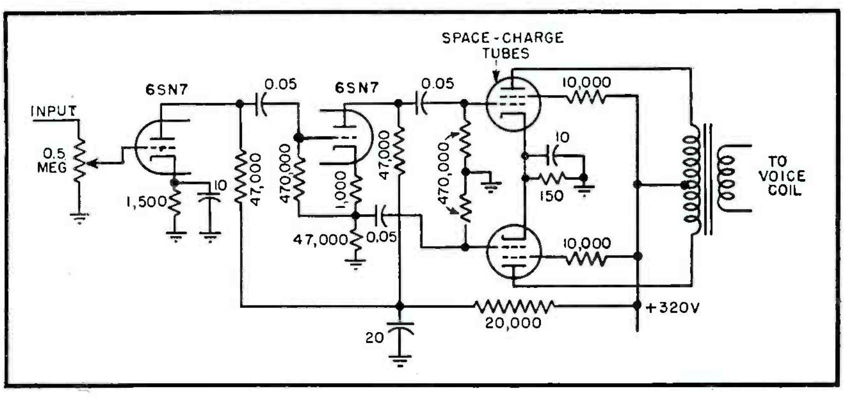
A word should be inserted here about the permissible limits of harmonic and intermodulation distortion for good quality amplifiers. For many years 5 percent harmonic distortion has been accepted as the tolerable limit for good amplifiers. This limit was found to be far too lenient for even medium-quality equipment, especially that using beam-power or pentode tubes, since 5 percent harmonics from these tubes is much more objectionable than 5 percent harmonics from triodes. Instead, it seems more practical to define a fair-quality amplifier as one having 2 percent total harmonics and 10 percent intermodulation, and a good amplifier as having 2 percent harmonics and 5 percent intermodulation. Judged by these ratings, many commercial amplifiers look pretty feeble.

Figure 1 shows the curves for harmonic distortion and intermodulation distortion in the four types of tubes. The bumps in the curves for the space-charge tubes are caused by the mismatch of the two tubes. It must be emphasized that these curves were plotted with the tubes working into a resistive load, with each pair working into its own best load resistance. To evaluate the performance of the amplifier working into a reactive load, such as a loudspeaker or cutting head, more extensive tests were made.

Comparison of Tubes

Characteristics of the four types of tubes used in these tests are given in Table I. Several interesting conclusions emerge from this comparison. Dynamic plate resistance, transconductance, amplification factor and plate supply voltage are listed merely to describe the tube and its condition of operation. The design engineer will find greater interest in the fifth heading, which shows that the drain on the power supply is greatest with the space-charge tubes. However, since these tubes are strictly class-A amplifiers, there is no rise of plate current toward full power output, the quiescent plate current being the maximum plate current; in the three other types of amplifier there is a plate current rise of from 10 to 30 ma at full power output. This plate current variation necessitates a power supply having fairly good regulation. The supply to the space-charge tubes can have a fairly high impedance without appreciable detrimental effect upon performance.

The ultimate power output repre-



Simplicity and low cost are features of this high-quality space-charge tetrode amplifier sents the power that the load connected to the tubes must withstand in the event of accidental overload. Much more significant is the grid voltage required to obtain this power. Here the triodes compare badly, while the space-charge tubes are found to be even better than the pentodes and beam tubes, which are notably easy to drive.

The efficiency of an audio amplifier has been defined as the ratio of the power output with 5 percent harmonic content to the d-c power input.

The figures for power output at a given percentage of harmonic distortion are greatly at variance with the published literature on the standard tube types. These measurements were carefully made, and all recommended operating voltages adhered to very closely. It is felt that these conditions often prevail in practice regardless of the results obtainable in the tube laboratory.

At low values of harmonic distortion, the space-charge tubes are about twice as good as the triodes. The others are not even close to this standard of performance. However, from the intermodulation standpoint, the triodes are about 1 db better which indicates that the small amount of harmonic distortion in the space-charge tubes is of a higher order.

The figures for practical efficiency are rather remarkable, because they show the triode to be the most efficient.

The effective amplification highlights the weakness of the triodes, and also brings out the astonishing fact that the 6V6 with an amplification factor of 230 provides a useful gain of only 13.3. The space-charge tube, on the other hand, realizes a net gain of 16.6 with an amplification factor of 20. This is another advantage of low plate resistance.

The effective generator impedance, or damping factor, is a most important characteristic of a power amplifier that is used to drive a loudspeaker. This impedance should be low because the electromagnetic damping of a loudspeaker depends on circulating currents through the generator impedance. Furthermore, it is desirable, when working into a reactive load, to develop as nearly as possible a constant voltage. To satisfy this requirement would demand a zero-impedance output stage, which is ordinarily impossible. In practice, however, a generator impedance equal to the nominal load resistance is satisfactory; a generator impedance less than this value is even better. The effective output impedance was measured by first observing the open-circuit voltage and then loading the amplifier until the voltage was reduced 6 db, or 50 percent. At this point the load resistance and generator impedance are equal.

Table I shows that the effective generator impedance is five times the load resistance for the beam-power tube, four times for the pentode, only 80 percent for the triode, and 50 percent for the space-charge tubes. This property of the space-charge tube makes the bass response cleaner and free from hang-over. It also prevents the voltage rise at high frequencies which is characteristic of the pentodes and beam-power tubes. It is primarily to obtain this damping effect that negative feedback is used with the latter types of tubes. To obtain the same damping effect with the 6V6 tubes which is inherent in the space-charge tubes 20 db of feedback is required.

Practical Amplifiers

Three complete amplifiers were constructed using push-pull 6V6's, 45's and space-charge tubes. Every effort was made to make each of the amplifiers of as high quality as possible. A great deal of difficulty was experienced with the driver stage for the triode tubes. It was found impossible with ordinary voltage-amplifier tubes to drive the grids of the output tubes with a resistance-coupled phase inverter or even a resistance-coupled amplifier stage without having the driver overload before the output tubes did. Therefore, transformer coupling was used, adding considerably to the cost of this amplifier. Experience indicates that overloading of the driver is a common problem in triode amplifiers.

The output-transformer primary inductance is in shunt with the load, and at low frequencies increases the loading on the amplifier tubes. This effect reduces the amount of useful power applied to the load, and in the case of the triode and beam-power tubes, substantially increases the distortion at low frequencies. Figure 2 shows the manner in which power output and distortion varies with load for the three types of tube. The ability of the space-charge tube to ignore variations in

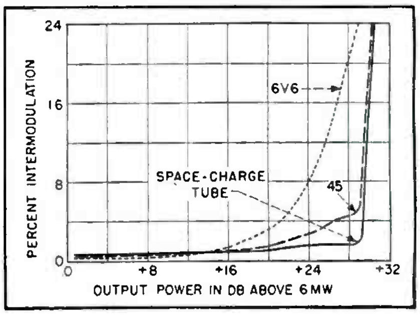


FIG. 4—Intermodulation distortion as a function of power output is shown for three amplifiers

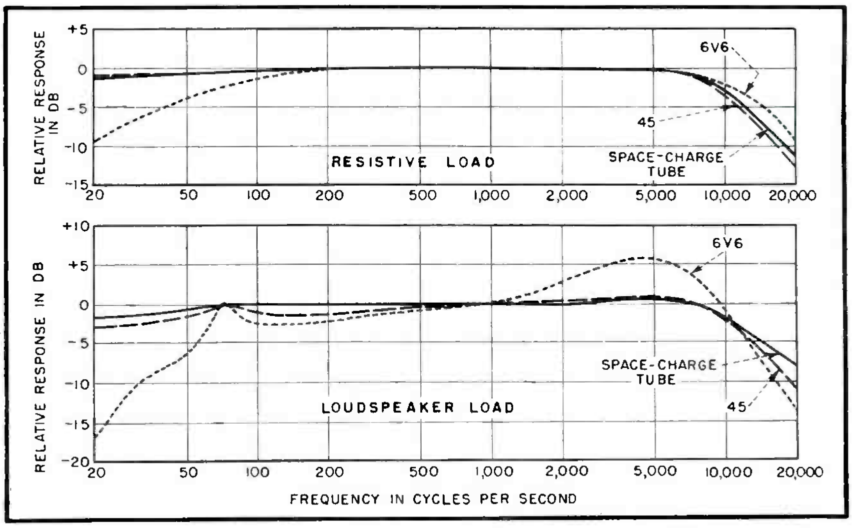


FIG. 3—These frequency response curves were obtained from amplifiers using three types of tubes with both resistive and loudspeaker loads

load impedance is an important advantage. No more primary inductance in the output transformer is required for the space-charge tubes than for the triodes. A value of 10 henries is quite adequate for response within 1 db to 30 cycles. The beam-power tubes, on the other hand, require at least twice the inductance for equivalent bass response into a resistive load. For the same core structure, the transformer for the space-charge tubes will have the same number of primary turns and half the number of secondary turns as the triode transformer. This construction will reduce the cost of labor and materials, at the same time reducing the I^2R losses in the secondary winding and reducing the leakage reactance. This is a case where something is had for nothing.

The measured frequency response of the three amplifiers with both resistive and loudspeaker loads is shown in Fig. 3. The same output transformer was used on all three amplifiers, the secondary taps being changed to match the various load impedances. The primary inductance was 15 henries, which is more than necessary for the space-charge and triode amplifiers, and less than desirable for the beam power tubes. The effect of a low generator impedance when working into a loudspeaker load can be seen clearly.

In order to conduct listening tests with any degree of similarity between pairs of amplifiers, it was necessary to equalize the 6V6 amplifier so that it had about the same high frequency response as the other amplifiers. This was accomplished by connecting a 10,000-ohm resistor in series with a 0.05-μf capacitor from plate to plate of the 6V6 tubes. Little could be done about the low-frequency peak.

Another effect which showed up when switching from one amplifier to another was an apparent change in relative volume at low and high levels. When all amplifiers were adjusted for the same loudness at low levels, the space-charge amplifier sounded louder at high levels. Conversely, when adjusted on loud passages to the same loudness, the 6V6 amplifier was loudest at low levels. Measurements showed that the 6V6 amplifier departs from linearity almost 10 db below its peak voltage input. The space-charge tubes, on the other hand, are linear to within about 3 db of maximum input. The triodes depart from linearity somewhere between these levels. Naturally, this effect is closely related to distortion, because a nonlinear device is by definition both a harmonic generator and modulator.

Table I—Comparison of Tube Characteristics

Tube Type	6V6	6K6	Space Charge	45
Dynamic plate resistance R_p at quiescent operating point, ohms	65,000	75,000	4,000	1,700
Transconductance g_m at quiescent operating point, micromhos	3,600	2,100	5,000	2,050
Amplification factor μ $(R_p \times g_m)$	230	150	20	3.5
Plate supply voltage E_b	285	285	325	325
Total cathode current I_c, milliamperes	74	62	110	92
Total d-c power supplied to tubes, $(E_b \times I_c)$ watts	21.2	17.7	35.7	29.8
Optimum load resistance R_L, ohms	8,000	12,000	20,000	5,000
Ultimate power output, watts	12.5	8.5	11.0	13.5
Peak grid-to-grid volts for ultimate power output	42	54	36	150
Power output at 5 percent harmonics, watts	2.4	2.4	10.7	12.0
Power output at 2 percent harmonics, watts	0.32	0.50	6.6	3.8
Power output at 10 percent intermodulation distortion, watts	0.76	0.61	4.8	6.0
Efficiency as a-f amplifier, percent	11.3	13.5	30.0	40.0
Gain—actual amplification, $\mu R_L/(R_L + R_p)$	13.3	11.1	16.6	2.6
Effective generator impedance, ohms, 500 ohms load	2,500	2,000	250	400

It is interesting to examine the intermodulation distortion of the three amplifiers with loudspeaker load, shown in Fig. 4. Observe that the space-charge tubes, because of their ability to work well into a load of variable impedance, show the lowest intermodulation percentages. The triodes are very nearly as good, but the 6V6 tubes are considerably worse.

Comparison of Amplifier Costs

To perform as well as the triodes and the space-charge tubes, the 6V6's require at least 20 db of feedback. For this feedback, an additional stage of amplification is required and careful attention must be paid to phase shift within the feedback loop. In addition to these expensive modifications, the circuit requires a costly output transformer having a frequency range far in excess of the useful passband, in order to prevent oscillation. There is the additional point that the same amount of feedback applied to an amplifier using space-charge tubes will improve it by the same factor.

The expense of the driver stage makes it difficult to construct a low-cost amplifier using triodes, even though the output transformer is less expensive than that for the beam power tubes.

Since inverse feedback is hardly necessary with the space-charge tubes, a high-quality amplifier can be built that is capable of supplying full power output over a wide frequency range from a grid input signal of 30 millivolts. Such an amplifier would need only three stages including the output tubes. Savings in the power supply result from reduced heater-winding capacity on the power transformer, and a reduction in the amount of plate-supply decoupling necessary. A suitable output transformer could be made for a retail price of about four dollars. The retail cost of the parts required to build a completely satisfactory amplifier, flat within 1 db from 30 to 15,000 cycles, with intermodulation of less than 5 percent at 10 watts, is less than twenty-five dollars, including tubes and power supply. The only drawback at present is the fact that the tubes are not yet available. It is hoped that they will be in production before too long.

Sensing element of the leak detector, a diode of unusual design employing positive ion rather than negative electron emission and operating in air

Leak detector with supersensitive nose, one example of an instrument utilizing a long-neglected principle to simulate another of man's senses

Electronics Simulates Sense of Smell

Platinum, heated to incandescence, freely emits positive ions in air and does not readily oxidize. Emission is increased when halogen vapor compounds, of which Freon and carbon tetrachloride are good examples, are present. Use is made of this principle to detect leaks

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THE SCIENCE of electronics has provided instruments which, in a practical way and to a remarkable degree, give responses similar to the human senses. Examples of this are the microphone, which performs like the ear; the loudspeaker and its similarity to the voice; the phototube and the eye, and a number of instruments equivalent to the sense of touch.

The sense of smell, as the human nose operates in air, has to date not been well duplicated, although for certain specialized cases very sensitive detectors[1] have been developed. The device to be described is thermionic in its nature and is sensitive to a large variety of halogen compound vapors and air-suspended particles. It thus extends man's ability to simulate the sense of smell.

Engineers working with electron tubes understand negative electron emission. On the other hand, the emission of positive ions from a red-hot metal is not as well known, and little use has been made of this phenomenon.

Unlike electrons, which are simply basic units of negative electricity, ions are positively charged particles of some specific substance.

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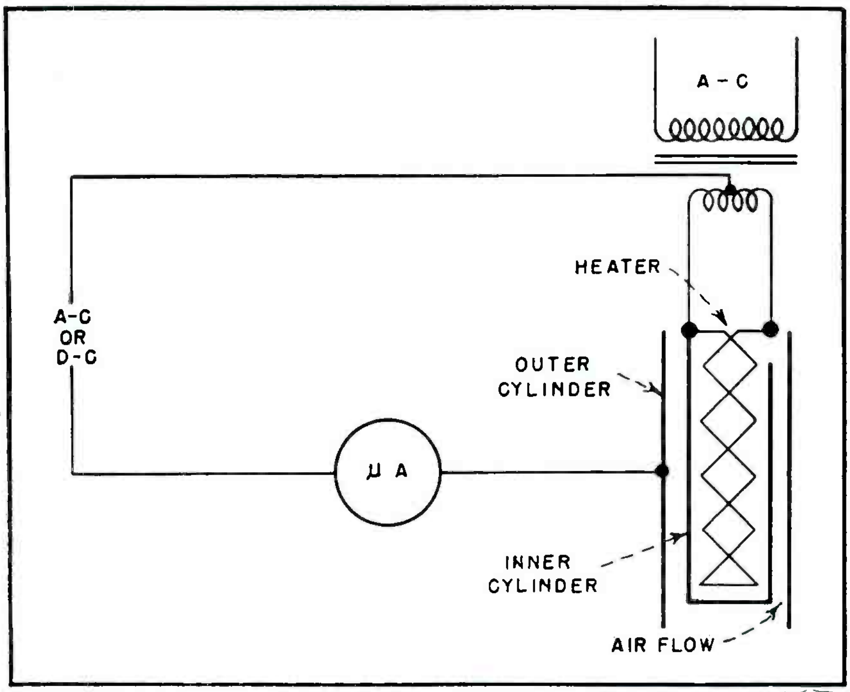

FIG. 1—Basic circuit of the new device

In general, emission of ions means a loss of material from the cathode emitting them. One unique feature of ion emission, however, is that it can be made to occur readily in the air.

Owing to the fact that platinum can be operated at a red heat with little oxidation and loss from evaporation, this metal is very useful as an ion-emitting source. The volume of ion emission from platinum varies greatly, depending upon temperature, area and nature of the surface, and purity of the metal. Ion emission current drops slowly with time, eventually reaching, however, a small but finite equilibrium value.

Twenty-five to fifty years ago, some scientific work was done on this phenomenon[2], but with the coming of electron tubes in their evacuated, sealed envelopes conduction in air was neglected for the newer, more intriguing, and simpler phenomenon of electron emission in a high vacuum. When early reports on conduction in air are studied it is soon realized that the experimental results obtained were very conflicting and the theories contradictory. In part this was due to the fact that electrical conduction through air is more complicated than in a high vacuum. There was also a less developed experimental technique available to early workers.

Operating Principle

It has been found by C. W. Rice that the steady emission of ions in air is increased to a marked extent when certain vapors strike the electrode surfaces. In the presence of even a small amount of a halogen compound vapor there is a marked increase in ion current. There is also a marked increase in current when suspended particles, such as smoke, containing a halogen compound contact the electrode surface.

Thus the essential elements of a halogen compound vapor detector, shown in Fig. 1, are:

(1) A two-element sensing structure, one suitable arrangement being in the form of concentric cylinders. The vapor to be detected is passed between these two closely spaced cylinders. The inner cylinder or cathode is kept red hot by an internal platinum-wire heater and the outer cylinder or anode is operated at a negative potential.

(2) A means of forcing air containing the vapor to be detected between the cylinders at a constant low velocity.

(3) Low-voltage a-c for the heater and another supply delivering a few hundred microamperes at somewhere between 50 and 500 volts a-c or d-c for use as the interelectrode potential.

(4) Sufficient amplification to make a small increase in d-c current due to ion emission variation readily detectable.

General Characteristics

One of the characteristics of the device under operating conditions is the small amount of current that flows even in the presence of pure dry air. This current is usually of the order of 1 to 10 microamperes. In the presence of an air-diluted vapor of a chemical element or compound to which the device is sensitive this current will increase several fold.

Sensitivity to a halogen compound vapor varies with the velocity of air flow between the two cylinders. With an air flow of the order of one inch per second or less there is an extreme sensitivity to some vapors of about one part in a million. With an air flow of more than one foot per second the sensitivity and response are reduced to a point where there is little response.

The device is very sensitive to carbon tetrachloride, chloroform and Freon (dichlorodifluoromethane). At room temperature it does not respond to Pyranol (chlorinated phenol) but, if the Pyranol is heated to 60 C or more the vapor

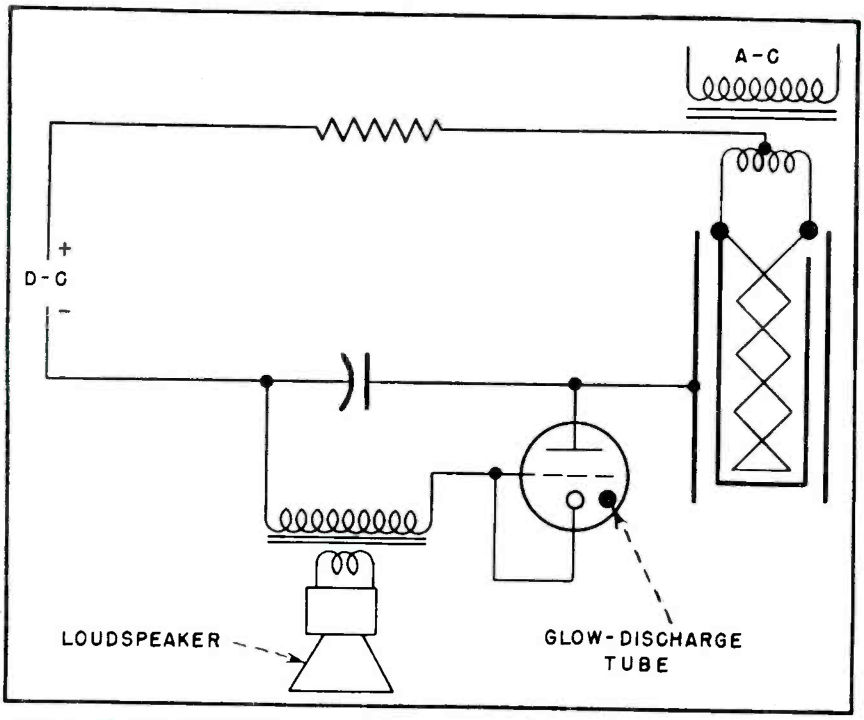

FIG. 2—Method of producing an audible response when the leak detector encounters halogen vapor compounds, or solid particles containing them, in the air

pressure becomes sufficiently high to give a response. It also responds to solid particles of the iodides, chlorides, bromides and fluorides. Therefore, it detects smoke from burning materials containing such compounds.

The detector is suitable in its present form for exposure to vapors, provided this exposure is limited to a relatively short time. If the sensing element is exposed to a halogen vapor for too long a time, or to a too highly concentrated vapor, it may lose its sensitivity. Long operation at full temperature in a current of pure air and with voltage between electrodes will restore its sensitivity if the contamination has not been too great. If the contamination has been too great it may be necessary to clean or replace the electrodes. The ease of contamination varies greatly from one compound to another. For instance, carbon tetrachloride contaminates the electrodes more easily than Freon.

If the sensing element has been hot for some time in the absence of an interelectrode voltage a heavy transient current flows when voltage is applied. The time taken to return to normal is dependent upon the time the element has been hot. A similar transient rush of ion current occurs if the interelectrode voltage is interrupted momentarily and then reapplied.

The device is quite sensitive to variations in air flow. If the air flow is too rapid then the vapor apparently has only limited opportunity to strike the hot cathode and dissociate. The sensitivity of the device therefore decreases as the air flow is increased. Part of the decreased sensitivity is also due to the additional cooling of the cathode with the increased air flow. On the other hand, if the air flow is at too low a rate the device will be extremely responsive to vapors to which it is sensitive but considerable time will elapse before the current returns to its normal no-vapor condition even after the inlet is again given a supply of pure air.

The response of the sensing element increases markedly with temperature over a narrow range. Below approximately 850 C, the emission current is too small to be easily utilized, and over approximately 950 C it becomes unstable and random fluctuations will hide any signal.

It is necessary to keep the space between the electrodes free from dust, cotton lint, or other particles that may be sucked in by the air flow. Such particles would short-circuit the electrodes and give false indications. It is usually desirable to filter the incoming air.

Indicating Methods

There are several ways by which the increase of current due to exposure to a vapor may be indicated. The simplest is by means of a microammeter or a galvanometer. Another method is to utilize the change in voltage across a high resistance to operate an amplifier which in turn operates a relay.

A third method is to add a relaxation-type of circuit incorporating a capacitor and glow-discharge tube, with a loudspeaker as an indicating element, as shown in Fig. 2. The current through the sensing element builds up a charge in the capacitor. When the voltage is sufficiently high the glow-discharge tube operates and the pulse of current resulting from the discharge of the capacitor produces a click in the loudspeaker. The repetition rate of the clicks is an indication of the amount of current passing.

With any circuit used, it is desirable to include a protective resistor to prevent injury to the sensing element and indicating device resulting from an overdose of vapor or a short circuit between electrodes. This may be of the order of 100,000 ohms.

Use as a Leak Detector

The device is very convenient for detecting leaks in pressure systems of tanks, pipes, valves and flanges. In the case of a refrigerating system utilizing one of the Freon compounds under pressure, the operation consists of moving the intake nozzle of the unit near spots where a leak is suspected. For other closed systems a little Freon or other suitable halogen compound vapor is introduced as a tracer gas and air pressure is applied.

It is believed that this device will find wide application in industry due to the many products which must be made free from leakage before being used. Many other uses of the principle are anticipated.

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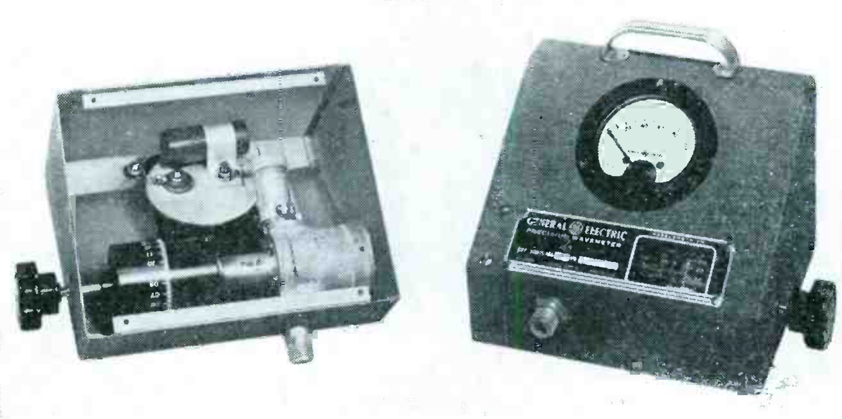

Postwar re-entrant line short-circuit type of wavemeter for use in the frequency range from 8 to 12 cm, as described below

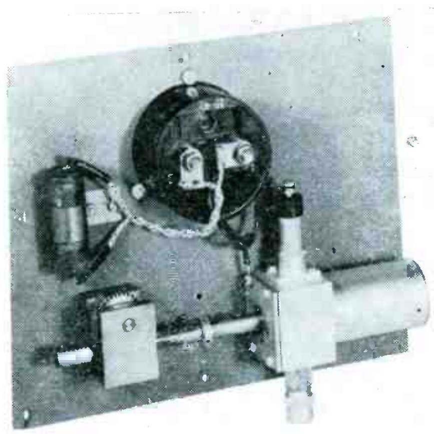

FIG. 1—A 5 to 30-cm searching wavemeter with finger contact to inner conductor

Direct-Reading WAVEMETER DESIGN

Construction details of direct-reading wavemeters for the range from 2 to 75 cm (15,000 to 400 mc). Theory behind maintaining linearity of wavelength-change-to-conductor-displacement is given for cavity devices of finger-contact and re-entrant line short-circuit type

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THE development of wavemeters for use in the centimeter-wavelength range was accelerated after 1939, before which Lecher wires were probably in greatest use. Development of resonant coaxial transmission line and resonant wave guide cavity types followed.

All forms of the Lecher wire wavemeter require that two or more observations of resonance be made and that the distance of motion of a short-circuiting bar or plunger between points of resonance be measured to get data from which the signal wavelength can be calculated. A 5- to 30-centimeter searching wavemeter was developed to replace the various forms of Lecher wire device in order to conserve space and man-hours.

The back-panel appearance of the direct-reading 5- to 30-cm searching wavemeter is shown in Fig. 1. The device will agree with a primary standard of wavelength of frequency within 0.1 cm and will repeat a reading made using a crystal-controlled signal source within 0.05 cm.

A cross-section of the resonant cavity of this wavemeter is shown in Fig. 2. A coaxial transmission line resonator operates in its quarter-wave mode. Finger contacts are used on the inner conductor, the length of which is adjustable by means of a rack and pinion. The visual indication of resonance is obtained by converting a small amount of microwave energy to direct current with either a thermocouple or a crystal rectifier and applying it to a d-c microammeter. An input of approximately 20 milliwatts is required for full-scale deflection with a thermocouple and approximately one milliwatt when a crystal rectifier is used.

In order to obtain better accuracy and precision in another equipment, the size and shape of the contacting fingers were chosen to cause a minimum departure from a linear characteristic over a range from 30 to 75 cm. In addition, the coupling loops were adjusted to give uniformly good sensitivity over the whole range together with a characteristic sufficiently linear to allow the direct reading scale to be guaranteed accurate to within 0.5 percent.

In order to increase the effective

scale length, the wavelength dial is rotated nearly two revolutions. The slope of wavelength versus conductor displacement was adjusted so that one set of graduations could be used with two sets of color-coded numerals. The correct scale is indicated by a colored target near the upper left edge of the dial.

Shielding for Accuracy

Experience with the 5- to 30-cm wavemeter showed a need for shielding against extraneous fields. Any r-f voltage induced in the nominally d-c path between crystal and microammeter is rectified to give a deflection. A combination bypass capacitor and instrument connection, together with grounding the input coupling and tuning shaft to the case, provided adequate shielding in the vicinity of high r-f fields.

A design similar to that of the 5- to 30-cm wavemeter has been made for the 2- to 8-cm range with the scale direct reading to within 0.05 cm between 3 and 8 cm.

Precision Wavemeters

An early form of laboratory wavemeter built for the dual purpose of investigating the characteristics of quarter-wave resonators as wavemeters of high precision in the 8- to 12-cm wavelength band and of measuring the output spectra of magnetron oscillators is shown in Fig. 3. Since the existence of discrete narrow spectra was suspected, a vernier tuning control shown at

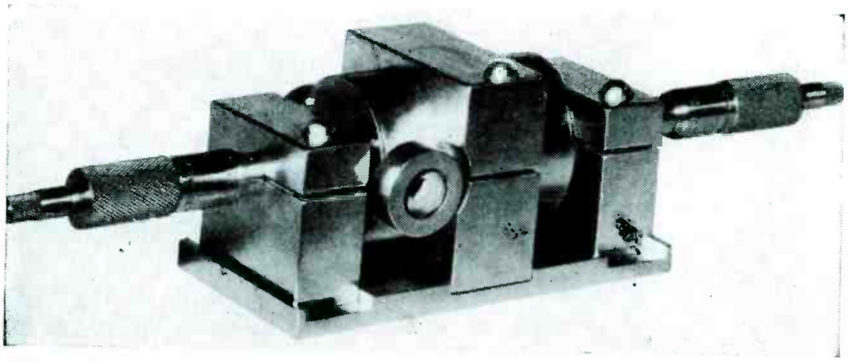

FIG. 3—A developmental 8 to 12-cm precision wavemeter with conductors for coarse and fine tuning

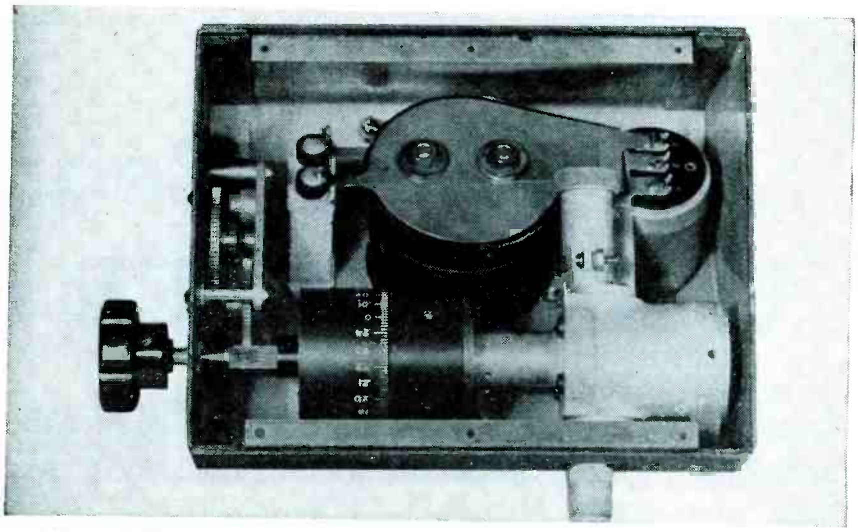

FIG 4—Field type precision wavemeter. Indicating meter is at upper center

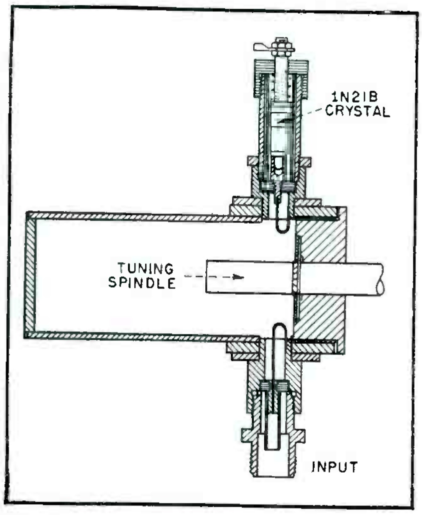

FIG. 2—Cross-section of 5 to 30-cm searching wavemeter

the right was included. However, the main tuning control proved adequate and tests showed that the resolution obtainable with a coaxial resonator employing a silver-plated micrometer spindle as adjustable center conductor was sufficient for all but the most specialized measurements in the 8- to 12-cm range.

Quantitative analysis and test of the performance of this laboratory wavemeter provided guidance in the design of wavemeters for field use. Improvements were made in the coupling loops, the contact between the micrometer-head mounting plate and the body of the wavemeter, the contact between the mounting plate and the micrometer spindle and in the body of the wavemeter itself. The measuring equipment had good sensitivity, full scale deflection for approximately 1 milliwatt input, and a wavelength versus displacement characteristic linear within 0.05 percent over the wavelength range of 8 to 12 cm. Positive low resistance contact is necessary both between the micrometer-head mounting plate and the body of the wavemeter as well as between the mounting plate and the micrometer spindle. It was found that the stiffness of a wavemeter body made of standard brass tubing was inadequate. Changes as great as 0.03 percent in tuning were caused by pressure on the clamp that held the body to the base.

In field wavemeters satisfactory contact between the micrometer-head mounting plate and the body of the wavemeter resulted from the combination of silver plating both parts and turning a lip approximately 0.005 inch high on the body of the wavemeter at its inner edge.

A satisfactory contact between the mounting plate and the micrometer spindle was obtained by making the micrometer spindle of sterling silver and the finger contacts of silver-plated phosphor bronze or beryllium copper. Motor driven accelerated wear tests indicated that a year of trouble free performance could be expected from this combination. However, the re-entrant transmission line type of short-circuit which is described below is superior to the finger-type contact in having low manufacturing cost and more uniform and stable electrical characteristics.

Adequate stiffness in the wavemeter body has been obtained by means of a sturdy bronze casting, silver plated for high conductivity, shown in Fig. 4. This casting is securely bolted to the sloping panel to provide a sturdy mount for the input jack, output coupling loop, crystal rectifier unit, and tuning control.

Re-entrant Short Circuit

One of the most valuable features of the field type precision wavemeter is the re-entrant transmission line short circuit between inner and outer conductors of the resonator, shown in cross-section in Fig. 5. This accomplishes the same purpose as the finger contacts of earlier designs but without a mechanical contact between conductors of the main resonant cavity. The re-entrant portions of the cavity are proportioned so that the reactance at the input to the re-entrant line is zero at some intermediate wavelength in the band. At other wavelengths, the reactance is small in proportion to that of the main cavity. The rotating joint between micrometer spindle and head is at a low current point, so that the effect of this variable resistance contact on the wavemeter performance is negligible.

This design has resulted in an ideal working condition for the micrometer screw, since there is no load on the spindle. The construction provides a close approximation to the ultimate in uniformity and stability of both electrical and mechanical characteristics.

Further features of the field-type precision wavemeter are the direct-reading wavelength scale, accurate within 0.1 percent and resettable within 0.002 centimeter, and the combined shielding and bypassing that protect the wavemeter from strong radio-frequency fields and prevent responses to other than the impressed signal.

The appearance and construction of a postwar 8- to 12-cm precision wavemeter for general laboratory use is illustrated on the first page of this paper. Comparison with Fig. 4 will show that the gear-stop and sensitivity control of the field type have been omitted and that a less expensive bypass capacitor has been used across the microammeter, but that the primary structural and shielding features have been retained. The electrical characteristics of the two wavemeters are identical. Many of the benefits that accrue in designing for field use are not visible, but require a comparative study of the designs developed here and in England.[1] It is believed that the use of friction to hold the positions of the drum, the thimble, and the extension piece fixed relative to the spindle is indication that field use was considered secondary during the British development. The use of a 0.002-inch clearance for a distance of from $\frac{1}{3}$ to $\frac{3}{4}$ inch in the noncontacting plunger type also points in the same direction.

It is interesting to note the differences in electrical design, also. In the designs described herein the cavity beyond the end of the adjustable inner conductor has been chosen to be below cutoff for all operating wavelengths; whereas in the British design, the cavity is in the pass band for operating wavelengths. This difference apparently resulted from considering the direct-reading feature more important than width of tuning range while developing these designs.

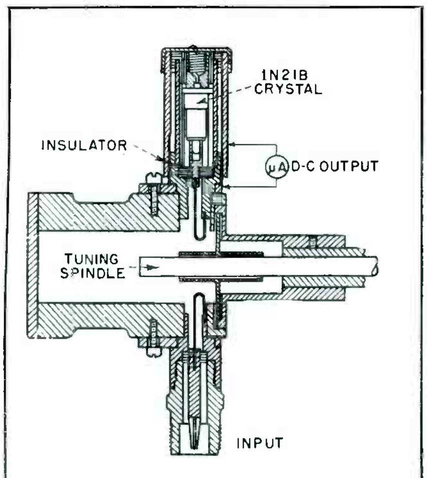

FIG. 5—Cross-section of re-entrant transmission line short circuit type

A 12- to 17-cm precision wavemeter operating on the same principles as those for the wavelength range 8- to 12-cm has the same quality of performance as detailed in Table I.

The precision type wavemeters are unusually well adapted for field service where extreme conditions of temperature, humidity, high-power radio-frequency fields in and out of the wavemeter range, vibration and shock are encountered. For example, the micrometer heads have been lubricated with a special oil which allows free movement at −60 C and yet does not evaporate at 50 C. Extensive use of these wavemeters for several years has shown that the wavelength calibration is maintained well within the 0.1 percent specification.

The devices have also been used as power indicators without modification, as receivers after connecting an audio amplifier across the crystal rectifier, and even as tunable band-pass filters after removing the crystal rectifier and connecting directly to the output loop.

Theory

The most important property of direct-reading wavemeters is the linearity of wavelength change to conductor displacement. The underlying theory of this property is presented below for those wavemeters employing finger contacts and those with a re-entrant transmission line short circuit.

It is an experimental fact that properly designed wavemeters having a resonator of the type shown in Fig. 6A have the property that a one centimeter increase in the length of the center conductor changes the fundamental resonant wavelength by four centimeters. It may at first seem obvious that this is the case, since the wavemeter is resonant in its quarterwave mode. Actually, however, the line is considerably shorter than a quarter wavelength because of the end-loading capacitance of the inner to outer conductor. This foreshortening may

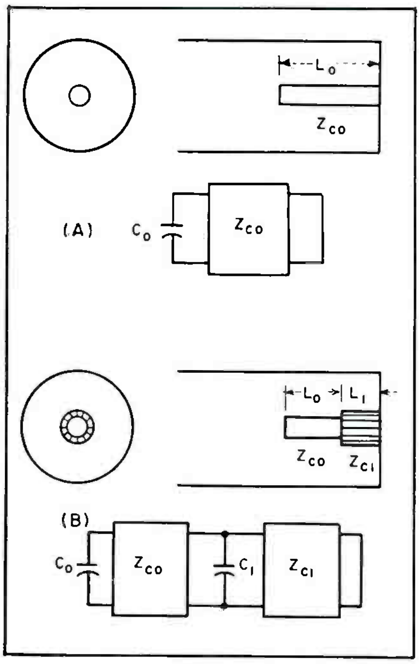

FIG. 6—Cross-section and equivalent circuit (A) of finger-contact type and (B) re-entrant type wavemeter

be as great as 18 percent of the quarter wavelength, and yet the rate of change of wavelength to conductor displacement is within 1 percent of the four-to-one relation.

It is difficult to make a good disc-type electrical contact of the kind needed in the resonator although such a contact was used in the early designs. The cylindrical type shown in Fig. 6B has been used in more recent designs requiring finger contacts because of its simpler construction. Resonators having a contact of this kind depart from the four-to-one relation and are not linear over the complete range of extension of the center conductor, but can be made direct reading within a fraction of one percent over a two-to-one wavelength range.

The resonator of Fig. 6A is a special case of that shown in Fig. 6B, the analysis of which is given below. The equivalent circuit for the latter consists of two cascaded sections of transmission line of characteristic impedances Z_{c1} and Z_{c0}. The former is short-circuited at its input end, and the latter is terminated in an equivalent end-loading capacitance C_0, representing the effect of the fringing field between the end of the center conductor and outer conductor. A capacitance C_1 is added to account for the step in the center conductor.[2]

The electrical length $\theta_0 = \beta L_0$ of the extensible portion of the center conductor can be related to the frequency and constants of the circuit. Referring to Fig. 6B, resonance will occur when the reactance of the parallel combination of line L_1 and fringing capacitance C_f is the conjugate of the reactance of line L_0 terminated in the equivalent discontinuity capacitance C_0.

The input reactance of line L_1 is

$$X_{L1} = Z_{c1} \tan \theta_1$$

where Z_{c1} *and* θ_1 are the characteristic impedance and electrical length, respectively of line L_1.

Combining with the capacitive reactance $X_{c1} = 1/\omega C_1$,

$$X_1 = \frac{X_{L1}\, X_{c1}}{X_{c1} - X_{L1}} = \frac{(Z_{c1} \tan \theta_1)\,(1/\omega\, C_1)}{(1/\omega\, C_1) - Z_{c1} \tan \theta_1}$$

The input reactance of line L_0 terminated in the capacitance C_0 is

$$X_2 = -\frac{1/\omega\, C_0 - Z_{c0} \tan \theta_0}{1 + (1/\omega\, C_0\, Z_{c0}) \tan \theta_0}$$

where Z_{c0} and θ_0 are the characteristic impedance and electrical length, respectively, of line L_0.

The condition for resonance, $X_1 = -X_2$, gives for θ_0 the relation

$$\tan\theta_0 = \frac{\dfrac{X_{c0}}{Z_{c0}} - \dfrac{Z_{c1}}{Z_{c0}} \tan \theta_1 \left(\dfrac{C_1}{C_0} + 1\right)}{1 - \dfrac{Z_{c1}}{Z_{c0}} \tan \theta_1 \left(\dfrac{Z_{c0}}{X_{c1}} - \dfrac{X_{c0}}{Z_{c0}}\right)} \qquad (1)$$

The relation for the special case of Fig. 6A is obtained from Eq. 1 by setting $\theta_1 = 0$, in which case

$$\tan \theta_0 = \frac{X_0}{Z_{c0}} = \frac{1}{\omega C_0 Z_{c0}} = \frac{\lambda}{2\pi v C_0 Z_{c0}} \qquad (2)$$

where v is the velocity of propagation and λ the wavelength in cm.

If it were possible to eliminate end-loading so that $C_0 = 0$, the electrical length θ_0 would be 90 degrees. The magnitude of the effect of end-loading capacitance can be seen from Fig. 7, in which values of θ_0 are plotted for a wavemeter operating in the 8- to 12-cm range.

Of more importance is the expression for the rate of change of conductor displacement with wavelength, which can be found by differentiating the expression for the length L_0 of the extensible line.

$$L_0 = \theta_0/\beta = (1/2\pi)\,(\theta_0 \lambda)$$

$$\frac{dL_0}{d\lambda} = \frac{\theta_0}{2\pi} + \frac{\lambda}{2\pi}\frac{d\theta_0}{d\lambda} \qquad (3)$$

The second term is obtained from the expression for $\tan \theta_0$,

$$\frac{d\theta_0}{d\lambda} = \frac{1}{D}\left[\frac{dN}{d\lambda} - \frac{N}{D}\frac{dD}{d\lambda}\right] \cos^2\theta_0 \qquad (4)$$

where N is the numerator and D the denominator of Eq. 1.

For the case in Fig. 6A, the expression for the rate of change of wavelength to conductor displacement reduces to

$$\frac{dL_0}{d\lambda} = \frac{\theta_0 + 1/2 \sin 2\,\theta_0}{2\pi} \qquad (5)$$

Let

$$\theta_0 = \frac{\pi}{2} - \epsilon$$

Then

$$\sin 2\,\theta_0 = \sin\,(\pi - 2\epsilon) \cong 2\left(\epsilon - \frac{2}{3}\,\epsilon^3\right) \qquad (6)$$

for $\epsilon < 0.5$ radian.

Therefore,

$$\frac{dL_0}{d\lambda} \cong \frac{1}{4} - \frac{\epsilon^3}{3\pi} \qquad (7)$$

The percent deviation from a

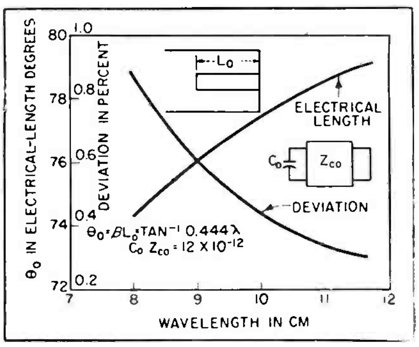

FIG. 7—Electrical length and deviation from the 4-to-1 slope in a finger-contact wavemeter

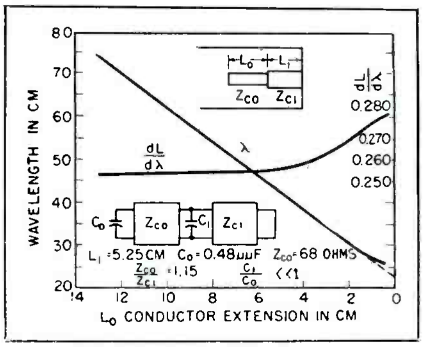

FIG. 8—Resonant wavelength versus conductor extension and slope for a re-entrant type wavemeter

4-to-1 slope has been calculated from Eq. 7 and plotted in Fig. 7 for the 8- to 12-cm range.

When the projecting type of contact is used, the rate of change is no longer four to one. The slope versus wavelength for a 30- to 75-cm wavemeter, and conductor length versus wavelength, have been plotted in Fig. 8. This wavemeter employed a contact line 5.25-cm long. The ratio of characteristic impedances Z_{c0}/Z_{c1} was 1.15. A reduction in the length of the contact line to 3.2 cm made the characteristic linear to within ± 0.5 percent over the range of 30 to 75 cm.

A cross section of a cavity type used in the 8- to 12-cm and 12- to 17-cm wavemeters is shown in Fig. 9. The main part of the cavity consists of two transmission lines, one having the variable length AB as inner and MN as outer conductor, the other having JK as inner and LM as outer conductor. The former line is terminated in a fringing capacitance from A to the outer conductor; the latter line is shorted by the plate KL.

The re-entrant portion of the cavity consists of the short-circuited line HI, GF, and the line CD, FE. The two parts of the cavity are connected by the choke line BC, JI. The center conductor rotates in its bearing at point D, this being the only point of mechanical contact between the outer shell and center conductor. The electrical quality of this contact is not important, since it is at a low current point relative to the current in plate KL.

An equivalent circuit for the cavity can be drawn, showing the interconnection of the five different transmission lines having characteristic impedances Z_{c1}, Z_{c2}, Z_{c3}, Z_{c4}, Z_{c5} and the discontinuity capacitances. The capacitance C_{02} represents the fringing capacitance from the end of the center conductor to the shell. Capacitances C_1, C_{12}, C_{03}, C_{13}, C_4, C_5 are those associated with the discontinuities at the junctions of the various transmission lines. These capacitances can be calculated from the dimensions.[2]

The following procedure is followed in calculating the wavemeter characteristic. The reactance appearing between terminals S and T due to the combination of networks 1, 3, 4, and 5, where each network consists of a transmission line and associated discontinuity capacitances, is calculated, ignoring losses. The electrical length of line of characteristic impedance Z_{c2} necessary to give the conjugate reactance across these two points is then determined. This calculation is carried out for several wavelengths over the band of operation to obtain the characteristic of extension AB versus wavelength. Matrix formulation simplifies the procedure of calculation.

The equivalent circuit can also be used to calculate other properties of the resonator. The ratio of current I_{05} in the rotating joint at D to current I_{01} in the short-circuiting plate KL is of importance in the design. Distribution of loss in various parts of the cavity and the Q value of the resonator can also be calculated.

Table I gives values of slope of wavelength versus conductor displacement, $\Delta\lambda/\Delta L$, current ratio I_{05}/I_{01}, Q, and loss distribution for a 12- to 17-cm cavity.

Table I—Characteristics of 12- to 17-cm Wavemeter Calculated From Equivalent Circuit

λ	$\Delta\lambda/\Delta L_2$	I_{05}/I_{01}	P_1	P_2	P_3	P_4	Q
12		0.046	8.8	1.8	11.0	0.10	2250
13.25	3.540						
14.50	3.566	0.073	8.6	3.5	10.3	0.15	2260
15.75	3.550						
17.00	3.555	0.104	8.3	5.3	9.7	0.22	2280

$\Delta\lambda/\Delta L_2$ = slope of wavelength versus conductor displacement
I_{05}/I_{01} = ratio of current through rotating joint to maximum current
$P_{1,2,3,4}$ = power loss in various portions of cavity shown in Fig. 9
Q = Q—factor of overall resonator

In order to make the wavemeter direct reading, utilizing a standard micrometer screw thread, a slope of $\Delta\lambda/\Delta L = 3.543$ was required. The dimensions of the cavity were varied in initial trial calculations until the following series was obtained in which all dimensions are the same except the diameter of the center conductor of line L_1.

diameter (inches)	$\Delta\lambda/\Delta L$ (average)
0.320	3.58
0.330	3.55
0.340	3.53

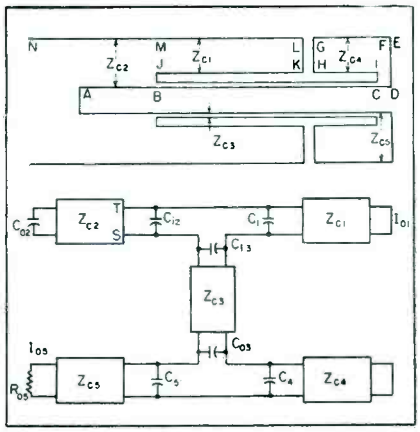

FIG. 9—Equivalent circuit for re-entrant type wavemeter

The experimental value of average slope for the final design with a diameter of 0.330 inch was 3.536. The calculated value is in error by less than 1 percent. The experimental value is somewhat affected by the coupling loops, so that better agreement could hardly be expected.

It should be pointed out that the analysis is valid only for loose coupling, since over coupling can greatly change the calculated characteristics.

Acknowledgement

The authors take this opportunity to acknowledge P. E. Hosegood's contribution of the expanded scale feature to the precision wavemeters, F. J. Moles' development of the 5- to 30-cm and 2- to 8-cm searching wavemeters, and E. D. Cook's encouragement during the course of these developments.

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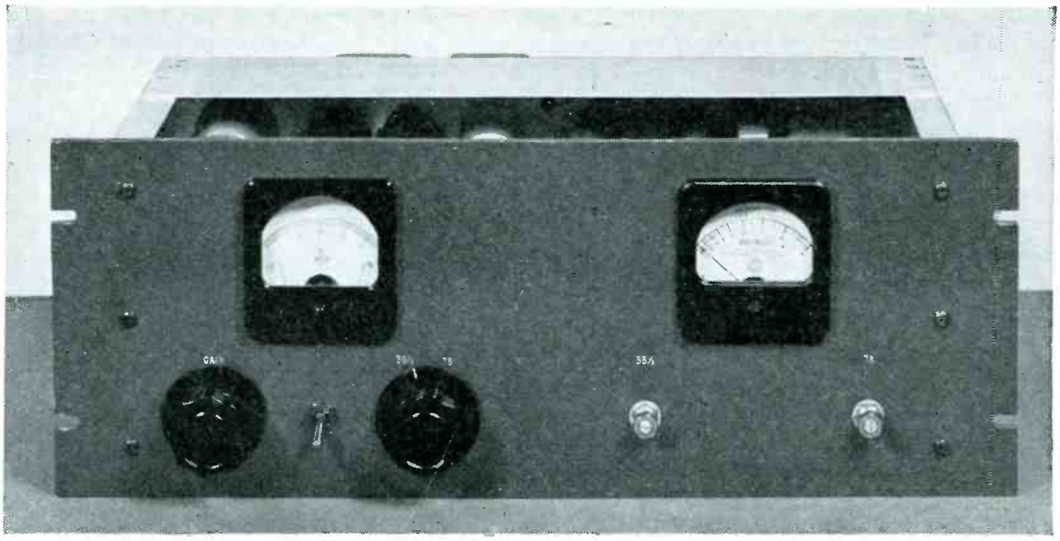

Electronic equipment used with the turntable tone generator

WOW METER for Turntable Testing

A toothed wheel rotating between two pickup coils connected for maximum output generates a tone. Output is fed through a peak clipper to a discriminator and rectifier. Instantaneous speed variation is shown directly on a calibrated meter

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IN DISC RECORDING a common but annoying fault in reproduction is instantaneous speed variation of the turntable commonly called wow. Everyone is familiar with the discordant quavering of sustained piano or bell tones that are encountered in the reproduction of phonograph music. This is the direct result of turntable speed variation.

Wow can be detected by the listener when it occurs at a relatively low cyclic rate. One to three cycles per second in variation of frequency at 1,000 cycles seems to give the most noticeable wow at that frequency. The amount of wow that is detectable varies with frequency. A small amount is noticeable at high frequencies but only larger amounts at low; that is, a larger percentage of variation in frequency is tolerable when a low frequency is being reproduced.[1] In general, three-tenths of one percent instantaneous speed variation is the maximum that can be tolerated at any frequency without introducing noticeable frequency change in the reproduced tone.

Causes of Variation

There are a number of reasons for wow in turntables and these may be classified by the type of drive used.

In the rim-driven turntable eccentricity of the spindle, oval shape of the turntable, line frequency or between the spindle and the surface of the turntable, line frequency or voltage fluctuation, as well as variations in friction of any part of the driving mechanism during a portion of a revolution result in wow. In the spindle-driven turntable, out-of-round shaping of the turntable does not cause wow, but eccentricities in the driving gears or an eccentric spindle drive contribute to wow. Again, nonuniform bearing friction, variations in line frequency and voltage, and any inaccuracies in the drive mechanism

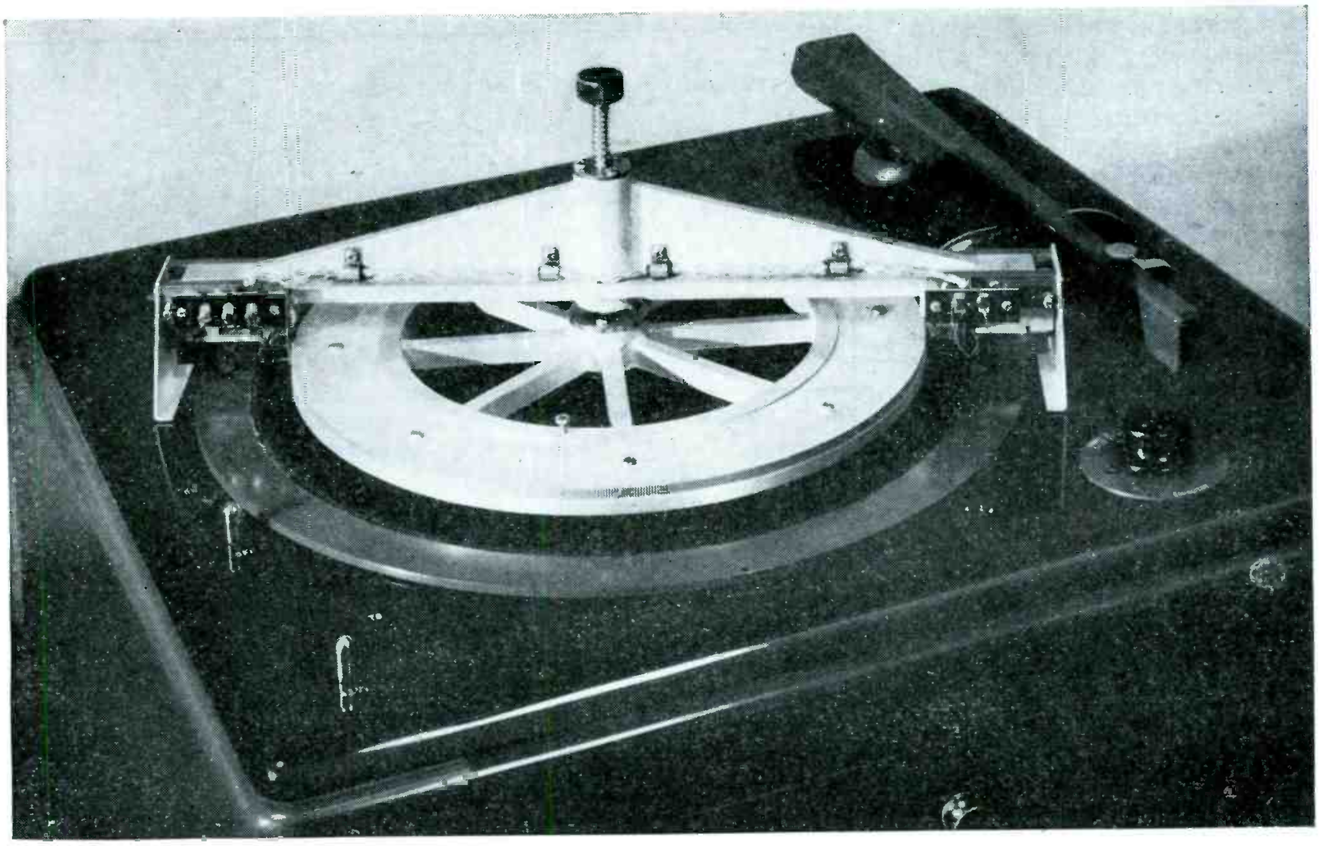

FIG. 1—Toothed-wheel tone generator centered on the turntable

tend to produce speed variation. Another factor that is somewhat difficult to control on the spindle-driven turntable is mechanical damping of the mechanism as the turntable is started. Frequently the turntable comes up to speed and overshoots slightly, then oscillates about the desired speed for a short time before it settles down to its constant-speed operation. In both types of turntable, variation in groove amplitude of the record causes a variation in torque that results in instantaneous speed variation if the drive motor does not have sufficient power or if the inertia of the turntable and its associated mechanism is not sufficient to carry through the momentary periods of greater torque requirements. This effect is similar to the problems involved in the design of a flywheel to maintain a required stability.

Since the requirements for constancy of speed in the phonograph turntable are so rigorous, it is important that a convenient means be devised for measuring instantaneous speed variation.

There are a number of methods by which the wow of a turntable might be measured.

Testing Methods

A method that comes to mind immediately is the familiar stroboscopic disc which is viewed in a 60-cycle light source. By observing the position of the dots or lines on the disc as the turntable is rotated, it is possible to check the average speed of the turntable. This method, however, is not practical for checking the instantaneous speed variation with an accuracy which is necessary in order to have a quantitative measure of turntable performance. It is true that the stroboscope disc does show up variations in turntable speed in the advancing rotation or reverse rotation of the virtual marks of the stroboscopic disc; but the motion is not easily measured because it ordinarily varies at a rate equal to that of turntable rotation. Since this method necessarily involves visual inspection, the observer errors are large.

Another method is to play a constant-tone record on the turntable using a conventional pickup, amplifier, and a frequency measuring system. There are a number of reasons why this is not entirely practical except as a rough approximation. This system must necessarily include any wow which is present in the original recording. It also includes wow contributed by any eccentricity of the record owing to off-center stamping of the blank or clearance in the center hole. These contributions to instantaneous frequency variation may add to or subtract from that present in the turntable being tested.

Another suggested means is to use a purely mechanical differentiating speedometer to measure instantaneous speed variation. This would be a rather difficult mechanical problem because the mechanism of the wow meter itself must be better at all times than the mechanism of the turntable. Building any measuring device to measure to within one-tenth of one percent is a major design problem. The differentiating speedometer must contribute no friction to the turntable itself and it must have low inertia so that it does not reflect into the turntable a speed variation which is not present normally.

The most practical means by which the instantaneous speed variation of a turntable can be measured seems to be the method suggested by H. E. Roys[2] in which a gear blank is cut with a suitable number of teeth so that by using magnetic pickup from the teeth a convenient tone is generated. This tone is fed into an amplifier and a frequency measuring circuit that operates a meter indicating the instantaneous speed variation. A gear is admirably suited for the generation of a constant tone because it is possible to machine the teeth accurately so that the errors in tooth spacing contribute very little to the error of measurement. The centering of the gear can be accurately maintained because the inside framework is constructed of metal as shown in Fig. 1.

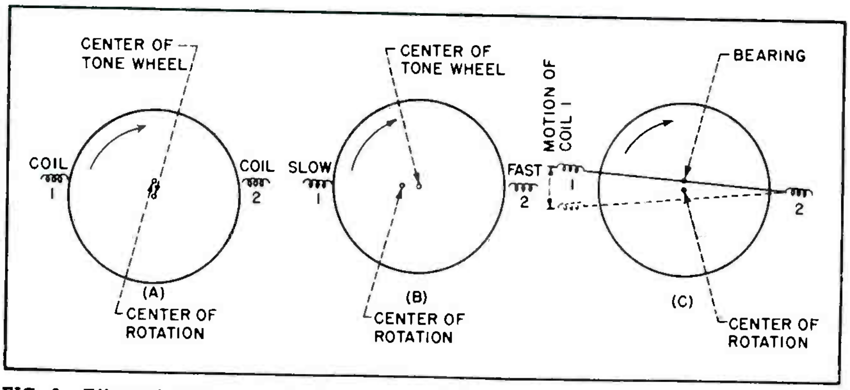

FIG. 2—Effect of wow on a single pickup coil (A and B) and upon a pair bearing on the center of the tone wheel (C)

Gear Dimensions

The gear wheel is cut from a plate of cold-rolled steel and mounted on an aluminum wheel having its center at the center of the turntable. The gear has a pitch diameter of 13.750 inches, and a diametral pitch of 56, giving an output of 1,004 cps at 78 rpm and 427 cps at 33⅓ rpm. A center-drilled shaft brings about alignment of the centers of the tone wheel and the turntable record-centering pin. Three screws are used for leveling the wheel on the turntable so that the pole piece of the pickup coil is in horizontal alignment with the teeth of the tone wheel.

At first thought it might seem that a single magnetic pickup from the tone wheel would be satisfactory. This, however, is not true. A single pickup coil would introduce a variation in tone generated by the gear itself owing to eccentricities that might be present. This effect is shown in Figs. 2A and 2B, in which the center of the tone wheel and the center of the turntable do not coincide. With the turntable and the tone wheel in the position 2A, the peripheral velocity at coil 1 is equal to the average speed of the turntable, while at 2B it is seen that because of the decreased radius the peripheral velocity adjacent to coil 1 is lower than the average. At coil 2 the velocity and hence the tone is higher than the average.

This effect suggests the spacing of two pickup coils at diametrically opposite points in the circumference of the tone wheel, so phased that a double voltage is obtained. Assuming a sinusoidal voltage from the coil (the output is actually very close to a sine wave), then the voltage from coil 1 is $E_{max} \sin(\omega t + \theta)$ and the voltage from coil 2 is $E_{max} \sin(\omega t - \theta)$ where θ is a variable which varies throughout the revolution. The two expressions for the voltage output from the pickup coil are seen to be phase modulated and the voltage from either of the coils would therefore result in an erroneous answer from any simple form of indicating circuit. If the two voltages are added together the sum is $2E_{max} \sin \omega t \cos \theta$. This operation demonstrates that the phase modulation drops out, leaving an amplitude term $\cos \theta$. Thus by using two coils an output voltage is obtained, the frequency of which is directly proportional to the speed of rotation of the turntable.

Originally, for the sake of convenience, the pickup coils were suspended on a bearing at the center of the tone wheel with one end of the pickup coil assembly prevented from rotating with the turntable by abutment with a fixed stop. In Fig. 2C is shown the result of having the pickup coil assembly eccentric with regard to the center of rotation of the turntable. If coil 2 is fixed in space, coil 1 oscillates between the solid and the dotted positions indicated in Fig. 2C, resulting in a variational output that is not balanced out even through the addition of the two coil output voltages.

The coils are made from number 30 wire, scramble wound, approximately 1,500 turns. A pole piece of cold-rolled steel projects through the pickup coil and is magnetically coupled to a permanent magnet of the type used in a moving coil meter and to the teeth of the gear. The exact magnetic structure of the pickup coil assembly is not important, since a satisfactory output is obtained with no difficulty.

Centering the Assembly

At the center of the assembly is a tapered centering shaft that is pressed down to engage with the center hole of the tone wheel so that the pickup coil assembly is properly positioned. Upon release of the centering shaft, the pickup coil assembly is supported at its extremities from the surface of the turntable cabinet. Adjusting screws are provided so that the pole pieces and pickup coils can be shifted slightly to obtain maximum voltage from the system. A maximum voltage is secured when the two coils are in corresponding positions with regard to gear teeth, giving an output voltage from each coil so phased that they combine additively.

Electronic Components

A wow meter developed by the writers for production testing of transcription turntables is built for mounting in a standard speech rack and is selfcontained except for the power supply. Provision for checking the turntables at both 33⅓ and 78 rpm is included. At the left of the instrument (illustrated) is a

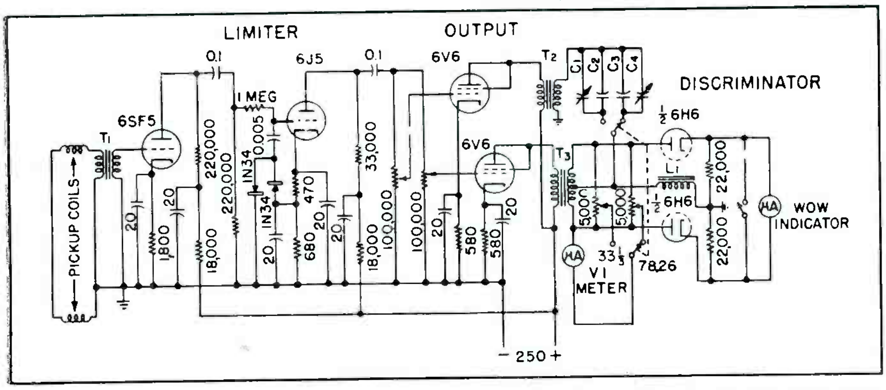

FIG. 3—Schematic circuit diagram of the wow meter. Shorting switch across the indicating meter prevents damage when turntable is started

meter directly calibrated in percent wow. On the right is a volume indicator for establishing the proper level for satisfactory operation. Below the volume indicator are two locking potentiometers for zeroing the volume indicator at both frequencies of operation. Below the wow indicating meter on the left is a meter shorting switch and the master gain control, as well as the 33⅓ and 78 rpm changeover switch.

In the schematic diagram of Fig. 3 may be seen a conventional voltage amplifier upon which no particular effort was expended to secure extended frequency response beyond 1,000 cycles and below 400 cycles. The input transformer matches the output of the pickup coils to the input grid with an impedance ratio of approximately 250 to 30,000 ohms. The first stage of the voltage amplifier uses a high-mu 6SF5 tube. The audio is then fed into a limiter circuit of the biased-diode type using germanium 1N34 diodes. This is in reality a peak clipper in which the diodes are biased with a voltage obtained from the cathode circuit of the second amplifier stage. A series grid resistor of 1 megohm provides a high impedance source so that effective peak clipping occurs whenever the peak a-c voltage exceeds the bias provided by the cathode circuit. The second amplifier stage consists of a 6J5 feeding the two output tubes. Since high frequency response is not required, it is satisfactory to feed the two 6V6 grid circuits in parallel. One 6V6 feeds the push-pull and the other the series portion of the discriminator circuit. A single 6H6 serves as a discriminator rectifier feeding a zero-center microammeter with an undamped movement. Two sets of capacitors, C_1 and C_2 for 33⅓ and C_3 and C_4 for 78 rpm, makes possible a more flexible wow meter for use with both turntable speeds. The variable portions of this tuned circuit C_2 and C_4 are high-capacitance variable ceramic capacitors that are convenient in this application. A volume indicator is connected across the output of one of the 6V6 tubes so that the proper voltage may be fed into the discriminator for satisfactory operation. This meter is switched with the variable capacitors used to tune the discriminator. Two 5,000-ohm potentiometers are used to adjust the volume indicator to zero at the level at which calibration was made. A shorting switch must be provided to protect the meter as the turntable comes up to speed. With a sensitive circuit such as must be used to detect wow of 0.1 percent, excessive deflection occurs with large frequency differences that are present before the turntable reaches its correct operating speed. Without the shorting switch severe pinning of the meter occurs during the starting of the turntable. The resonant circuit of the discriminator must use a high-Q audio coil at L_1 to secure adequate sensitivity. Since the inductance of L_1 varies with the a-c voltage present across it, it is necessary to hold the level into the discriminator at a value corresponding to that which was used during calibration.

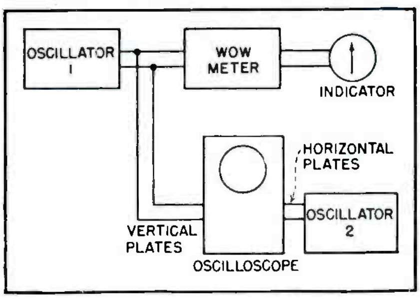

FIG. 4—Method of calibrating the meter by Lissajous figures

Standards of Calibration

The block diagram in Fig. 4 shows a method by which the wow meter can be calibrated. Oscillator 1 is fed into the wow meter and the vertical plates of an oscilloscope, while oscillator 2 feeds the horizontal plates of the scope only. With the two oscillators at the same frequency, the usual circular pattern is observed on the screen.

Before indicating how to measure minute frequency variations accurately, the fundamental relationship of Lissajous figure should be reviewed. The figure seen when there is a slight variation in frequency between the two input voltages applied to an oscilloscope progresses from a circle to a straight line, to a circle to a straight line, and so on. The figure passes through two straight line portions a second for a frequency difference of one cycle a second. By using a stop watch and counting for a period of a half minute or so, it is possible to measure the frequency of the oscillator accurately even to a portion of a cycle a second as is required in practical wow measurements. In a like manner, for each frequency difference at which the meter is to be calibrated the reading of the discriminator is recorded. This plot of readings gives an accurate calibration of the wow meter. By repeating the process it is possible to calibrate the meter to read both at 78 and 33⅓ rpm. Since the microammeter used is undamped, the meter swings up and down scale in synchronism with the wow frequency during the operation of the instrument. The peak wow is half the total deflection plus and minus from the average position of the meter.

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Shoran ground station antenna installation near lighthouse in Caribbean area

Shoran for Surveying

AAF tests indicate that shoran has advantages over ground triangulation and astronomic control for many geodetic survey, photo mapping, and geophysical prospecting jobs. Operating principles, circuits, and application techniques are given

THE shoran (SHOrt RAnge Navigation) system of two ground stations or beacons, together with associated shoran-equipped aircraft, was developed primarily as a precision bombing device. As such it was used with extremely accurate results during the latter phases of the war. Shoran now appears to be one of the few military electronic developments to have practical postwar uses, and is therefore worthy of consideration as a new tool of industry.

Principle of Shoran

A shoran-equipped aircraft carries a transmitter which radiates pulses in alternate groups at two different carrier frequencies. One of the two ground stations is tuned to one carrier frequency and the other station to the remaining frequency. Reception of a pulse from the aircraft causes a ground station to act as a transponder and relay a pulse on a different frequency back to the aircraft, where it is received and displayed, and the distance to that station recorded. Since the ground beacons, called Rate and Drift stations, transmit on a common frequency, the system utilizes three different radio frequencies, all in the neighborhood of 250 mc.

Since radio waves travel in approximately straight lines at 250 mc, the theoretical maximum measurable distance from the aircraft to any one ground station will vary with the height of the plane. This distance varies from about 100 miles with the aircraft at 5,000 feet to about 280 miles at an altitude of 50,000 feet. Maximum separation of the two ground stations is thus from about 350 to 500 miles, depending upon the type of survey.

The airline distances from aircraft to ground are converted to actual point-to-point distances on the ground by mathematical formulas. Estimated probable error with unmodified shoran equipment is ±50 feet.

As a system for accurately positioning an aircraft with respect to two fixed stations, the commercial importance of shoran becomes enormously significant. In the field of geodesy, for instance, it is often necessary to determine accurately the distance between two ground points. Use of shoran for this purpose has been successfully investigated by the 7th Geodetic Control Squadron, 311th Reconnaissance Wing, AAF, and techniques are still under development.

Shoran bombing equipment was not sufficiently accurate for geodesy. Possible sources of error were therefore studied and a knowledge of their magnitude led to more accurate determination and control of system delay times.

The path length of the radio wave traveling between ground station and aircraft is affected by weather conditions. Accurate weather data is consequently obtained and corrections made in the value used for velocity of radio wave propagation.

For surveying with shoran, the aircraft is flown to a previously specified area under the direction of the navigator. The navigator then directs the aircraft on a line perpendicular to one drawn between the two ground stations. The pilot

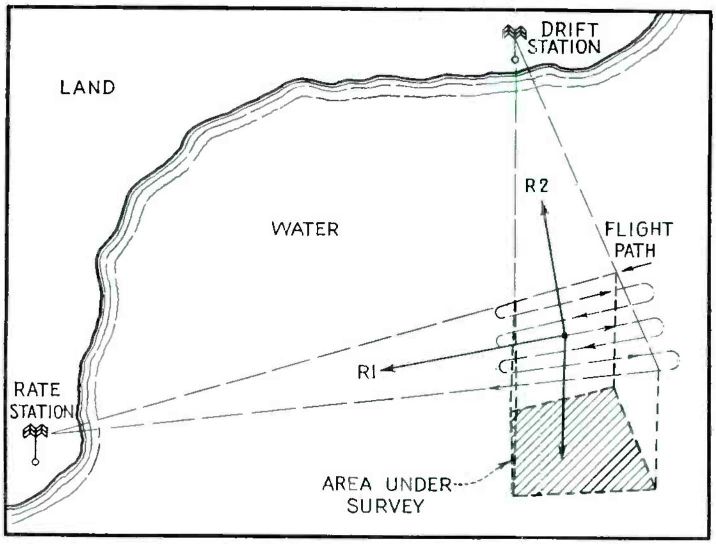

FIG. 1—Use of shoran for aerial photographic surveys. Indicator on aircraft shows airline distance to each ground station, and operator uses this data to determine deviation from desired flight path

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guides the plane on this line with the aid of a PDI (pilot direction indicator). Meanwhile the flight team operates the shoran equipment and the various data recorders. At a predetermined point the pilot turns the aircraft to a new line at an angle of approximately ten degrees to the line between the stations and now controls the aircraft with the autopilot. Necessary data for computations is then recorded on film every three seconds as the airplane continues on course. The plane then starts a crossing in the reverse manner, completing a figure-of-eight path over the center of the line between stations.

Somewhere in the accumulated data appears the minimum air-to-ground distance to the stations. This minimum is determined by fitting a curve to the various consecutive distances plotted against time by a method of least squares.

A complete geometrical figure of five ground station points is flown, measuring all sides and diagonals of the pentagon thus produced. After all network distances are measured and corrected for errors, a further least squares adjustment is made of the entire network, to obtain the most probable set of consistent distances.

Cost of Shoran Surveys

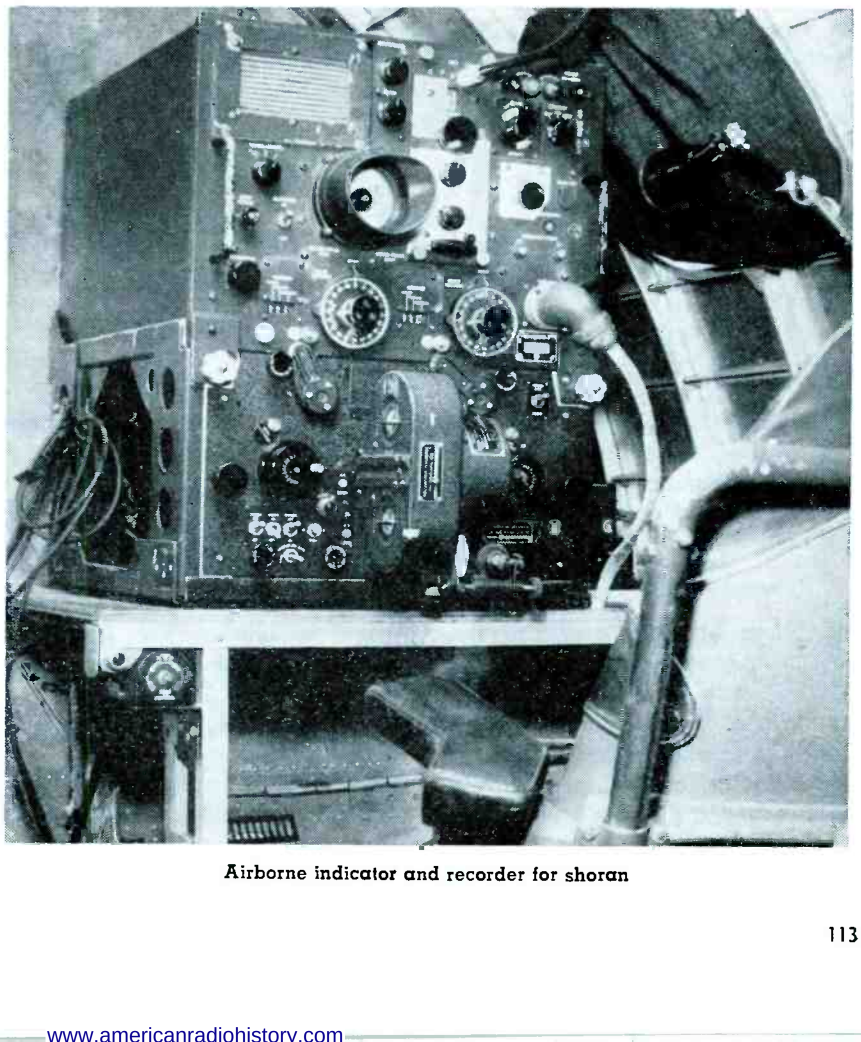
Careful operation of ground station and airborne equipment by qualified technicians, combined with accurate equipment calibration and mathematical computations, has resulted in measured distances comparable to ground survey by usual first-order triangulation methods. Further study and investigation will undoubtedly increase efficiency and reduce operation costs.

Shoran can be used cheaply to make maps up to 1-25,000 in scale, but because shoran stations are so far apart, monumenting of the surveyed area cannot be done. Then again, in island areas where locations between points cannot be seen because of great distance, or where anomalies exist that preclude accurate use of astronomic control, good surveys cannot be made quickly by any other method.

Astronomic control can be used for scales as large as 1-250,000 and no larger. Ground triangulation with monumentation becomes very expensive when the scale is of the order of 1-25,000 or larger.

Perhaps the most general commercial use of shoran is its combination with photogrammetry for aerial surveys and mapping. A possible survey of this type is shown in Fig. 1.

The usual method of photo map-



Airborne indicator and recorder for shoran ping involves taking a series of photographs as the aircraft proceeds along a predetermined course. Successive course lines are flown with about a 60 percent forward lap and a 30 percent side lap of photographs taken. Photo charts are then made from the series of overlapping individual photographs. The resultant chart is only as good as the accuracy with which the aircraft is flown on course.

Using shoran, course lines of the aircraft are plotted in advance, the operational team guides the aircraft along the desired course through the use of the PDI and operation of the shoran equipment, and all necessary data on position and altitude is recorded photographically while map photos are being taken.

Two general types of course lines have been flown. With reference to Fig. 1, consider the aircraft in space at the point shown, with a distance of R1 to the rate station and R2 to the drift station. As the aircraft flies its path, these distances change constantly if the path is a straight line as diagrammed. If the plane were to fly a series of arcs over the given area, one distance from a station would remain constant and the other would vary. In either case a PDI is driven from the shoran equipment to show course deviation. Both types of flight path have been used with success.

Photographs taken with shoran guidance can be used with multiplex equipment to make accurate maps quickly with scales as large as 1-25,000. These maps can be as accurate as any other existing maps of the area if the ground stations are installed carefully and tied to existing monumentation by either shoran or usual ground triangulation methods.

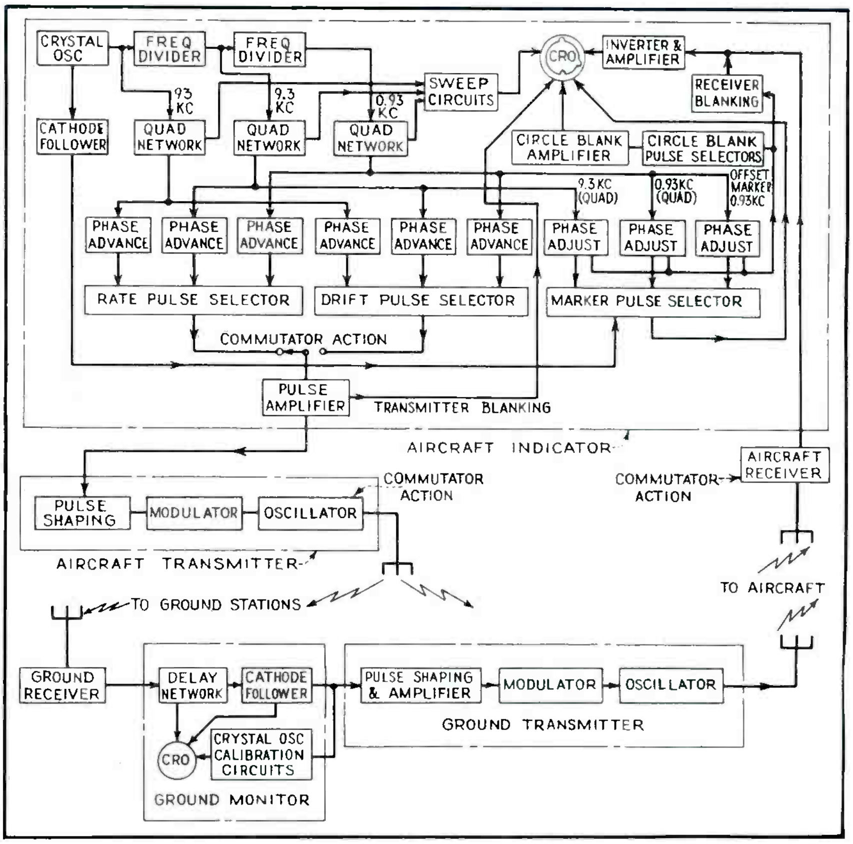


FIG. 2—Simplified block diagram of shoran system as used for aerial surveying

Geophysical Prospecting

Another outstanding wartime device, the magnetic airborne detector (MAD), was developed to locate submarines. This device, used with shoran, an aerial camera, and a radio altimeter, will allow accurate contour mapping or reduce costs of geophysical reconnaissance. The technique therefore has application in the oil and similar industries. Aircraft-locating requirements for magnetic surveys are adequately met by shoran.

The camera used with MAD is a 35-mm Sonne, with image stabilization added, that records a continuous film strip of the terrain. Correlation with the magnetic record is achieved through serial numbers and edge marks on the film. The aircraft is flown on arcs from one ground station through PDI control, and deviations from course are noted on tape. A recording radio altimeter provides continuous information of the aircraft altitude. Resultant magnetic readings can therefore be plotted to a space of approximately a 100-foot cube, and the complete survey made quickly and economically. The value of such a system becomes obvious when otherwise inaccessible areas or water and island areas are considered for survey.

Shoran has also been successfully used in locating the position of ships off shore, providing the distances do not exceed line of sight from antenna to antenna. Thus accurate positioning of the craft is provided, while the desired hydrographic or geophysical surveys proceed with other associated equipment.

Technical Details

The block diagram in Fig. 2 shows the major units in airborne shoran equipment and in one of the two identical ground stations. The associated photo recorder, remote indicator, radio altimeter, and similar devices are not shown for simplicity.

Aircraft Indicator

The aircraft indicator is the heart of the entire unit. It is here that the pulses are generated and recorded, and the distances to the stations shown.

The crystal-controlled tuned-plate oscillator circuit uses a 6AC7 tube with capacitive feedback, tuned to approximately 93 kilocycles. This frequency gives a maximum directly indicated distance of 100 miles; greater distances up to line of sight require appropriate interpretation of indirect readings. The time for a 200-mile round trip of a pulse is 1,074 microseconds, hence the pulse repetition rate must not be greater than 930 pps. Since the final indication is to be a pip alignment on a circular cathode-ray oscilloscope (cro) screen, the sweep frequency should also be 93 kc. Accuracy of alignment is facilitated by two higher sweep speeds, 9.3 kc and 0.93 kc, providing ten- and one-mile ranges.

The crystal oscillator is followed by two regenerative frequency dividers, each of which divides by ten. Referring to Fig. 3, two frequencies beat in the nonlinear 6V6, providing the output at one-tenth the input frequency. The output phase is stable, and correlated with that of the input.

The three sinusoidal output signals of the oscillator-frequency divider chain are fed to three separate quadrature networks, each designed to produce at its own particular frequency two sinusoidal signals of equal voltage, but in quadrature. One set of these signals goes to the sweep circuits, and then to the cro for generation of the circular motion of the luminescent spot at the correct rate for the scale chosen. The other outputs are fed to the variable phase advance circuits, with the 9.3- and 0.93-kc quadrature signals going also to the phase adjust circuits.

The phase advance circuits feed into rate and drift pulse selector sections, which generate the rate and drift pulses used to drive the aircraft transmitter. The phase adjust circuits feed the marker pulse selector which generates the pulses that serve as a time base, producing outward deflections of the circular sweep at the top of the cro screen.

The rate and drift received pulses also appear as deflections of the circular base line of the cro. When the shoran operator superimposes the marker, rate, and drift deflectors, the indicator dials read the distance to each station in miles.

The transmitted rate and drift pulses must be advanced in phase with respect to the marker pulses by an amount exactly equal to the time in transit of the signal to the stations plus the time delays of the equipment. This phase advancing is accomplished by accurately calibrated goniometers of the continuous type, in which the two quadrature inputs are applied to two stator coils oriented so their planes intersect at an angle of 90 degrees. The output is taken from a rotor coil, the angle of which determines the relative phase of the output through 360 degrees. There is a phase advancer for each frequency and hence range; the drift advancers and three rate advancers are separately ganged, so the resultant indicating dials connected thereto read the required distance.

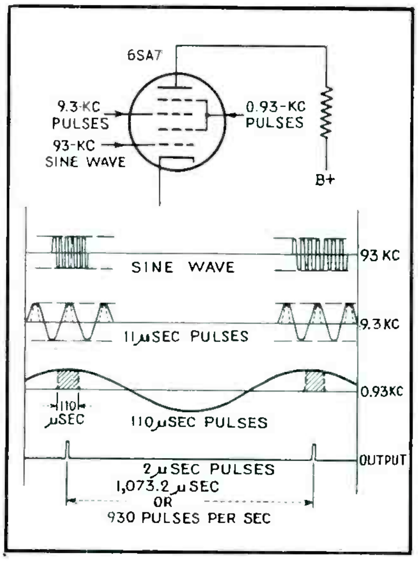


FIG. 4—Operating principle of pulse selector tube, which passes a single output pulse in its plate circuit whenever the three different pulses applied to the three grids are all reaching positive peaks at the same instant

Pulse Selector Circuit

The pulse selector circuit for the rate and drift channels, shown in Fig. 4, is representative of the type of circuit used in the unit as a whole. Pulse selection is a means of blocking the passage through a signal channel of all but one of the positive sine-wave peaks of the 93-kc sine-wave train which occurs during each 0.93-kc wave. The one peak passed forms a short pulse with a repetition rate of 0.93-kc or 930 pulses per second. The method allows accurate selection of the pulse desired, or accurate phasing of the pulse produced without use of complicated high-accuracy circuits.

The 6SA7 pulse selector receives three inputs from phase advance circuits. The grids are biased beyond plate current cutoff so that no current will flow unless all three grids are made more positive by a considerable amount. The output at the plate of the tube therefore consists of pulses at a repetition rate of 930 pps with a pulse width of two microseconds.

We thus have a continuous output of pulses from the selectors of the rate and drift channels. The amount of phase advance for each channel will depend upon the distance of the aircraft from the station in question, and some means must be incorporated for the transmitter following to differentiate between the rate and drift pulses. This differentiation is accomplished by a motor-driven commutator which performs a complete sequence of switching operations every one-tenth second. Actually, the two pulse outputs are used alternately for periods of 1/40 second, with periods of 1/40 second interspersed between them. This means that during one period about 23 rate pulses are transmitted, and 23 drift pulses go out the next time the aircraft transmitter is pulsed.

A pulse amplifier feeds the commutator output pulses to the aircraft transmitter. This amplifier, using a 6AC7 tube, also feeds a short blanking pulse to the control grid of the cro with such polarity

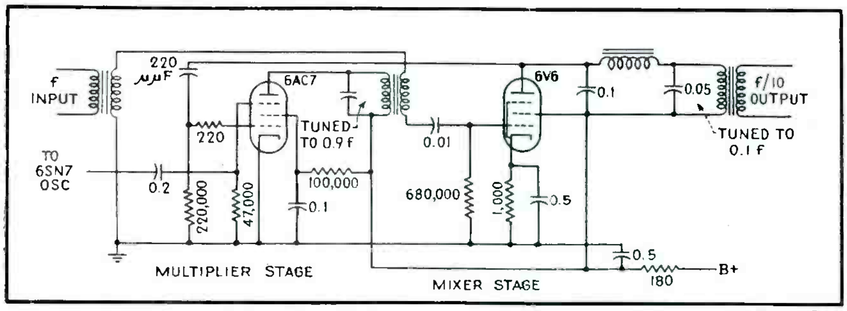


FIG. 3—Typical regenerative frequency divider circuit used in shoran equipment

as to cut off the beam current momentarily until the transmitted pulse has time to leave the antenna. This prevents the pulses sent out by the transmitter from appearing on the cathode-ray oscilloscope.

The phase adjust network consists of a potentiometer across diagonally opposite points of the quadrature network. Varying the potentiometer varies the phase of the signal over a 180-degree range.

The 93-kc signal for the marker pulse selector is taken from the crystal oscillator through a phasing capacitor and cathode follower. The lead is coaxial cable. The cathode follower prevents the large and variable capacitance of the cable to ground from detuning the oscillator.

Since the marker pulses have a frequency of 930 pps, one marker pulse would appear on the cro for every sweep of the 100-mile range, but only one marker for every ten sweeps on the ten-mile range, and one for every hundred sweeps on the one-mile range. Obviously the same condition would exist with respect to the received pulses. The applied solution is the use of a circle-blanking pulse selector (6SA7) and a blanking amplifier (6SN7) which blanks out all sweeps except those during which the marker and received pulses occur, and at the same time intensifies the desired sweep.

Noise voltages would be displayed on all portions of the sweep if the aircraft receiver output were fed to the cro at all times. For this reason, the receiver output is disconnected during the display of the marker pulses. This is accomplished by screen and suppressor modulation of the inverter and amplifier tubes. Blanking pulses are obtained from the offset marker network, and supplied through the receiver blanking amplifier and blocking capacitors in negative polarity with respect to the inverter and amplifier tubes so as to cut off plate current in these tubes.

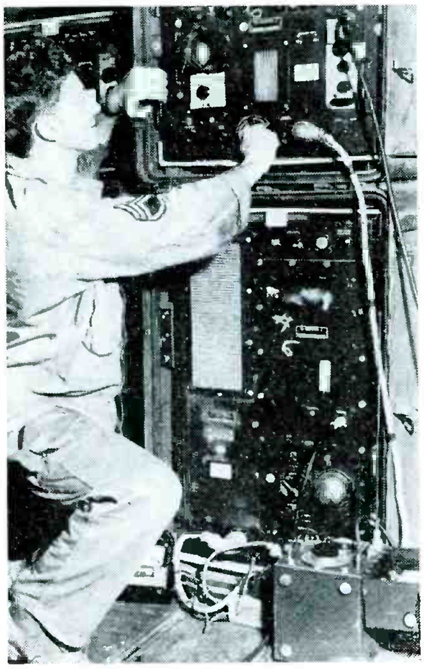
If the marker pulse and the received rate and drift pulses occur on the same sweep, alignment of the two pulses would be difficult since they would tend to become additive the closer they were brought in alignment, and it would be hard to discern the three pulses. The marker and the received pulses should occur on different sweeps, since the latent image on the tube is sufficient for alignment purposes. On the 100-mile sweep the marker occurs on each sweep, so separation is not possible. On the 10-mile and one-mile range, the marker pulse is offset by one and by ten sweeps respectively. This is accomplished through a differently phased 0.93-kc source for the generation of marker pulses in these positions, known as the offset marker.

Aircraft Transmitter

The successive rate and drift pulses are delivered to the aircraft transmitter for transmittal to the respective ground stations. In the pulse shaping section of the transmitter the pulses are amplified and steepened and their tops flattened without changing the timing of the leading edges.

The modulator driver and the modulators are of conventional design. The driver is a 3E29 twin-pentode tube with the sections connected in parallel, while the modulator consists of two tubes of the same type with all four sections paralleled.

The oscillator is a tuned-grid tuned-cathode push-pull circuit in which the grid and cathode circuit tanks are resonant transmission lines. The plates are at zero r-f voltage with respect to ground, and hence the stage does not oscillate except during the time when positive pulses are supplied from the modulator to provide plate voltage.



Shoran ground station

Oscillator tuning is adjusted by varying the electrical length of the grid line with a movable shorting bar. Another bar is used to short-circuit the line closer to the tube. A vacuum relay, excited by commutator action, switches the output from one line condition to the other, producing two output frequencies differing by 15 to 30 mc and used for triggering rate and drift station receivers respectively.

The ground station and airborne antennas are identical and are essentially vertical quarter-wave antennas working against ground. The antenna is placed directly on the aircraft, but at the ground station it is mounted on a fifty-foot plywood mast and backed by a 90-degree corner reflector.

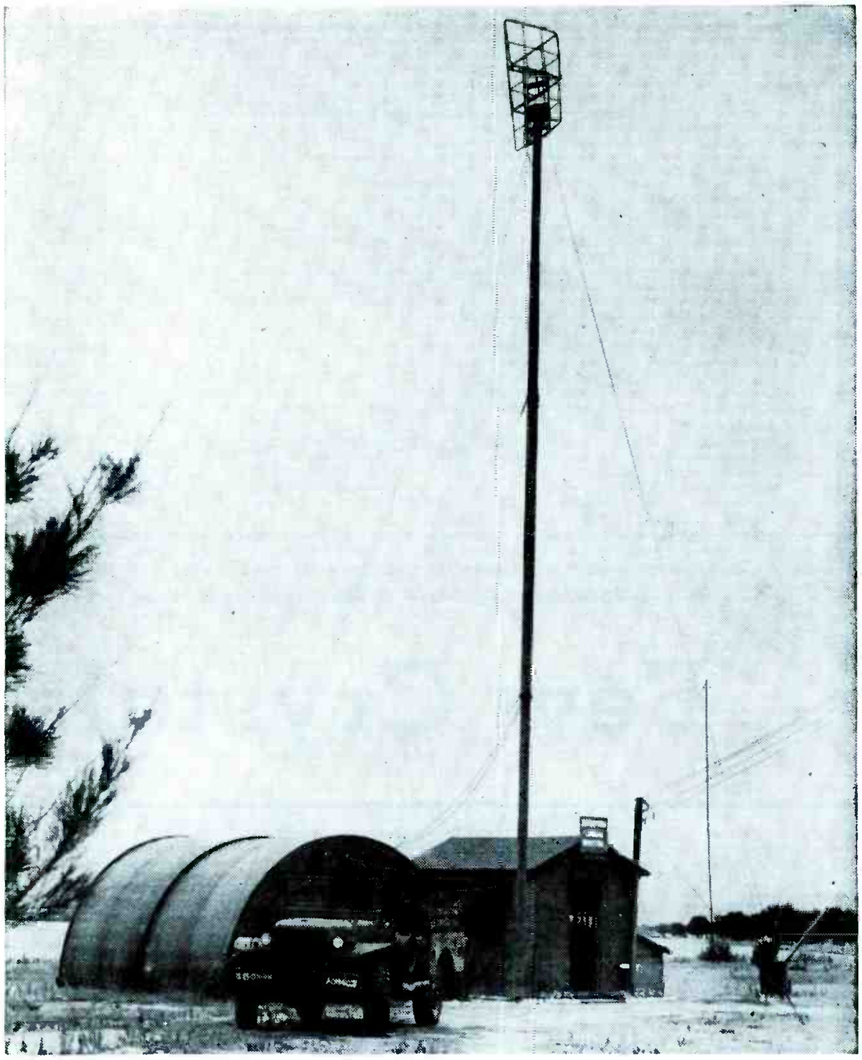
Ground Station Receiver

The frequency range of the uhf superheterodyne receiver at the ground station is from 210 to 230 mc, with a band width of 4 mc, measured from points on the selectivity curve at which gain is 70 percent of maximum. Sensitivity is 2.5 microvolts, or 9 db above the thermal noise level. The i-f circuits are single-tuned, with their resonant frequencies stagger-tuned to the middle and both edges of the 30-mc i-f pass band. Converter and oscillator circuits are tuned to rate or drift carrier frequency by a variable transmission line controlled manually from the front panel.

Ground Station Monitor

The monitor at the ground station is interposed between the receiver for incoming pulses and the ground transmitter that sends them back to the aircraft. It provides a standard signal to the aircraft as a frequency standard for the system, and also provides a means for checking the delay of the station through fixed time delay networks.

The output pulses of the ground receiver go to the variable delay network. This artificial transmission line allows the operator to



Typical shoran ground station as set up by surveying crew, using 50-foot plywood mast to support a vertical quarter-wave antenna backed by 90-degree corner reflector

standardize the overall delay of the ground station at a predetermined value.

A cathode follower stage provides impedance transformation between the relatively high impedance of the variable delay circuit and the low impedance of the cable line to the transmitter.

The accuracy of the entire system depends upon the accuracy of the fundamental frequency of the crystal oscillators. The oscillator circuit in the aircraft is subject to drift, hence the 93.109-kc crystal oscillator of the monitor is used as a standard. The output of this oscillator passes through a frequency-dividing chain in which its frequency is divided by 100. The resulting 931.09-cycle signal is converted into short pulses of suitable power and shape, and the pulses are used to key a uhf oscillator operating at very low power. This oscillator is tuned to the same frequency as the receiver (in the 210- to 230-mc range), and the pulses are fed through a transmission line and coupling loop into the path of the received pulses. The standard pulses are also used for measuring overall ground station delay.

Ground Station Transmitter

Pulses leaving the monitor enter the shaping and amplifying stages of the transmitter. The general purpose of these stages is to eliminate noise in the signal, amplify, and shape the pulses for use by the modulator and oscillator stages.

The modulator driver and modulator are of conventional design, incorporating 3E29 tubes with the sections paralleled.

The oscillator consists of two type 4C28 triodes in a push-pull tuned-grid tuned-cathode circuit, in which the grid and cathode circuit tanks are resonant parallel-conductor transmission lines. The plates are grounded with respect to r-f, so the stage will oscillate only when pulses are supplied from the modulator. Frequency is adjusted by varying the electrical length of the grid line through the use of a movable short-circuiting bar across it. The cathode tank can also be tuned through the use of a similar shorting bar.

Aircraft Receiver

The returned pulse is accepted by the aircraft receiver (identical with ground station receiver), and the receiver output is sent to the inverter and amplifier stages in the indicator. Here the polarity of the received pulses is reversed intermittently by a polarity-reversing switch phased with the commutator action in such a way as to have the received rate pulses produce an outward deflection of the cro trace, and the drift pulses an inward deflection. This circuit also terminates the receiver blanking system.

If the shoran airborne operator operates the indicator so that the marker, drift, and rate pulses are superimposed, the mileage dials will accurately show the distance to each station in miles, tenths, and hundredths.

Installation and Maintenance

Practically speaking, the ground station equipment can be installed in about eight hours, including auxiliary living, radio, and associated equipment, by a crew of five men. It can then be operated by two men, one on the monitor and the other in radio contact with the aircraft and other stations in the net. All equipment can be carried in a jeep and trailer, making for reasonable maneuverability in rough terrain.

The aircraft equipment should be mounted in a plane having stable flying characteristics. Most Air Forces work has been done in the B-17 type.

Although not completely perfected at the present writing, shoran has definitely shown its practicability in its present state as a new tool of industry.

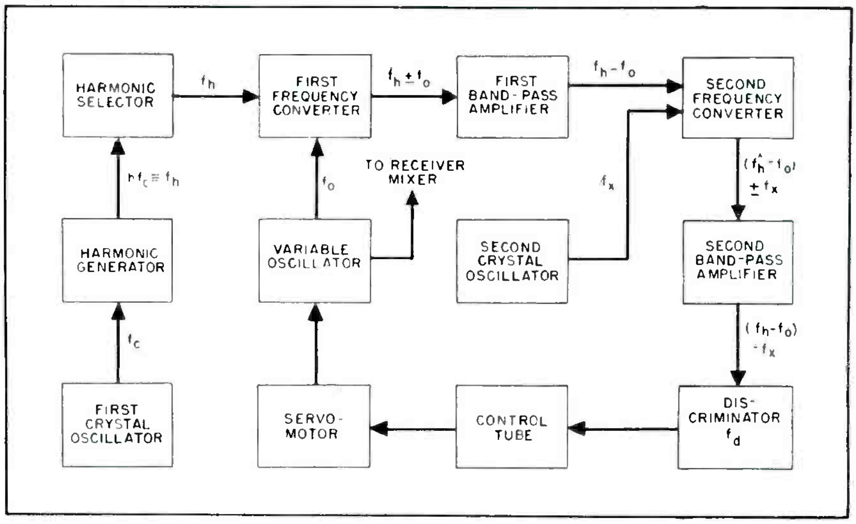


FIG. 1—Variable oscillator of receiver is stabilized on any one of 120 channels in the vhf aircraft band by means of this crystal saver circuit

Few Crystals

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RADIO RECEIVERS, to be sufficiently stable in the very high frequency portion of the spectrum, require crystal control. However to provide separate crystals for each channel is often impractical.

The need for simplicity is especially great in aircraft equipment operating in the 108 to 132 megacycle band, in which such avigational facilities as localizers and omnidirectional ranges, and such communicational facilities as tower and airways channels and domestic and international operational stations are located. An aircraft flying from coast to coast in the United States can use as many as forty frequencies in this band, if it stays on the same company airway; if the plane is interchanged between companies at terminal points on the way, more frequencies would be used. All these frequencies should be crystal controlled.

To minimize the required number of crystals both to reduce production cost and simplify servicing, a crystal saver circuit has been devised for use in the Bendix MN-85 vhf navigation system receiver.

Circuit Principle

The basic problem to be solved in aircraft receiver design is to provide crystal control on the 120 channels spaced every 200 kilocycles throughout the 108 to 132 mc band. Each frequency must be maintained to better than 0.01 percent. Control must be established using a small number of self-contained crystals. retaining simplicity of design, and providing ease of maintenance and reliable performance. To meet the requirements of frequency stability, a superheterodyne receiver is necessary. This discussion is concerned only with producing the required number of crystal-controlled local oscillator frequencies to obtain the desired number of channels, and does not consider overall receiver design problems.

Consider Fig. 1; the variable oscillator is the receiver local oscillator. It is a free oscillator, capable of being tuned over the frequency band required. The radio-frequency tuning circuits are ganged and tracked with the local oscillator tuning. The actual frequency-rotation curve is unimportant, but an approximation to straight-line frequency-rotation is helpful in stabilizing tuning motor control circuits.

Some of the output of the variable oscillator is fed to the first frequency converter where it is combined with the output of the first crystal oscillator from which one harmonic is selected by means of fixed tuned selective circuits. The first band-pass amplifier passes the difference frequency of the output from the first frequency converter on to the second frequency converter into which is also fed the output from the second crystal oscillator. This oscillator may be at any one of a number of frequencies as determined by its crystal selector. The second band-pass amplifier passes the difference frequency of the output from the mixer second frequency converter. Output from this band-pass amplifier is fed to a number of fixed tuned discriminators, of the Foster-Seeley type, to obtain d-c output which feeds the control tube. The latter, in turn, operates the servomotor.

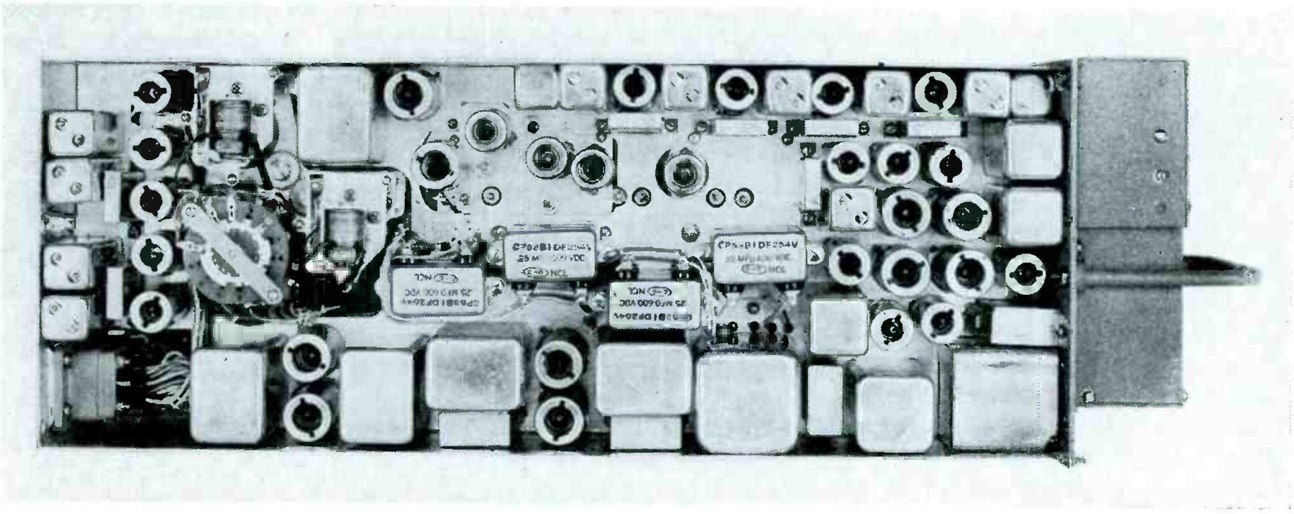
Output from the discriminator provides intelligence for frequency correction and for initial tuning. If f_o is the frequency of the variable oscillator, f_h is the frequency of harmonic selected, f_x is the frequency of second crystal oscillator, and f_d is the frequency of discriminator, then

$$f_o = f_h + f_x \pm f_d \qquad (1)$$

when the system is balanced by being on frequency. Either the plus or the minus sign can be selected as the stable frequency position by changing the sense of the servomotor. Thus by a few changes of several variables, many frequencies can be crystal controlled.

Servomotor Control

To explain the motor control circuit it is helpful to examine a simplified form such as is shown in Fig. 2, which shows only a variable oscillator driven by a motor, with a discriminator to determine the



Omnidirectional range and communications receiver has the frequency monitoring circuit described in this article at the left of the chassis. The r-f and i-f circuits occupy the upper center and right, navigation circuits extend along the lower side of the chassis. Two crystal ovens are in cans on the underside of the chassis

Control Many Channels

Local oscillator of multichannel superheterodyne receiver used for aircraft communication and navigation is crystal controlled on 120 channels by only 10 crystals. Conditions for minimum number of crystals, frequency spacing, and stability are described

oscillator frequency. The direction of motor rotation is determined by relay contacts HC, LC, their coils being energized from the output of the discriminator, through the control tube. Normal plate current of the control tube without discriminator output is sufficient to energize LC only, in which condition the motor will not run.

The discriminator output will reverse in polarity depending on whether the oscillator frequency is above or below the discriminator frequency. If discriminator output is negative, plate current in the control tube will decrease and LC will drop out, causing the motor to run in one direction. If discriminator output is positive, plate current in the control tube will increase and both HC and LC will be energized, causing the motor to run in the opposite direction. Thus the oscillator frequency is maintained equal to the discriminator frequency.

Figure 3 shows the next step in expanding the system, and shows how the plus or the minus sign for the discriminator frequency is chosen. The discriminator, instead of being fed directly from the oscillator, is fed from the output of a frequency converter. The converter mixes the output of a crystal oscillator, and the oscillator to be controlled. A low-pass filter in the converter plate circuit passes the difference frequency. If the oscillator frequency differs from the crystal frequency by the discriminator frequency, the motor does not run. The oscillator frequency may be either greater or less than the crystal frequency to obtain this result. But only one position is stable, depending upon the motor polarity. For, if the oscillator frequency is the smaller, then an increase in oscillator frequency decreases the difference between oscillator and crystal frequencies, while if the oscillator frequency is the greater an increase in its frequency will increase the difference between oscillator and crystal frequencies. Thus, by reversing motor polarity, two stable oscillator frequencies are obtained for each crystal used.

In tuning a system of this type, normal procedure is to start the local oscillator tuning from one limit of the frequency band, and to allow it to sweep the band. As its frequency changes, it will pass a position where Eq. 1 will be satisfied; here the servomotor will stop. If for any reason the frequency of the local oscillator changes, the motor again will drive to retune the local oscillator.

In order to save wear and tear on the motor, it has been found advantageous to control frequency only coarsely by the motor tuning, and to obtain fine frequency control by means of a reactance tube operated by the output from the discriminator. Whenever the range of control of the reactance tube is exceeded by slow frequency drifts, the motor restores mechanical tuning to the center of the range of control of the reactance tube. The reactance tube also eliminates frequency-modulation of the local oscillator due to vibration or to other causes, because, being completely electrical, it can act fast enough to eliminate such modulation.

Number of Frequencies

The number of frequencies which can be selected for control is equal to the number of combinations of harmonics, crystals, and discriminators which can be obtained. But for any combination there is one, and only one, stable local oscillator frequency. If H is the number of harmonics used, X is the number of crystals, D is the number of discriminators and N is the number of control frequencies or channels, then

$$N = 2HXD \tag{2}$$

The factor of 2 is obtained because of the $\pm$ sign in Eq. 1. In effect, two control frequencies are obtained from each discriminator, because either algebraic sign may, by choice of servomotor sense, describe a stable control frequency.

With this system of control, the most convenient design results if adjacent channels are obtained by means of adjacent discriminators, while using the same harmonic and crystal. If x is the channel spacing, then x is also the discriminator frequency spacing designated as Δf_d. If there are D discriminators, then the spacing between crystals Δf_x is

$$\Delta f_x = D\Delta f_d = Dx \tag{3}$$

After using all discriminators once, the next higher crystal frequency is selected, and the discriminators are used again. This selection is repeated until the highest frequency crystal has been used, whereupon discriminator polarity is reversed. The lowest frequency crystal then is re-employed with all of the discriminators, but this time the discriminators are used in the reverse order with respect to frequency. The same thing is done with the remaining crystals. If, then, there are X crystals, the spacing between harmonics

$$\Delta f_h = 2Xf_x = 2XD\Delta f_d = 2XDx \tag{4}$$

The spacing between harmonics is, of course, the frequency of the first crystal oscillator in Fig. 1.

Choice of discriminator frequencies is not arbitrary, but is determined uniquely once the number of crystals, the number of discriminators, and the channel spacing is chosen. This situation can be explained by Eq. 1 when it is realized that the frequency described by the nth harmonic, the highest frequency crystal, and the lowest frequency discriminator (polarity negative) must be adjacent to the frequency described by the nth harmonic, the lowest frequency crystal, and the lowest frequency discriminator (polarity positive). If these frequencies are f_1 and f_2, respectively then, from Eq. 1

$$f_1 = n\Delta f_h + f_{x\,max} - f_{d\,min} \tag{5}$$

and

$$f_2 = n\Delta f_h + f_{x\,min} + f_{d\,min} \tag{6}$$

Furthermore $f_2 - f_1 = x$ because these frequencies are adjacent. Then, subtracting Eq. 5 from Eq. 6

$$f_2 - f_1 = x = f_{x\,min} - f_{x\,max} + 2f_{d\,min} \tag{7}$$

or

$$f_{d\,min} = \frac{x + f_{x\,max} - f_{x\,min}}{2} \tag{8}$$

but

$$f_{x\,max} - f_{x\,min} = (X-1)\Delta f_x \tag{9}$$

That is to say, the difference between the maximum and minimum crystal frequencies is equal to the frequency spacing between crystals, times the number of spaces (the number of crystals less one). But from Eq. 3, $\Delta f_x = Dx$, therefore Eq. 9 becomes

$$f_{d\,min} = \frac{x + (X-1)\,Dx}{2}$$

$$= \frac{x\,(1 + D\,(X-1))}{2} \tag{10}$$

Equation 10 means that discriminator frequencies are chosen uniquely once channel spacing, number of discriminators, and number of reference crystals are chosen.

Choice of harmonic and crystal frequencies is determined, to some extent, by the local oscillator. The lowest oscillator frequency should be above the highest crystal frequency. The lowest crystal frequency should be above the pass-band of the first amplifier of Fig. 1, and the highest harmonic frequency should be below its pass-band. This arrangement of frequencies eliminates the possibility of spurious conversion products in the frequency monitoring circuits. With the arrangement shown a 2-to-1 frequency coverage ratio is the maximum possible. However, several other arrangements are possible, by means of which the coverage can be extended to 4-to-1 or 8-to-1.

The usual choice of the number of harmonics, crystals, and discriminators is that which leads to the smallest total number of elements, and is accomplished if they are all equal in number. If this number is n, then, from Eq. 2

$$n = (N/2)^{1/3} \tag{11}$$

Equation 11 is not a necessary condition, and may be departed from if, by such departure, other and more desirable benefits can be obtained; for example, direct channel frequency reading from a simple control box.

Frequency Stability

To estimate frequency stability factors it is necessary to inquire

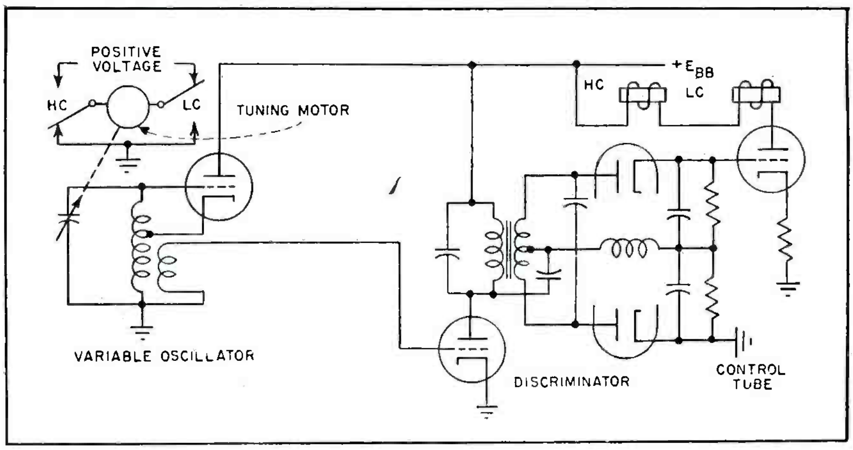


FIG. 2—Basic control circuit maintains variable oscillator at center frequency of discriminator by relay-actuated motor tuning

into the values of f_h, f_x, and f_d over the frequency band. From Eq. 10

$$f_{d\,min} = (x/2)\,(1 + DX - D) \qquad (12)$$

Then, if $D \geq 1$

$$f_{d\,min} = (x/2)DX \qquad (13)$$

From Eq. 4 $f_h = 2XDx$; therefore

$$f_{d\,min} < \Delta f_h/4 \qquad (14)$$

indicating that Δf_h must be considerably less than the absolute frequency f_o because f_h is only a part of f_o. *Also* $f_{d\,min}$ must then be only a very small part of f_o, because it is less than $\frac{1}{4}\Delta f_h$, as shown in Eq. 14. Thus very large percentage errors in the absolute value of f_d will cause only very small percentage errors in f_o.

The principal frequency error, therefore, will be that owing to errors in f_h and f_x. These frequencies are crystal controlled, and can be held to ±0.005 percent individually by means of temperature controlled ovens. The resultant frequency error due to f_h and f_x collectively will also be ±0.005 percent because these frequencies are of the same algebraic sign in Eq. 1.

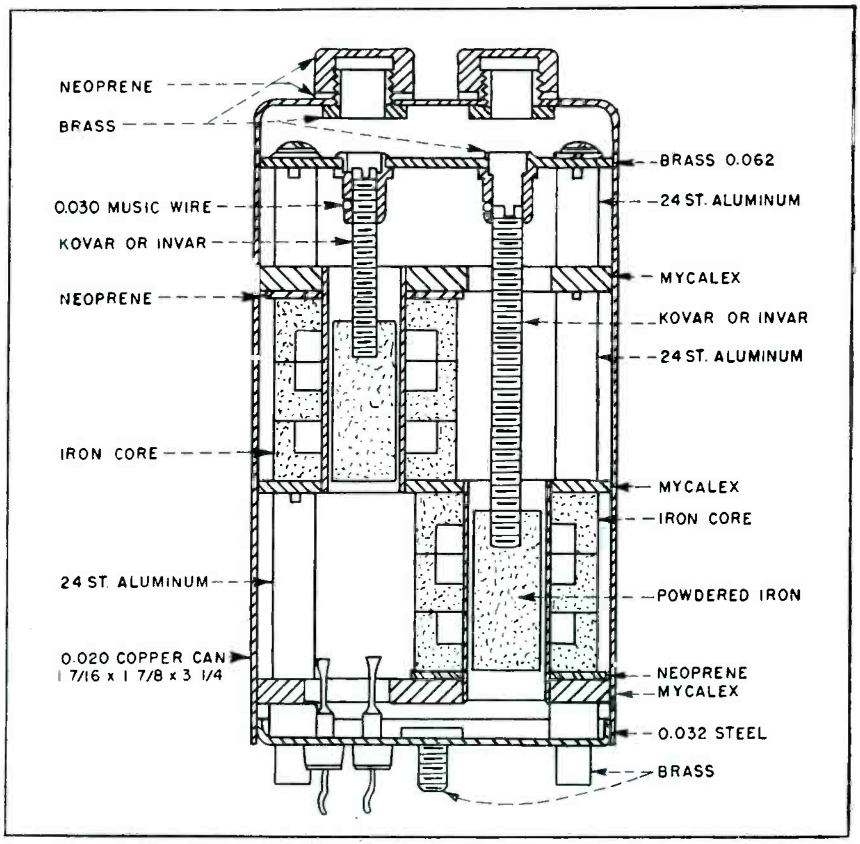


FIG. 4—Discriminator is constructed of compensating materials to insure stability

Considerable research into the construction of fixed frequency discriminators has revealed a method of construction which provides frequency compensation for temperature changes by means of choice of materials having the proper thermal coefficients of expansion to hold the relative positions of active parts fixed over a very wide temperature range. This construction avoids the use of temperature coefficient capacitors to obtain temperature compensation; by it and because of the high Q obtained, only ±0.2 percent of the discriminator center frequency need be allowed for center frequency drift plus reactance tube control. This error will be not greater than ±0.002 percent of the local oscillator frequency. The reactance tube will allow ±2 percent of the band covered in mechanical detuning before affecting output frequency by more than the allowable deviation. Figure 4 shows the discriminator construction.

Under the worst conditions, using ±0.005 percent crystals and a ±0.2 percent discriminator, a final frequency stability of better than ±0.007 percent can be obtained by this circuit over a very wide range of frequencies.

The above circuit lends itself quite readily to remote control over a very few wires. The description of a radio frequency channel is accomplished by the selection of one harmonic, one crystal, and one discriminator. This effectively breaks channel selection down into successive steps, each step being finer than the one preceding. If it is desired to effect a remote choice of ten possibilities, then ten leads plus a remote switch can be used. In the case at hand, if there were four each harmonics, crystals, and discriminators, then four leads for each variable plus one ground lead, and three remote four-position switches will suffice for the control of 128 channels. In the practical case for the 108-132 megacycle receiver, 7 harmonics, 10 crystals, and 2 discriminators are used. The switches in this case are arranged coaxially for conservation of space and ease of reading.

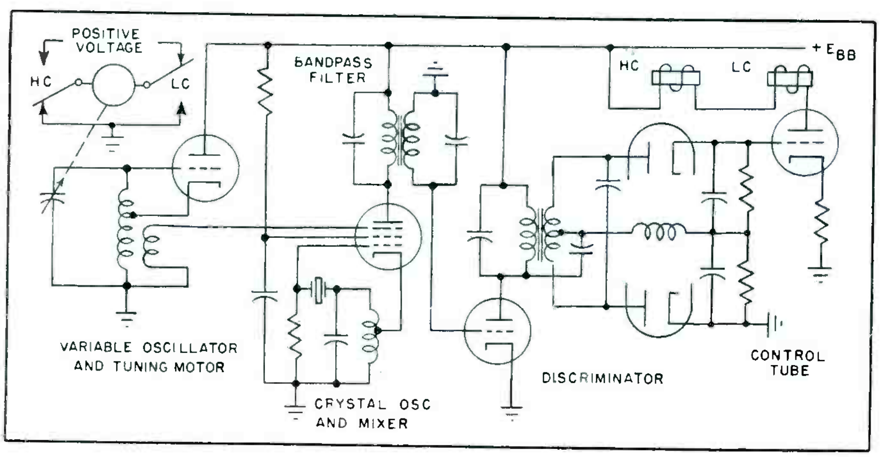


FIG. 3—Frequency stabilization is obtained by beating variable oscillator against crystal oscillator; compare with Fig. 2

High-Speed N-SCALE COUNTERS

By T. K. SHARPLESS*
Technitrol Engineering Company
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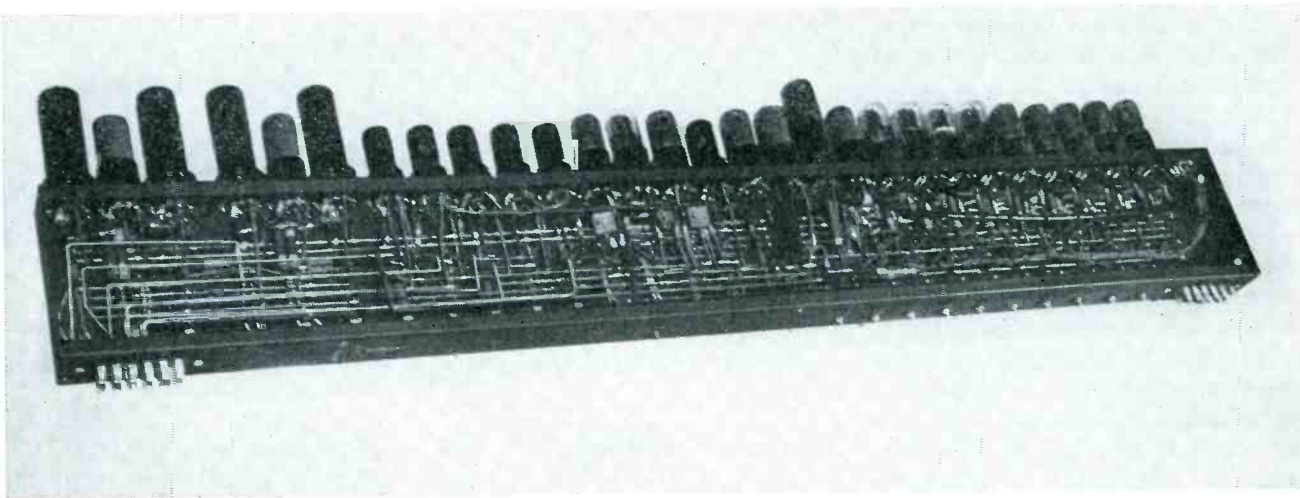
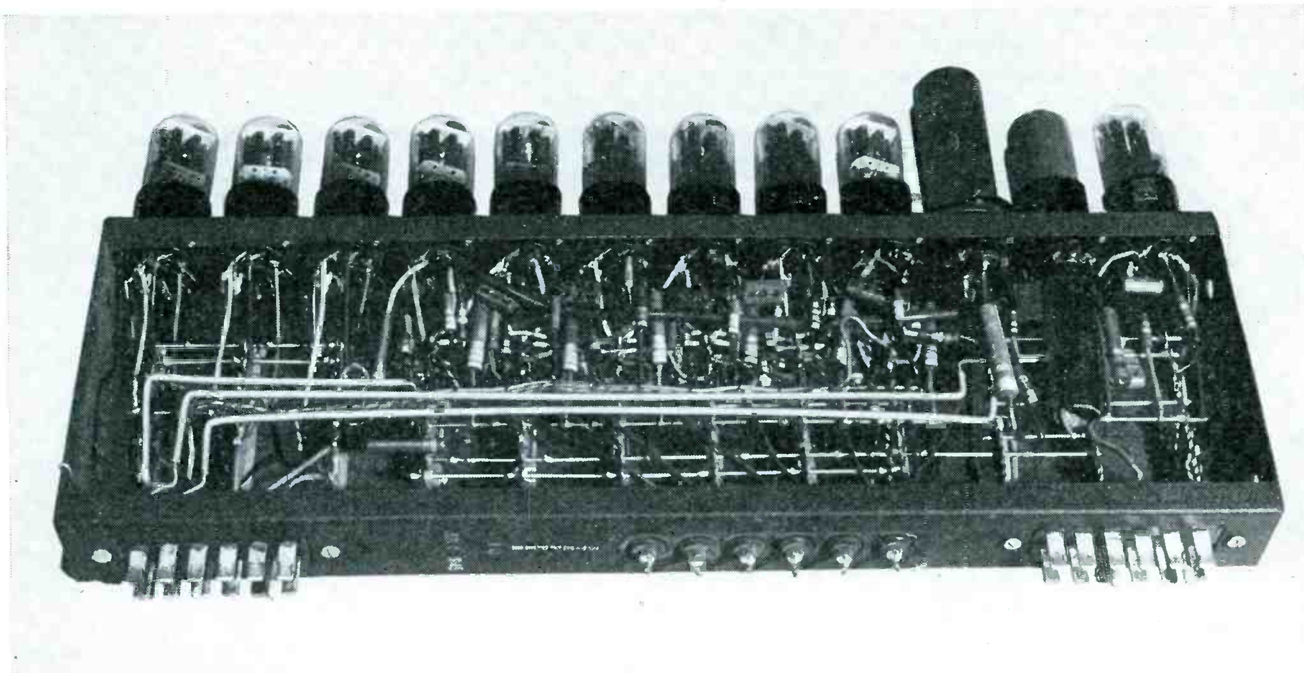


Ten stages at right form counter in this plug-in decade unit; other circuits are for carryover and transmission of count



This stepping switch unit incorporates a six-stage counter. Three tubes at right are part of input pulse-forming circuit

Basic flip-flop and scale-of-two circuits are reviewed, and extension of techniques to the design of ring and chain counters of higher scale is given. Cathode-pulsed n-scale circuit described requires no complex indicating schemes, eliminates counting errors and operates at speeds as high as 180,000 pulses per second

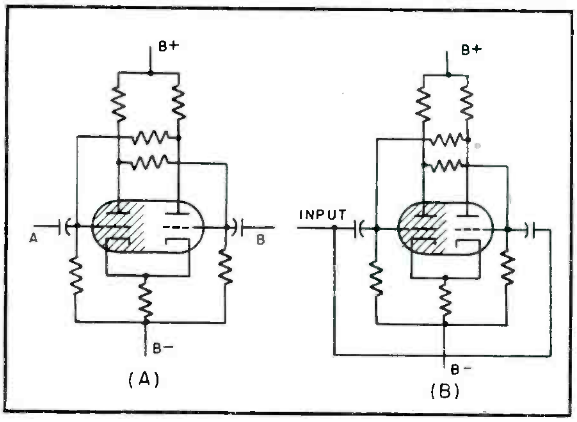


FIG. 1—Flip-flop circuit (A) is tripped by a negative pulse at input A and is reset by negative pulse at input B. Basic scale-of-two circuit (B) has two operating states, alternating from one to the other as successive negative pulses are fed to input

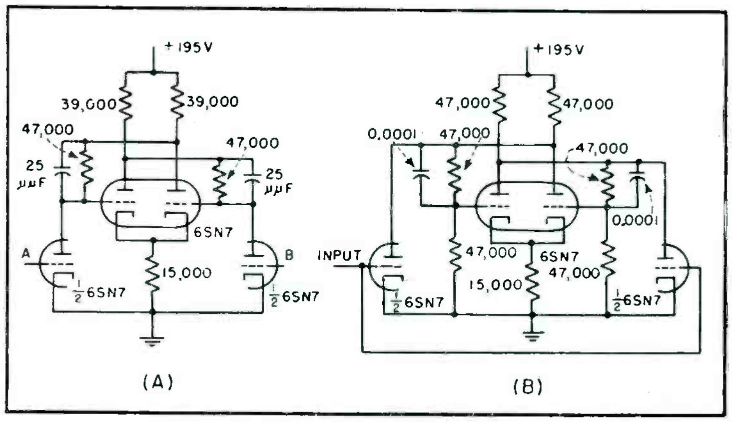


FIG. 2—Flip-flop (A) and scale-of-two (B) circuits used in ENIAC. Negative pulses are used to trip the flip-flop circuit; positive pulses trigger triodes which deliver negative pulses to plates of scale-of-two counter. This example illustrates the fact that trigger pulses of suitable shape can be applied to points other than the grids

ELECTRONIC counters have been known for a number of years and have found extensive use in physics laboratories. In these applications, their major function has been to scale down rapidly occurring pulses to a frequency suitable for the operation of mechanical counters. The fact that such scaling circuits have been used mainly for the study of radiation phenomena has meant that, in the past, electronic counters were regarded solely as laboratory equipment. In recent years, however, the application of these counters to many other problems has resulted in the production of several of them for the general market by a number of manufacturers.

The first publication of a counter circuit intended for commercial production was made in 1944 by Potter.[1] In 1939, Perry Crawford, in a thesis written at MIT, proposed the use of such counters in a computing device. RCA Research Laboratories, in 1941, examined such applications in a computer for a gun director.

Counter Applications

The ENIAC, first large-scale, practical, computing device making use of electronic counter circuits, was designed and built at the Moore School of Electrical Engineering of the University of Pennsylvania and put into operation in December 1945. This machine, involving 300 electronic counters, was built for the Army Ordnance Department and marked a tremendous advance in the art of computing.

Electronic counters are usually derived from two basic types of trigger circuit, the flip-flop and the scale-of-two counter. Both of these circuits are examples of the Eccles-Jordan trigger circuit, first published in 1919.[2]

To explain the operation of the flip-flop, Fig. 1A, assume the lefthand triode section to be conducting, and let this condition be designated as state 1. A negative pulse appearing at *A* will cut off the lefthand triode; the positive signal appearing at its plate will cross over to the opposite grid and turn on the righthand section. The negative signal from this plate is fed back to the lefthand triode and keeps it cut off. The circuit is now in state 2. A subsequent negative pulse on *A* will have no effect. However, a negative pulse appearing at *B* will reset the circuit to state 1.

Pulse Dodging

The scale-of-two counter is shown in Fig. 1B. It will be seen that a negative pulse applied to the input tends to hold the righthand triode cut off while the positive signal from the plate of the lefthand tube is trying to turn it on. Thus, in converting a flip-flop to a scale-of-two counter, the problem arises of producing in the crossover a signal

* Developments reported were made while the author was Technical Director of the Digital Computing Program at Moore School of Electrical Engineering, University of Pennsylvania.

that will override the externally applied signal. This problem can be called the pulse-dodging problem. It is apparent that the shape and magnitude of the tripping pulse in a counter are of utmost importance, although in flip-flop applications such is not the case.

Figure 2 shows the flip-flop and scale-of-two counter circuits actually used in ENIAC. Note that the flip flop is designed to operate with negative pulses applied to inputs *A* and *B* while the counter operates with positive pulses on its single input. Moreover, the counter circuit shows that tripping pulses need not be applied to the grids but can be applied to any suitable point. Application of pulses to the plates of the trigger circuit, in the case of the counter, helped considerably in solving the pulse-dodging problem mentioned above. A number of practical circuits for both flip-flop and scale-of-two counter applications have been devised.[3]

Once a counter having a scale of two has been designed, the extension of the scale to higher numbers immediately suggests itself. Scale-of-*n* counters can be made by merely cascading stages of scale-of-two counters, as done by Wynn-Williams.[4] With this arrangement, *n* can only be a power of two unless special tricks are resorted to as in the Potter counter.[1] As a result, the conducting triode combinations are not linear, so that it is difficult to display the numerical counts simply.

Lewis[6] designed a circuit of one tube per stage which behaves essentially like the basic Eccles-Jordan circuit, in that one conducting tube is sufficient to keep the others cut off. A five-tube example of this circuit is shown in Fig. 3.

The plate of each tube is connected to the grid of every other tube, giving the circuit stable states in which *n*—1 tubes are turned off and one on. Proper progression of carryover in the counter is achieved by use of capacitance coupling between any one stage and the next, in parallel with the direct resistance coupling which is used to hold the circuit in its particular state. Since the last tube is connected to the first in this same manner, the circuit is called a ring counter.

The major objection to counters of this sort is that each plate and each grid is loaded by *n*—1 resistors. Thus, as the number of stages increases, the device becomes quite complex. Morever, this loading of each stage results in a reduction of gain around the loop formed by the *n* stages. Since this gain must be greater than unity for the counter to step, it can be seen that counters of this type are limited in the number of stages that may be used. With presently available vacuum tubes, five stages are about all that seem practicable.

Counter circuits of this type can also be built with *n*—1 tubes conducting and 1 tube cut off. Although this arrangement provides more current for cutting off the one tube, it has the disadvantage that the circuit may run away, for there may exist one moment when all tubes are on and the phase shift around the loop may be some multiple of 360 degrees at a particular frequency so that oscillation can occur.

Lewis combined a scale-of-two with a scale-of-five counter of the type described above, to produce a scale-of-ten counter. Such arrangements have the disadvantage that the operating state of the circuit at any moment is not directly indicated but can be known only by reference to its binary and quinary parts.

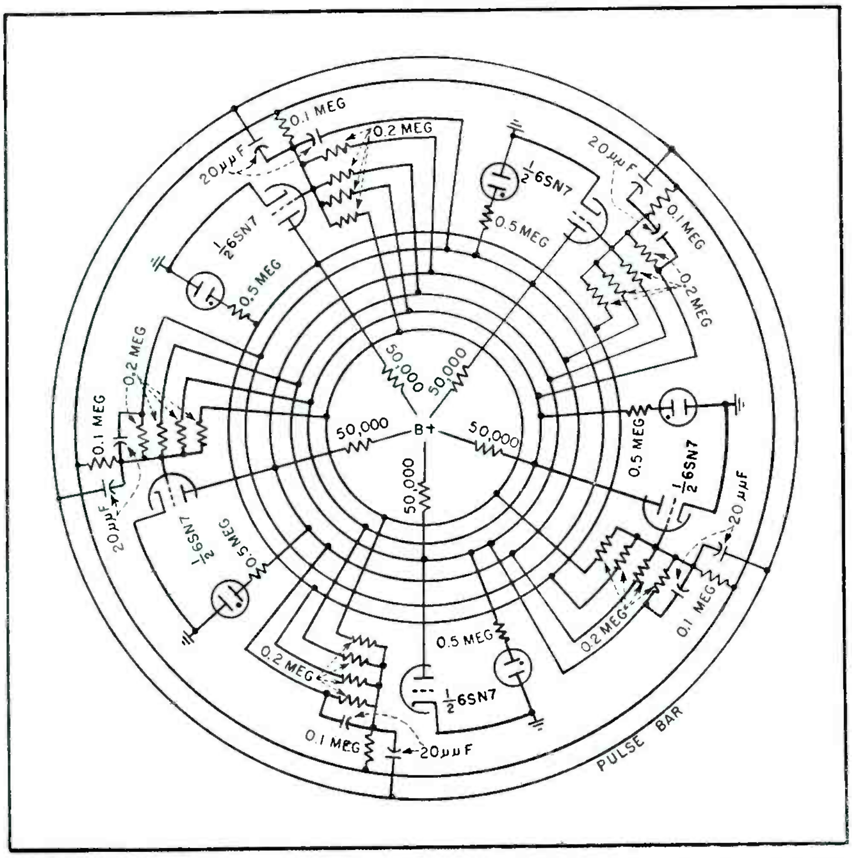


FIG. 3—Lewis five-stage ring counter. Successive pulses fed to pulse bar step the counter through five states; on sixth pulse the counter recycles

n-Scale Counters

In ENIAC, n-stage counters are formed using two triodes per stage in standard trigger circuits. Such counters are found in scales of six, nine, ten, fourteen, and twenty.

Figure 4 shows this type of circuit generalized for *n* stages. Consider the circuit to be operating with the shaded tube sections conducting as shown. The counter is now in its first stable state with a positive potential at the lefthand plate of the initial or 0th stage. This condition is indicated by the lighting of the 0th neon glow lamp. No other lamp is lit since the currents drawn through the conducting lefthand tubes are sufficient to drop the plate potentials below the ignition point of the glow lamps. The application of a negative pulse to the lefthand cathode of the 0th stage turns that triode on and the trigger action of the stage cuts off the righthand triode producing a positive signal at its plate. This signal, transferred through C_2, turns on the righthand section of stage 1, thus triggering this stage into the condition that previously existed in stage 0. Successive pulses applied to the pulse line produce similar stepping from stage to stage down the line. If, as shown in the diagram, the last stage is connected back to repeat the cycle, a ring counter results.

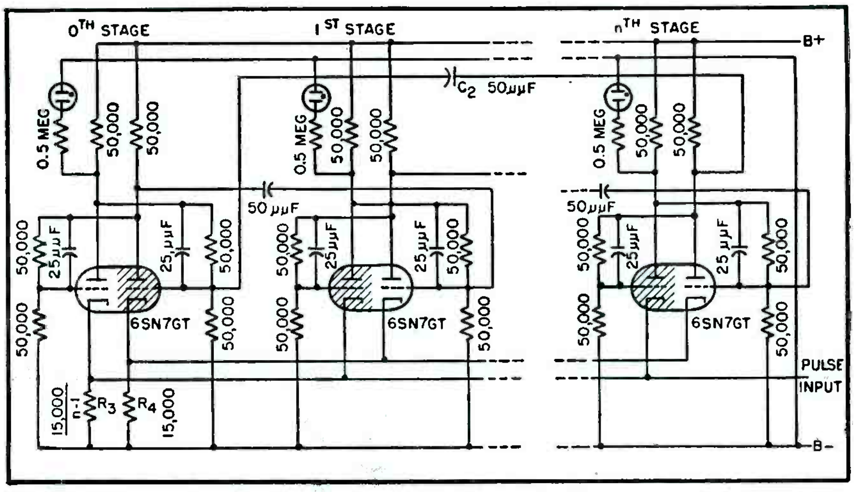


FIG. 4—N-stage counter differs from cascaded binary systems in that cathodes of trigger circuits are interconnected with pulse input causing successive stages to trip in linear sequence

As in all previously mentioned counters, the pulse-dodging problem is present, for the negative pulse on the cathode which turns on the lefthand side of an abnormal stage also tends to keep on the lefthand side of the subsequent stage which it is desired to change. That this does not occur is due to the fact that the crossover signal through C_2 is of such amplitude and duration as to override the effect of the negative input pulse. For this overriding action to take place, it is necessary that the applied pulse shape be maintained and its amplitude controlled within quite close limits. This pulse shape and amplitude control is achieved by incorporating as part of each counter the pulse standardizing circuit of Fig. 5.

The fact that each tube in a counter is operated as a binary device, thus having only two states: conducting and nonconducting, is used to advantage. Though the applied pulse, circuit parameters, or bias voltages may vary considerably in amplitude, so long as the grid is driven to cutoff on the one hand and to zero or a slightly positive value on the other, the plate current has only two values. This principle is of basic importance in counter design, since reliability of operation is achieved by minimizing the effect of changing circuit parameters.

Design Considerations

A counter circuit should be so designed that coupling between stages is effected without the use of extra tubes or buffers. Furthermore, it is desirable to arrange the circuit so that there is a minimum of connections and so that not too many of these go to any one element of the tube, such as the grid. There must be in the decade counter, for example, internal coupling, connections between stages, connections to the pulse bar, connections to the neon indicating lamps, static output connections, and reset connections for clearing the counter. One disadvantage in grid pulsing lies in the fact that the grids are already used for the internal connections so that using them also for the pulse bar connections loads them too heavily.

A counter circuit may be so arranged that it can operate in modes other than the one desired. Thus, if a stable state of a decade counter consists of 9 tubes off and 1 tube on, it may be that the counter can also operate with 2 tubes on and 8 tubes off. If a counter is expected to operate in the first mode, but happens to get started operating in the second mode, then though the circuit will count, the output voltages will be incorrect and the counter useless. The counter of Fig. 4 is capable of only one mode of operation because of the relation between R_3 and R_4.

In computing machine applications, a counter must be completely reliable, that is, it cannot be permitted to lose a single pulse. Some 300 counters of the type shown in Fig. 4 have been used in ENIAC for the past year and have met this criterion of reliability. Production models operate at a maximum count rate of 180,000 pulses per second or better and count at 100,000 pulses per second with applied voltage ranging from 90 to 500 volts. They are quite insensitive to variations in circuit parameters and particularly to changes in tube characteristics. Indeed, tubes of twice the plate resistance of 6SN7's have been inserted with the result that the counters operated at about 140,000 pulses per second. Since they are designed to operate at 100,000 pulses per second, their use was not impaired. Present electronic computing machine research has produced a number of counting circuits that are reliable at rates up to 2 or 3 million pulses per second.

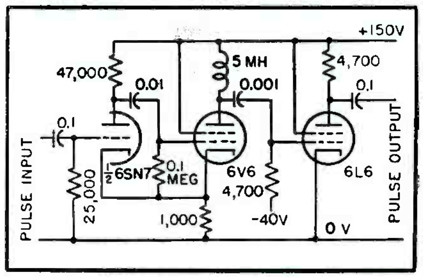


FIG. 5—Pulse-forming circuit for cathode-pulsed counter of Fig. 4. This circuit controls shape of input pulses to insure correct pulse-dodging action

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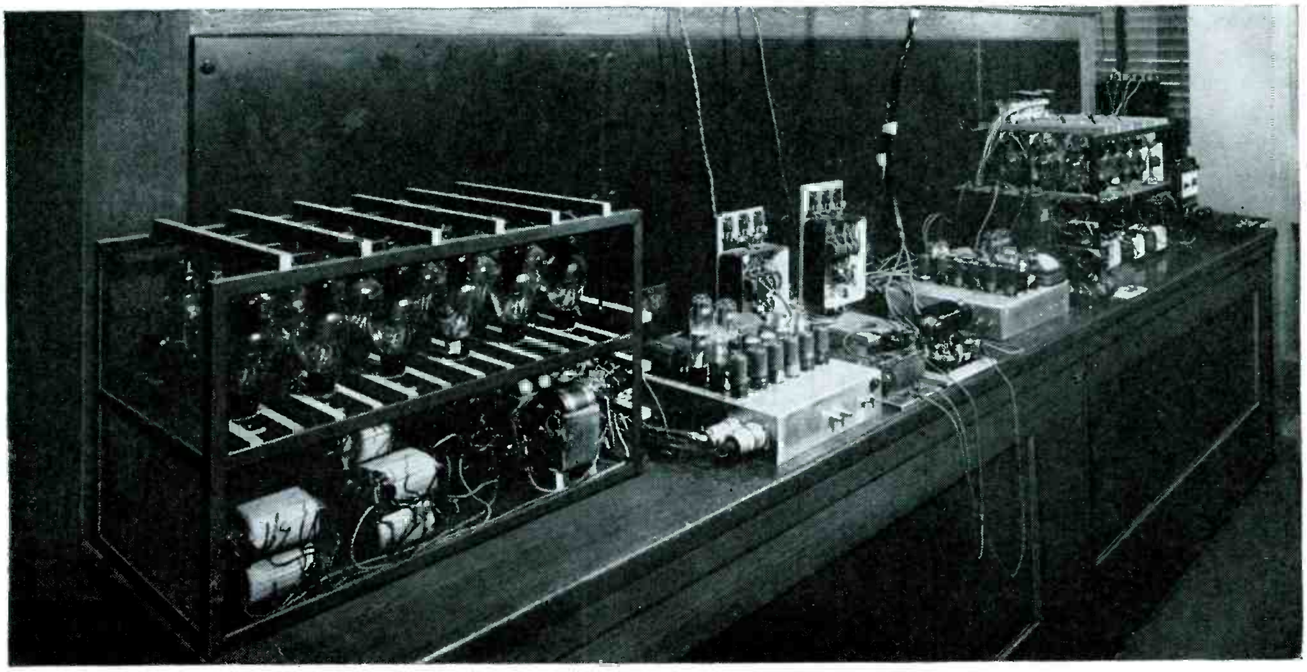

Frequency-changer power circuits include parallel-inverter type, left, and cycloconverter, extreme right. Frequency and phase control units are in the center. Connections between control circuits synchronize the two systems to permit parallel operation

THYRATRON Frequency Changers

Designed to permit parallel operation of three-phase aircraft alternators driven at unequal and varying speeds, the converter and control circuits described here produce three-phase power having constant frequency and regulated voltage. Characteristics of two types of power units are compared

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One of the interesting problems in connection with modern large aircraft is the provision of adequate electrical power. The number and size of electrical loads increases yearly as new models of gun turrets, radar, automatic controls, and radios are installed. The present systems use 24 volts d-c, but for weight saving with these increased loads, there is considerable interest in 120-volt 3-phase a-c systems.

A major obstacle to a-c operation of the heavier motor loads is the difficulty of obtaining large blocks of power economically. For fuel economy, it is desirable that aircraft generators be driven by the main engines, and for reliability the power should be available from any or all of the engines of a multi-engined aircraft. This implies that the outputs of several main generators be paralleled at the load bus. Paralleling is difficult, as even with the airplane's engines synchronized well enough to reduce vibration the generators are still a long way from the exact synchronism demanded. As the generator horsepower is only a small part of the total engine output, the synchronizing torques of the generators are inadequate to hold the system together. In addition, the engine speed for most efficient operation varies with flight conditions and would seldom be that required to give the desired 400-cycle output from the generator.

This situation calls for some method of obtaining synchronization and correct frequency in the electrical system. Mechanical or hydraulic methods might be used to give a constant-speed drive for the alternators, or the alternators could be directly connected to the aircraft engines and the necessary frequency change obtained electronically. The latter method was chosen as the basis for some experimental work which Chrysler Corporation Engineering Division was asked to do on 4-kva units for the parallel operation of aircraft type alternators. Two units were built and successfully operated in parallel at 400 cycles with input frequencies varying from 300 to 900 cycles[1]. The photograph shows the two units set up for bench test. The electronic frequency changer used consisted of a power circuit using eighteen grid-controlled gas-filled rectifiers and a frequency-control circuit with fourteen assorted receiving type tubes. The control circuit provided three-phase, 400-cps, square waves.

Two power circuits were tested, one of the parallel-inverter type[2], the other of the cycloconverter type[3] and certain differences in their operation noted. For three-phase operation, the cycloconverter offered advantages in weight, efficiency, and power factor of the generator. If only single-phase 400-cps power is needed the parallel inverter has possibilities.

Cycloconverter Power Circuit

The complete power circuit of the 4-kva test unit is shown in Fig. 1. The alternator available was rated at 30 volts output, so that a delta-wye connected step-up transformer was used to supply approximately 200 volts to the tubes. The current from one phase of this transformer passes through a load-division current transformer, one of the six tubes connected to it, half of a reactor, a series capacitor, and one phase of the load. As the neutrals are not interconnected, the current

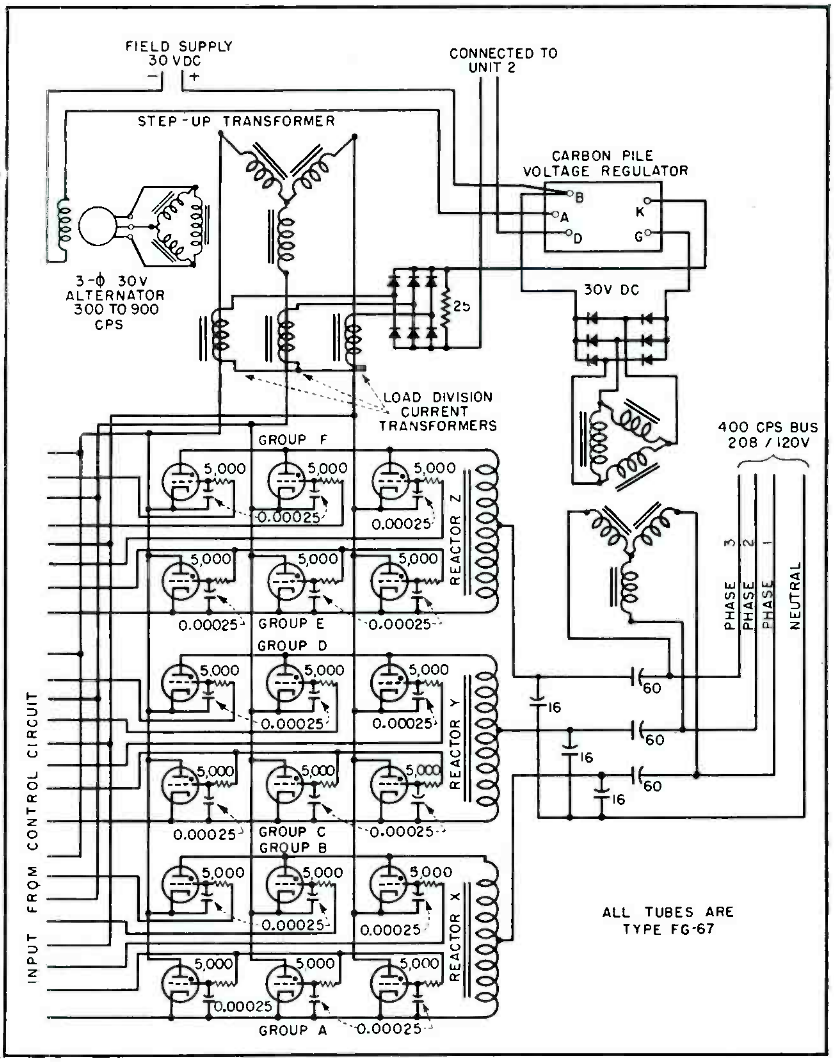

FIG. 1—In the cycloconverter, each phase of the step-up transformer secondary supplies voltage to three pairs of thyratrons. Output frequency is held at 400 cycles by auxiliary control circuit that determines thyratron firing sequence

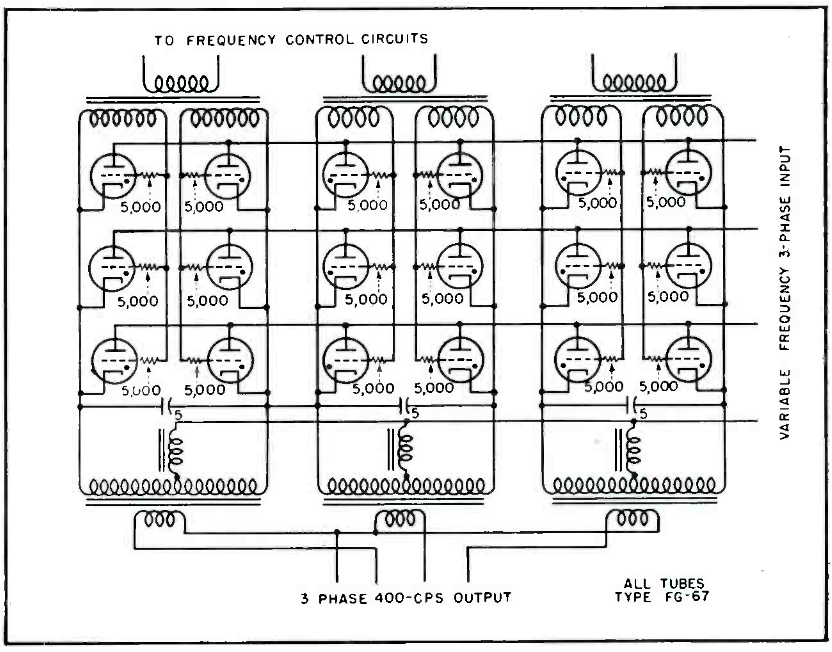

FIG. 2—Three-phase parallel-inverter shown here consists of three interconnected single-phase units with phase sequence determined by circuit of Fig. 4. Losses in transformers and chokes make this circuit less efficient than cycloconverter

returns through another load phase, a series capacitor, half of its reactor, one of the three tubes connected to the end of the reactor, and the phase winding of the transformer.

Operation of the tubes is controlled by the square-wave voltage applied to the grids by the control circuit and by the input voltage applied to the plates and cathodes as shown. Consider group A and group B for example, which together supply one phase of the load. The tubes of group A have their cathodes tied together and their grid bias supplied from a common point in the control circuit. If the grid voltage is positive, then the tube having the most positive plate potential will conduct and raise the common cathode potential high enough to cut off the other tubes. As the input voltage varies through its cycle, another tube anode in group A becomes more positive and it conducts, cutting off the previously conducting tube.

When a half cycle of the 400-cycle output frequency is completed, the grids of group B are made positive relative to their cathodes. Since the group B anodes are connected together, the tube with its cathode connected to the most negative input line conducts and also prevents conduction in the other two tubes.

Commutation

Commutation between groups, that is, extinguishing a tube of group A when a tube of group B fires, is produced by reactor X in the following manner. When a tube in group A is conducting, the cathode end of reactor X is positive relative to the center tap. However, when a tube of group B fires, it instantly makes the anode end of the reactor positive relative to the center tap, and the cathode end is made temporarily negative due to the autotransformer connection of the reactor. The duration of the negative swing is dependent upon the size of the series and shunt capacitors in the output circuit. The negative swing must last long enough to permit the tubes to deionize. This deionization appears to be hastened by the negative grid voltage applied during the off cycle for group A[4,5].

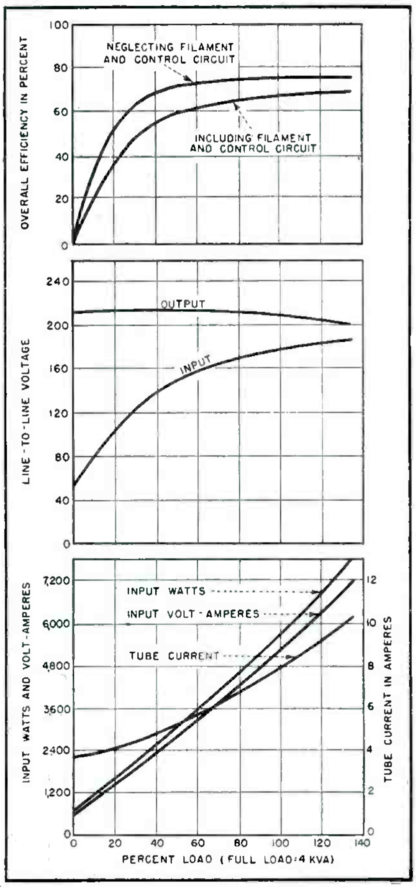

FIG. 3—Performance curves for cycloconverter power circuit

It is interesting to note that for the special case when the input frequency exactly equals the output frequency, six of the eighteen power tubes will be completely inoperative. If sustained operation is possible under this condition, then either the tubes should be chosen with ample capacity or some provision made to shift the output frequency slightly to prevent sustained operation.

Parallel Inverter

When operated as a frequency changer, the parallel inverter is basically a device using 3-phase input at one frequency to give single-phase output at another frequency. The anodes of six tubes are connected in pairs to the source, and the cathodes in two groups of three to the output transformer. Figure 2 shows how three such units are connected to give 3-phase output and shows also the neutral return for the supply lines. Tests on this circuit showed satisfactory operation but larger I^2R losses in the various transformers and chokes. The circuit also required an output transformer as well as the series reactor.

The overall efficiency, input voltage variation and power input of the cycloconverter are shown in Fig. 3.

Parallel Operation

The two types of frequency changers operate well in parallel, with load division on the alternators controlled by the voltage regulators as in a d-c system. Heavy resistive loads, even to the point of short circuiting the output terminals, were carried with ease. Inductive loads require correction to nearly unity power factor for satisfactory operation, because of effects on both wave form and commutation. One-quarter hp motors start and operate normally. A 3-hp motor will start and operate normally, provided there is ample resistive load on the bus to stabilize the system.

Control Circuit

The control circuit, as mentioned, supplies a 3-phase 400-cycle square wave for the power tubes. It is these control circuits which are synchronized for parallel operation of two frequency-changer units as shown in Fig. 4. The basic frequency is determined by an 884 gas triode which discharges 2,400 times per second. These pulses are fed to the grids of three 6J5 triodes connected in a ring-of-three counter circuit[6]. Each 6J5 goes through an on-off-on cycle 800 times per second, and each tube operates 1/2,400 of a second after its predecessor in the ring. This gives 3-phase voltages at 800 cycles.

The final stage of the control circuit comprises three pairs of 6V6GT pentodes connected in a modified Eccles-Jordan circuit. The cathode, grid, and screen of each tube are in the flip-flop circuit and the anode is connected to the transformer which forms the output connection of one phase of the control. The tubes in each pair conduct alternately and thus produce in the transformer a 400-cps square wave of voltage. The vacuum tubes used in these counting circuits operated with much more stability than the gas triodes first used.

Output frequency is determined

by a single-tube inverter circuit. Referring to Fig. 4, capacitor C_1 is rapidly charged through tube V_1 to somewhat above line voltage by virtue of the inductance of the primary of transformer T_1. Since the cathode at this instant is positive with respect to plate and the grid is held negative with respect to cathode, the tube is extinguished. Capacitor C_1 then discharges through resistors R_1, R_2, until the combination of plate-to-cathode and grid-to-cathode voltages are such as to fire the tube. Capacitor C_1 is again rapidly charged. The cathode voltage has a sawtooth waveshape with sharp rise and slow decay.

The sawtooth voltage is fed through capacitors C_2, C_3, C_4 at the grids of tubes V_2, V_3, V_4 in the three-tube switching circuit. These tubes are biased in such a manner that at any instant two are conducting while the third is cut off. Each pulse of the sawtooth voltage causes the tube which is cut off to conduct and causes one of the other two tubes to cease conducting. The cutoff condition passes from one tube to the next in definite sequence.

In Fig. 4, assume tube V_2 to be nonconducting and tubes V_3 and V_4 to be conducting. The plate of tube V_2 is near supply potential and, by means of the voltage dividing resistors R_4 and R_7, tends to hold the grid of tube V_3 at or above cathode potential. Also, by means of resistors R_{11} and R_8, the plate of tube V_2 tends to hold the grid of tube V_4 at or above cathode potential. Tubes V_3 and V_4 are held conducting. When conducting, the plate potential of tubes V_3 and V_4 is approxi-

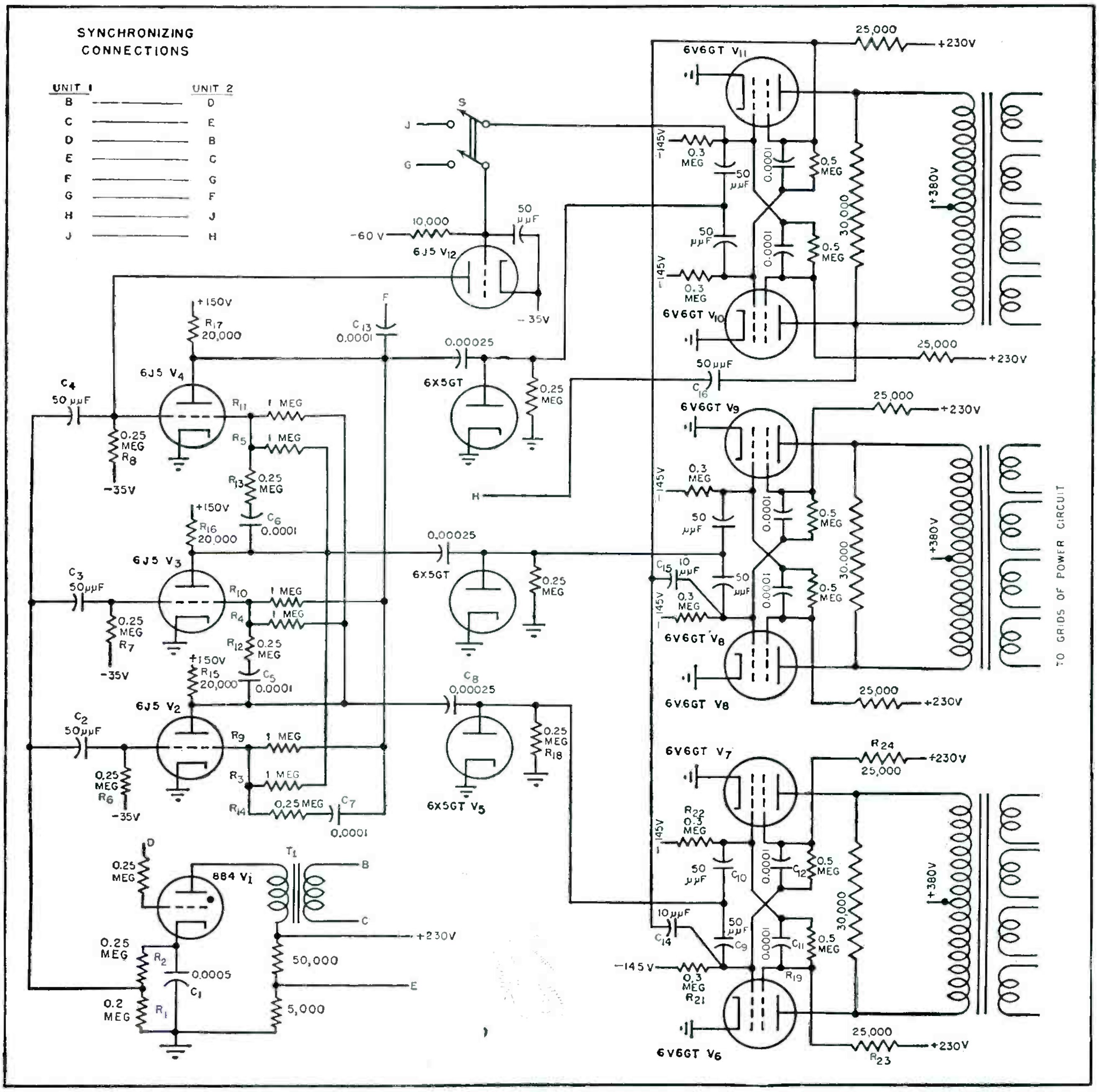

FIG. 4—In the control circuit, a 2,400-cycle relaxation oscillator drives a ring-of-three counter that develops three 800-cycle square-wave output voltages having 120-degree phase relationship. Each of these voltages drives a flip-flop circuit coupled to the thyratron

mately one-third the supply-to-cathode voltage. By means of resistors R_3, R_9, and R_6, the grid of tube V_2 is held sufficiently negative with respect to cathode to block the flow of plate current. When the next upward sawtooth voltage pulse is transmitted through capacitors C_2, C_3, and C_4 to the grids of all three tubes, the grid of tube V_2 is made less negative with respect to cathode causing plate current to flow. As soon as plate current flows, the plate voltage drops by virtue of resistor R_{15}. This drop, being transmitted to the grids of tubes V_3 and V_4, tends to reduce the plate current in these tubes. At the same time, the grid of tube V_3 is given an additional downward kick by capacitor C_5 and resistor R_{12}. Consequently, the plate voltage of tube V_3 rises faster than that of V_4. Tube V_3 assumes control by holding tubes V_2 and V_4 conducting. The next upward sawtooth voltage pulse renders tube V_3 conducting and tube V_4 is selected by capacitor C_6 and resistor R_{13} to become nonconducting. The next pulse renders tube V_2 nonconducting, and the process continues in this manner.

The plate-to-cathode voltage from tube V_2 is clipped to form an inverted saw-tooth wave. The clipping circuit consists of tube V_5, capacitor C_8, and resistor R_{18}. On the positive swing of the input voltage, tube V_5, being a diode rectifier, passes current causing capacitor C_8 to be charged with the input side positive. On the downward swing of the input, a voltage suddenly appears across resistor R_{18}. During the horizontal portion of the input voltage, the charge on capacitor C_8 gradually leaks off through resistor R_{18}. The cycle repeats on the next upward swing of the input voltage.

The inverted sawtooth voltage is transmitted to tubes V_6 and V_7 through capacitors C_9 and C_{10}. In the flip-flop circuit comprising tubes V_6 and V_7, consider first the part connected to screen grid, control grid, and cathode. The tubes are so biased that, in the steady state condition, one tube blocks current while the other passes current. Each input pulse from the clipper circuit reverses the condition on the tubes, that is, the one which was blocked is made to pass current and the one which was passing current is made nonconducting.

Assume tube V_6 blocked and tube V_7 conducting. Then the screen grid of tube V_6 is near line potential and the control grid of tube V_7 is held at or above cathode potential by means of the potentiometer circuit consisting of resistors R_{19} and R_{22}. Likewise the screen grid of tube V_7, because of the drop across resistor R_{24}, holds the control grid of tube V_6 below cutoff by means of resistors R_{20} and R_{21}. The next negative pulse from the input voltage drives the control grid of tube V_7 negative, reducing the flow of screen current. The rise in screen voltage transmits a positive kick through capacitor C_{12} to the control grid of tube V_6. The resulting rise in screen voltage on tube V_6 is transmitted through capacitor C_{11} to the control grid of tube V_7. The process once started, continues until the current is transferred from one tube to the other. A square voltage wave is obtained between screen grid and cathode.

The primary of a center-tapped transformer is connected between the plates of tubes V_6 and V_7 with the centertap connected to positive d-c line voltage. By connecting a resistor across the primary, a square output voltage can be obtained. Four secondary windings are provided for connection to the control grids of the FG-67 power tubes.

It will be noted there are three separate flip-flop circuits. Action of the other two is identical to that of the one explained.

Synchronization

The secondary of transformer T_1 in the plate circuit of tube V_1 transmits a transient pulse through connector pins B and C to connector pins D and E in control circuit 2. This pulse is further transmitted to the control grid of tube V_1 in control circuit 2, in such a manner to fire the tube, unless, of course, it is already conducting. Likewise, the secondary of transformer T_1 in the plate circuit of tube V_1 in control circuit 2 transmits a transient pulse to the control grid of tube V_1 in control circuit 1. Whichever tube fires first fires the other. The tube with the shortest period will determine the output frequency.

Tube V_{12} is used to synchronize the three-tube switching circuits in the two control circuits. Capacitor C_{13}, attached to plate of tube V_4 in control circuit 1, transmits a pulse to grid of tube V_{12} in control circuit 2 when synchronizing switch S is depressed. When tube V_4 in control circuit 1 is blocked, tube V_{12} in control circuit 2 is made conducting. Tube V_{12} holds the grid of tube V_4 in control circuit 2 below cutoff. In this manner, tube V_4 in control circuit 2 is made to be nonconducting during the same period tube V_4 in control circuit 1 is nonconducting. Once the circuits are brought into step, switch S may be opened.

In the flip-flop circuit, the tubes must fire in the following sequence: V_6, V_8, V_{10}, V_7, V_9, V_{11}. Capacitors C_{14} and C_{15} hold them in this sequence. Three of the six tubes are conducting at any given instant. From the above sequence it may be seen that when tube V_{11} becomes conducting, tubes V_6 and V_8 must be nonconducting. When tube V_{11} fires, a downward pulse is transmitted through capacitors C_{14} and C_{15} to the control grid of tubes V_6 and V_8, rendering the tubes nonconducting if they are not already in that condition.

There still remains a possibility of the flip-flop circuit in control circuit 2 being 180 degrees out of phase with the flip-flop circuit in control circuit 1. To bring them in step, a small capacitor C_{16} is connected from the plate of tube V_{10} in control circuit 1 through switch S to the grid of tube V_{11} in control circuit 2.

The three-tube switching circuit and the six-tube flip-flop circuit are synchronized by the same switch S. Both control circuits are connected so that either may be synchronized to the other.

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(4) W. G. Shepherd, Deionization Conditions in a Harmonic Generator Employing a Gas Tube Switch, *Proceedings IRE*, p 66, Feb., 1943.

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Filter Ripple Chart

Where choke input is used, output characteristics are readily predetermined. Curves are given for 50 and 60-cycle, half-wave and full-wave, and single and three-phase rectifiers. A rectifier attenuation table is included

By C. K. HOOPER

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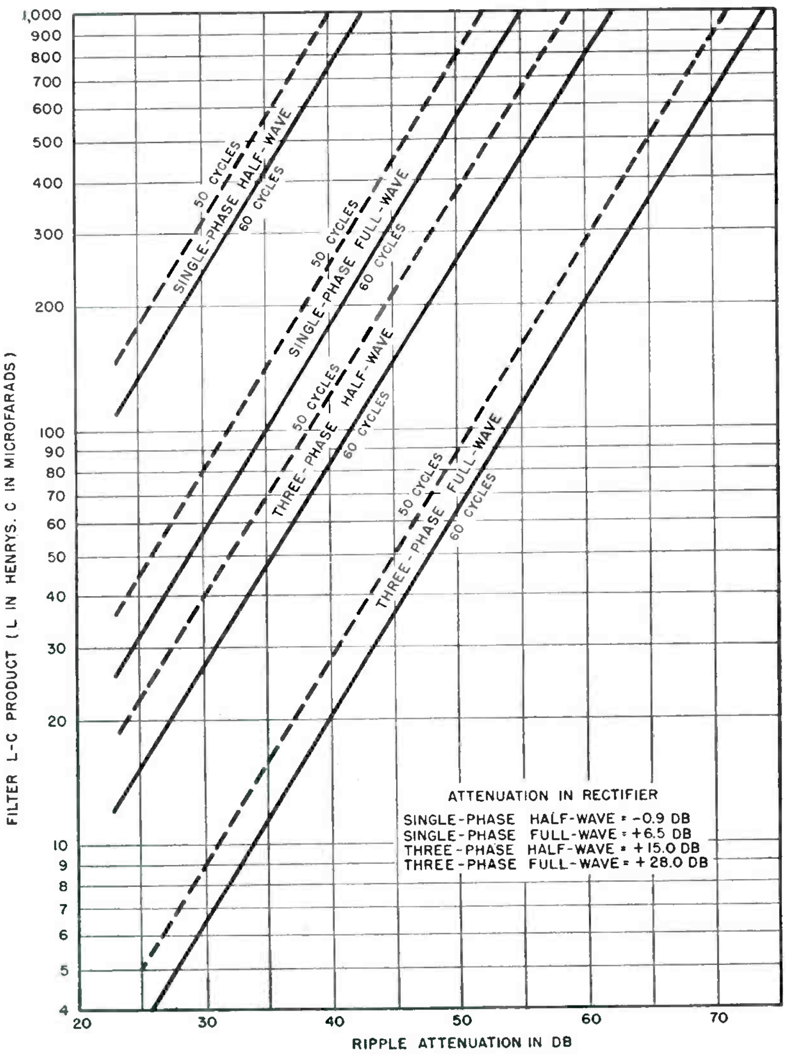
WHEN USING choke-input filters, the output ripple of rectifier-type power supplies can be predetermined from the accompanying chart.

It is necessary to know the inductance value, in henrys, and the capacitance, in microfarads, for each filter section. Knowing the product of these two terms, the amount of attenuation in db for each filter section can be read directly on the chart. Curves are given for 50-cycle (dashed lines) and 60-cycle (solid lines) power, for the four types of supplies most often used in industrial equipment.

To obtain the total output ripple in db below the d-c level, the equivalent rectifier attenuation must be added to that of the filter sections.



Practical Example

The following example will illustrate the use of the chart. Assume that a single-phase full-wave rectifier operating from a 60-cycle supply has a two-stage choke-input filter. One of the filters consists of a 2-henry choke and 15-μf capacitor. The other filter consists of a 2-henry choke and 20-μf capacitor.

For the first filter, with an L-C product of $2 \times 15 = 30$, the attenuation is read as 24.5 db. The second filter has an L-C product of $2 \times 20 = 40$ and the attenuation is read as 27 db. From the table the equivalent rectifier attenuation of a single-phase full-wave rectifier is given as + 6.5 db.

The total resulting ripple attenuation is the sum of that of the individual filter sections plus that of the rectifier. In this case, the total is $24.5 + 27 + 6.5 = 58$ db rms below the d-c level.

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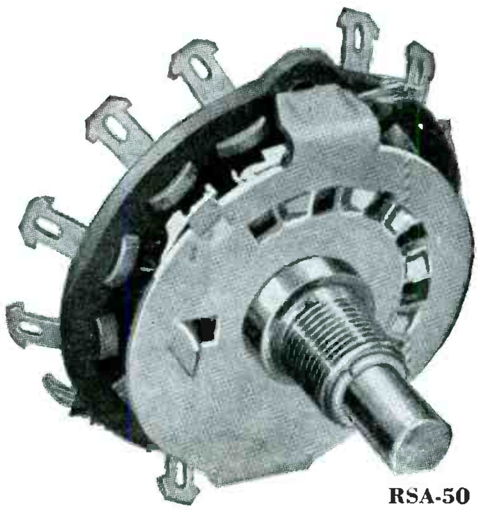
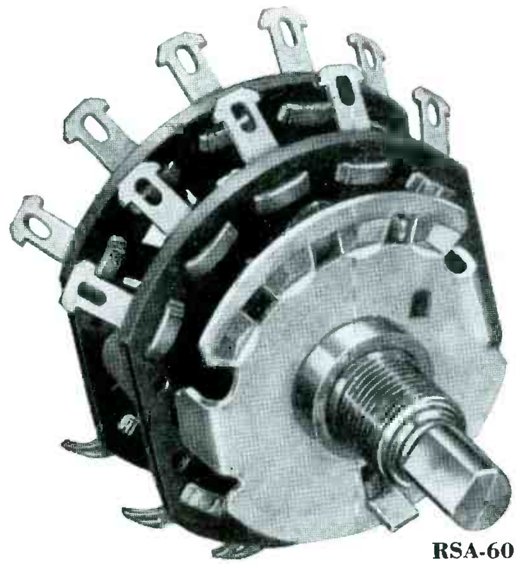


RSA-50



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These *new* circuit selector switches, with section and terminal design identical to that of the famous Mallory RS-50 and RS-60 switches, are designed for band and tone control switching in radio receivers and other electronic applications where medium and low torque indexing action is desired.

The index assembly is of durable design and constructed with a minimum of parts—affording dependable service life with low torque and positive indexing action.

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- **Insulation of high-grade, low-loss laminated phenolic.**
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- **Double wiping action on contacts with an inherent flexing feature—insures good electrical contact with the rotor shoes throughout rotation.**
- **Six rotor supports on the stator—insure accurate alignment.**
- **Brass rotor shoes, heavily silver-plated—insure low contact resistance.**
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The RSA-50 and RSA-60 are both available in one or two section construction. The RSA-50 accommodates up to twelve terminals on either side of the section and provides from 2 to 6 positions. The RSA-60 accommodates up to ten terminals on either side of the section and provides from 2 to 5 positions. The RSA-60 has the narrow section design—ideal for under chassis mounting, where space saving is paramount.

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Send for the Mallory Engineering Data Sheet on the RSA-50 and RSA-60. It contains complete specifications for available circuit combinations with respective terminal locations, dimensional drawings — everything the engineer needs to adapt the RSA-50 or RSA-60 switch to a particular circuit.

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Specification sheets for the RSA-50 and RSA-60 switches have also been prepared. These sheets are printed on thin paper to permit blueprinting. The sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to your requirements.

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TUBES AT WORK

Including INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Instrument for Intermodulation Measurements

By George Daniel
Western Electric Company
New York, N. Y.

Intermodulation measurement makes possible important findings on the subject of distortion not available by other methods. In intermodulation, the interaction of two frequencies is studied, the purpose being to discover the degree to which one frequency is modulated by the other.

More versatile than its predecessor, a new Western Electric equipment for making these measurements consists of a signal generator in which two independent frequencies are produced and combined and an analyzer in which the degree of modulation of the higher frequency by the lower is determined.

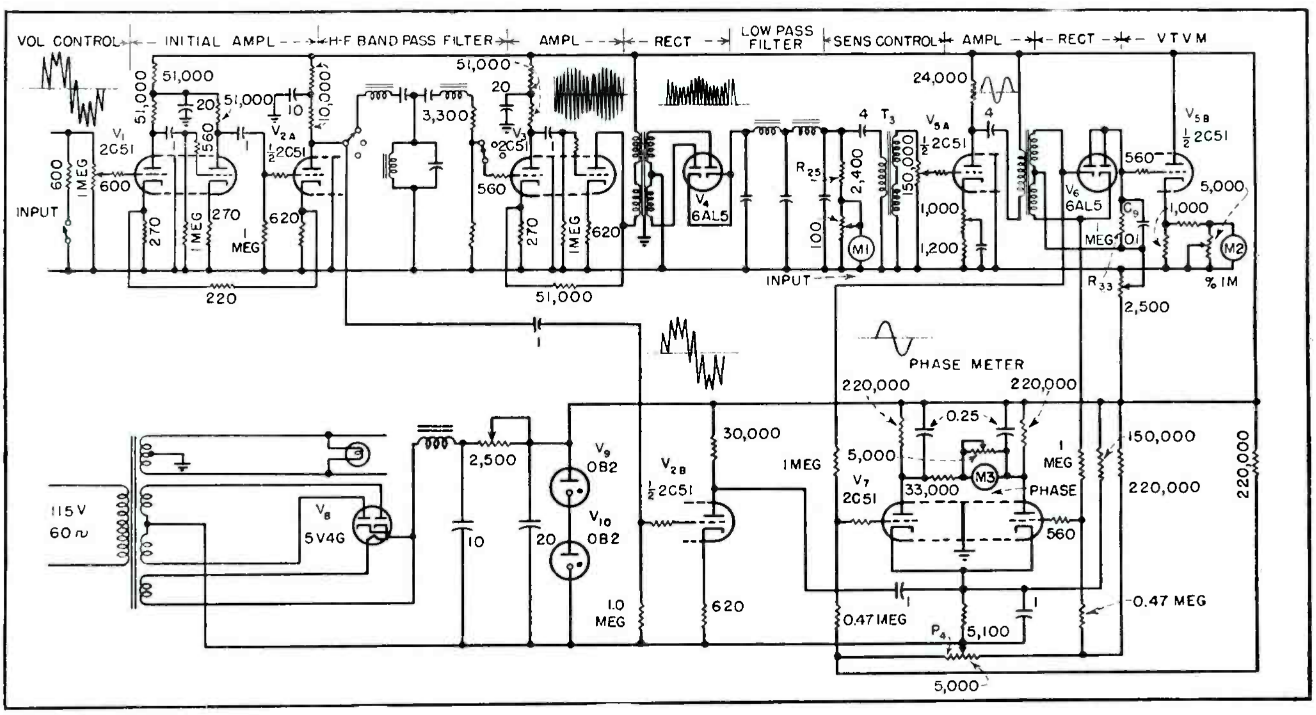
A novel feature of this measuring system is the inclusion of a phase meter which indicates whether compression is occurring on the positive or negative half of the input signal by comparing the phase relationship between the output of the low-pass filter and the low-frequency signal at the input to the analyzer.

Oscillators

In the signal generator two oscillators, each made of a 2C51 miniature dual triode in a resistance—capacitance tuned oscillator circuit, generate the low and high frequencies. Combinations of capacitors provide frequencies of 40, 60, 100, and 150 cycles from the low-frequency oscillator, while similar provision is made for the selection of high frequencies of 1,000, 2,000, 7,000, and 12,000 cycles. Each oscillator circuit includes a 1A type thermistor, or thermally sensitive resistor, which operates on one of the cathodes of each of the 2C51's and, together with a voltage divider, provides negative feed back. The thermistors increase the stability of the oscillator outputs by minimizing variations occurring with changes in gain.

Each oscillator feeds a three-stage amplifier consisting of both halves of a 2C51 and a final push-pull stage. The amplified high frequency is attenuated to 0, 6, 12, or 30 db in relation to the low-frequency output and the two outputs combined in a hybrid coil. The use of a hybrid coil makes possible the combining of the two frequencies with a minimum of intermodulation because each of the amplifiers is separated from the other. At low outputs and for most frequency combinations, this intermodulation is less than 0.2 percent.

In the third stage of the initial amplifier, the plate load is a filter



Schematic of the analyzer section of the intermodulation meter

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THE FRONT COVER

THE CHASSIS shown on this month's cover combines three amplifiers, one modulator, and pulse shaping and clamping circuits, of the Ludwig electronic-hydraulic high speed industrial computer. This unit solves continuously a differential equation involving error, integral of error and derivative of error.

The computer has been developed to solve problems of register in web processing, any manufacturing or converting operation involving a continuous sheet of material, as in printing, cutting, slitting, winding, and rolling. Processing registration accuracies up to and beyond 0.0001 inch on any web can be built into a control which will be fully automatic over a web speed range of ten to one.

The computer on the cover, shown with inventor John W. Ludwig, was adapted to multicolor registration on high-speed rotogravure presses. It holds color register to 0.0001 inch at web speeds ranging from 100 ft per min to 1,000 ft per min. Errors are corrected within 0.15 second. In the case of slow gradual errors, corrective control is thus anticipatory. Comparable accuracies and correction times are engineered into controls governing metal rolling, sheet metal processing, cutting, slitting, roll wind and rewind, fabric and synthetic web processing.

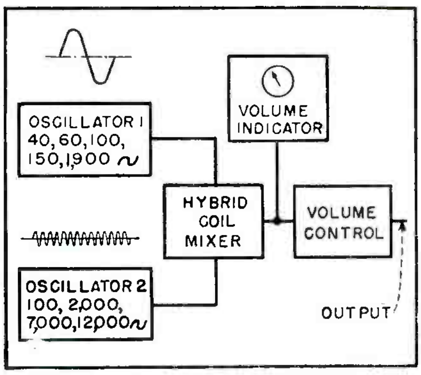
which may be selected by a switch as a band-pass filter of 1,500–2,500 cycles or a high-pass filter of 6,500 cycles. This signal is amplified by both halves of a 2C51 to produce an output of the high-frequency signal modulated by the low-frequency signal to a degree dependent upon the amount of intermodulation in the input signal.

The output of the high-frequency amplifier is rectified and filtered through a low-pass filter with a terminating resistor of 2,400 ohms, R_{25}. The amplitude of the low-frequency voltage impressed on this resistor is relative to the degree of intermodulation in the input signal, while the average current passing through R_{25} indicates the amplitude of the high-frequency input signal.

The low-frequency component from the low-pass filter is impressed upon the primary of transformer T_3, the secondary of which is connected to a variable attenuator which has provision for settings of 5, 15, 50, and 100-percent intermodulation, allowing full-scale intermodulation readings. The output of the attenuator is amplified by one-half of a 2C51 and this output rectified by the 6AL5 full-wave rectifier.

The voltage developed across R_{33} is applied to the grid of the other half of the 2C51 used in the low-frequency amplifier—a space-saving feature made possible by the shielding of the individual sections within the tube—and the triode used as a vtvm in connection with M_2, on which the percentage intermodulation is read directly. In the preceding rectification, the voltage polarity developed is always such as to make the grid negative with respect to ground. The cathode voltage is adjusted by a control on the front panel so that M_2 will read zero percent intermodulation by applying positive d-c voltage to the grid, increasing plate and cathode voltage.

Since the output of the rectifier V_4 is such as to make the grid of the vtvm more negative as the amount of intermodulation increases, the plate current and cathode voltage decrease with intermodulation increase, causing the pointer of M_2 to move.



Essential stages of the system for measuring intermodulation distortion

Although the new system will be of value in many fields where audio frequencies are used, it will be of particular importance in the measurement of intermodulation on variable density sound track where intermodulation occurs not only during recording, but within the film itself.

Application

To determine optimum processing and recording techniques, the output of the signal generator is adjusted so as to modulate the light valve about 1.5 db below the clash point, or the point at which the two ribbons of the light valve overlap in the path of the light beam, thereby providing the maximum safe modulation. Recordings are then


The signal generator and analyzer mounted on the rack form the two units of the Western Electric intermodulation test set for measuring audio-frequency distortion caused by intermodulation

made at several recorder lamp intensities and the negatives processed for various values of gamma. Positive prints are next made for each negative at several printer light values in a region which past experience has shown to be acceptable.

Each of the several positives is then run on a suitable reproducer and the output fed into the intermodulation analyzer. The print which gives the optimum reading in terms of intermodulation percentage is then used as a guide in making further, more specific tests by

(continued on p 150)

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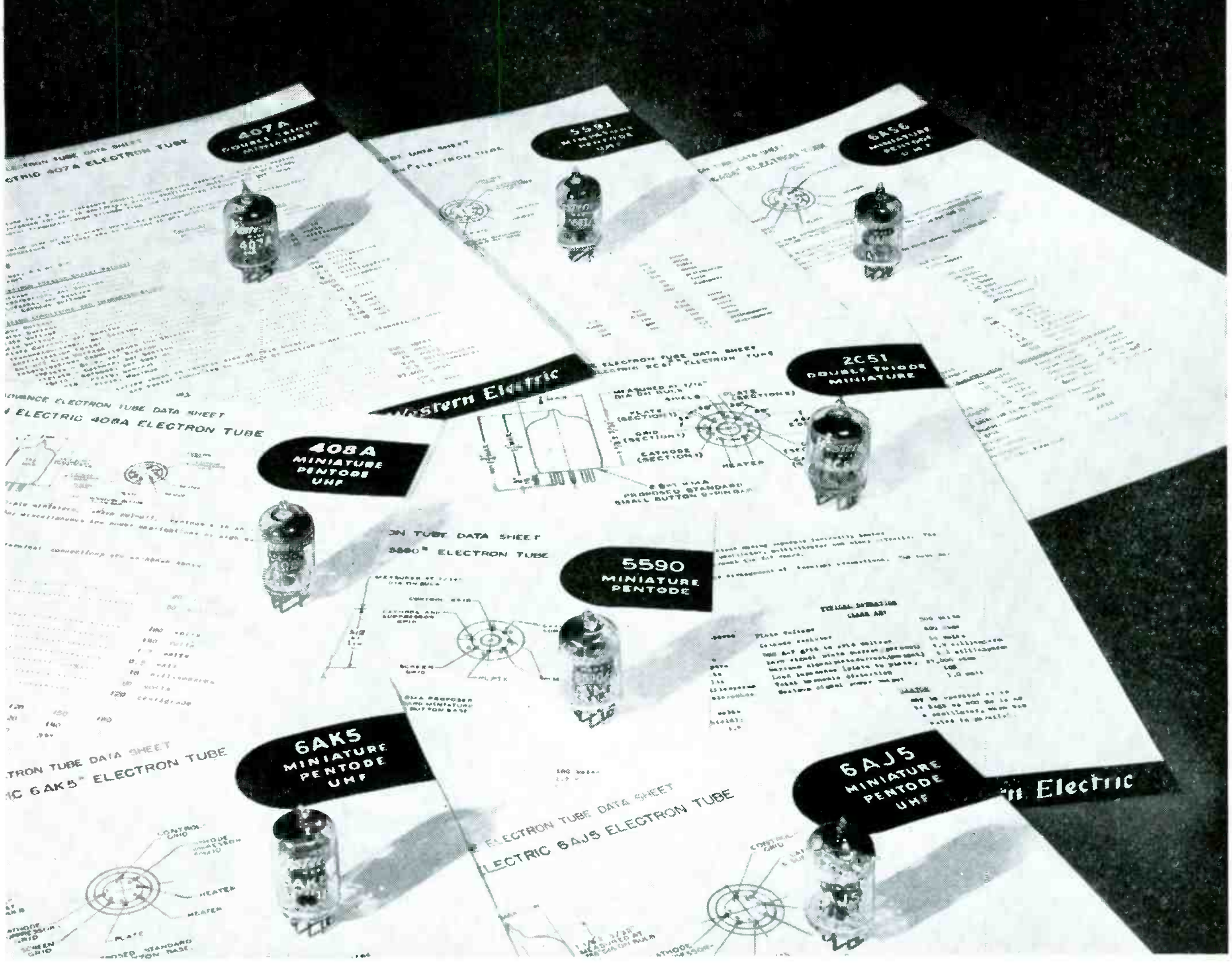

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6AJ5	Pentode	6.3	175	180
5590	Pentode	6.3	150	180
5591	Pentode	6.3	150	180
408A	Pentode	20	50	180
2C51	Twin Triode	6.3	30	300
407A	Twin Triode	20 (parallel)	100 (parallel)	300
		40 (series)	50 (series)	300

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THE ELECTRON ART

Edited by FRANK ROCKETT

Theoretical Requirements for Communication Systems

ADDITIONAL LIGHT was shed on new methods for determining effectiveness of communication systems in utilizing frequency spectrum, transmission time, and transmitter power to convey information from point to point in the presence of noise by W. G. Tuller, Project Engineer of Melpar Inc., before 120 members of the Princeton Section of the IRE on January 8 at Princeton University. After philosophizing as to whether communication systems convey information or intelligence, Mr. Tuller presented criteria by which such systems can be evaluated. The concepts, reported below, are extensions of the Hartley Law, which has been recently modified to include the effect of signal-noise ratio (ELECTRONICS, p 72, Jan. 1948).

Elements of Communications

To determine efficiency with which a communication system, the essential feature of which is usually the modulation, utilizes its transmission medium, the fundamental laws of communications need to be known. Knowing these laws, their influence on specific systems can be determined. However, here the interest is limited to the laws themselves.

Consider the simplified communication system of Fig. 1A. Laws governing this system can be deduced most directly by considering its abstract (mathematical) properties. Thus, the transmitter can be considered to map the information signal S from its two-dimensional (time and amplitude) aspect or space to the modulated carrier C in its multidimensional space, with a one-to-one correspondence between S and C. The receiver reconverts C to S. The information occupies a bandwidth F and continues for a time T. The carrier occupies a bandwidth B and (in this discussion) is transmitted for time T. White thermal (completely random) noise N unavoidably enters the system.

If there is any known correlation between parts of the signal of higher probability than between parts of the information that is to be transmitted, it should be removed before modulation; the signal will then have the same characteristic as white noise passed by the same bandwidth. (What is meant by the mathematical concepts of the foregoing statement can be illustrated by a typical example. An operator, in copying telegraphy through strong interference, is able to fill in unintelligible letters by knowing what the words ought to be. He correlates what precedes and follows portions of the signal to find out what the garbled portions are. In this case more letters are transmitted than the probability of the receiving operator's deducing them necessitates. Not all the letters needed to be transmitted in the first place for the operator to have deduced the complete message.) For example: because the amplitudes for the frequency components of speech decrease with increasing frequency, whereas the amplitudes of all the frequency components of noise are equal, pre-emphasis should be used to remove the amplitude-frequency correlation of speech.

At the receiver output, because of the noise, there is a region of uncertainty about the amplitude of the signal as shown in Fig. 1B. The noise N fixes the depth of this region. (The system must be designed to provide a maximum amplitude of the signal so that the signal-noise ratio meets the requirements of whatever service the channel is to be used for.) Therefore only $(1 + S/N)$ discrete amplitudes of signal can be distinguished. (The "one" arises from the fact that, if a line is cut by M intersections, it is divided into $1 + M$ segments, counting the ends as well as the segments between intersections.) The amplitude dimension of the signal is thus broken into a series of discrete levels. The signal is said to be quantized because of the parallel to the quantum theory. Quantization is done at the amplitude intervals that can be just distinguished in the presence of the finite noise.

It is unnecessary to transmit a continuously varying signal. Therefore the quantized signal can be sampled at the fastest rate at which it is expected to exhibit a distinguishable change in amplitude because of its finite bandwidth, as

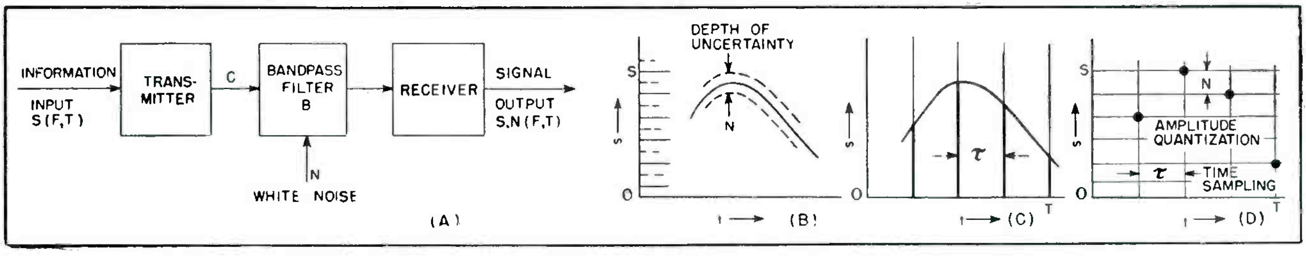


FIG. 1—Basic elements of simple communication system indicate that transmission can be by two-dimensional points

shown in Fig. 1C. Sampling produces T/τ samples in time T at intervals of τ, $\tau = 1/2F$, where F is the highest frequency component in the signal. The result of amplitude quantization and time sampling is a series of signal points as shown in Fig. 1D.

Because all information-bearing signals can be reduced to such points, the series of random points is the most general form of signal. Only the coordinates (time and amplitude) of these points need be considered in communication theory. In practice these coordinates are transmitted in any convenient way such as carrier amplitude modulation, frequency deviation, or binary pulse code. At the receiver the particular modulation process is performed in reverse.

Characteristics of Systems

The foregoing treatment shows that the number of two-dimensional information points is $2FT$, and that each one occurs at random from a set of $(1 + S/N)$ possible points. Therefore, to handle this signal, an area capable of handing $(1 + S/N)^{2FT}$ total signals is required, or the capacity H of the information signal space is

$$H = (2FT) \log (1 + S/N) \quad (1)$$

whereas heretofore the basic communication law has stated that the capacity was proportional to the product of the bandwidth and the time FT.

In a similar manner, the capacity for containing information of the carrier space is $(2BT) \log (1 + C/N)$. In designing a communication system, the capacity of the information space is made equal to that of the carrier space, so that $(2FT) \log (1 + S/N) = (2BT) \log (1 + C/N)$. To simplify the mathematics, assume that both information and carrier signals are well above the noise, so that the equation reduces to

$$(S/N) \gtreqless (C/N)^{B/F} : \text{Case I}$$

where the "less than" is necessary because of the immediately foregoing simplifications. In Case I the transmitter sends more or less than one point for each information point; that is, it maps into a higher or lower order space, as in pulse code modulation in which each information point is transmitted as several pulses of the code group.

If the transmitter sends one point for each point from the information signal, mapping into the same order space, the relation is the familiar

$$(S/N) \gtreqless (B/F)\ (C/N) : \text{Case II}$$

applying to a-m, p-m, and f-m. The characteristics of any communication system can be expressed by one of these two relations.

Examples of Realization

These theoretical considerations can be used to study properties of any method of modulation, or to determine minimum requirements for a given service. For example; if B/F is to be smaller than unity, when transmission occupies less bandwidth than the information, C/N must be large to maintain a useful S/N. Or in general, the capacity of the two portions (information and transmission) of the system are made equal by adjusting the signal-noise ratio to compensate for changes in bandwidth. In Case I the exchange of signal-noise ratio for bandwidth is exponential, in Case II the exchange is simply multiplicative.

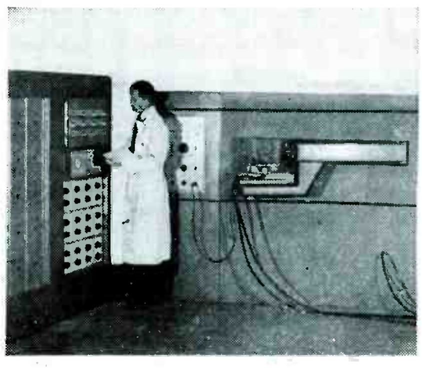
To visualize how wideband information can be transmitted in a narrow band, consider a generalized signal that consists of an amplitude-modulated pulse train. The amplitudes of three consecutive pulses of the train are 3, 5, and 7 units, the peak possible amplitude being 10 units. Instead of transmitting these three sharp pulses in rapid sequence, they can be converted, by complex terminal equipment operating along the lines of digital computers, into a single pulse 357 units in amplitude. This pulse can then be transmitted in the same time that the three would have required, and it can be much wider than any one of the original three. The transmitted bandwidth is thus reduced. If the amplitudes of the three original pulses are to be recovered to an accuracy of one part in ten, $S/N = 10$, the C/N will have to be 1,000. Because three information points are transmitted as only one point, this is a Case I system. The transmitted bandwidth would be about a third the information bandwidth.

Unfortunately, in Case II systems, bandwidth can be reduced only by increasing transmission time because, as originally postulated, each information point is transmitted as a single transmission point. The most obvious example of a narrower band Case II system is that based on recording the message and transmitting the record at low speed. This method requires consideration of message duration, the law for which has long been known and need not be reviewed here. In general, Case II systems are best used to improve signal-noise ratio by increasing bandwidth, as is done in frequency modulation. In this instance $(S/N) = \sqrt{3}(C/N)$, the $\sqrt{3}$ arising because a rectangular spectrum is assumed in the derivation, but is not used practically.

Although terminal equipment for such systems is costly, being both more complex and requiring higher transmitter power, it may be justified by the necessity to provide facilities for the growing volume of communication to be handled in the available frequency spectrum.

Recording Spectrometer

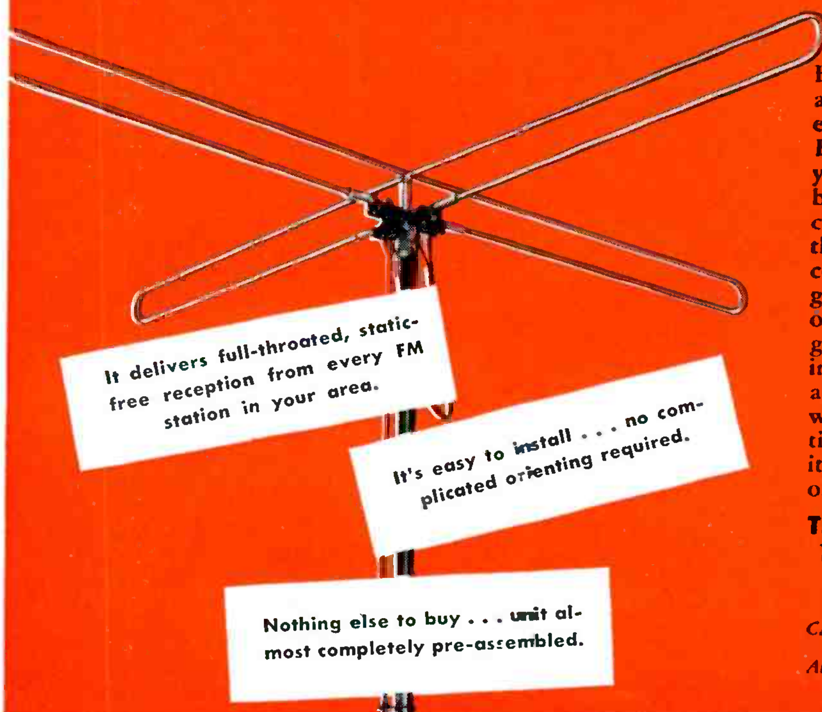
QUANTITATIVE ANALYSIS of low-alloy steels can be made quickly with a direct reading spectrometer containing 12 light receivers. The instrument comprises a conventional exciter for producing a high intensity spectrum from the metallurgical sample to be analysed, and a grating spectrometer producing a long focal curve. To obtain direct indications of percentages of alloys present, 12 light receivers with in-



Industrial materials can be analysed in a minute with this direct-reading

(continued on p 174)

This amazing WARD aerial sells FM better than 10,000 words!



THE SMARTEST WAY TO MERCHANDISE FM

Every FM receiver needs an outdoor dipole aerial and, when you hear the amazing difference this new Ward Magic Wand* makes in FM reception, you'll be sold solid. For, then you'll agree there's only one way to sell, or buy, FM . . . that's with aerial installation included. Equally efficient from all directions, this new broad band turnstile folded dipole continues to get all stations in your area regardless of how many more are yet to come on the air. Equal in signal strength to a high-gain folded dipole, it has a quarter-wave phasing loop which places elements 90 degrees apart electrically. Construction is all-metal, weather-proof. Complete fittings for installation included. Stock it, demonstrate it and sell it to present owners, and future purchasers, of FM radios!

THE WARD PRODUCTS CORPORATION
1530 East 45th Street, Cleveland 3, Ohio
DIVISION OF THE GABRIEL COMPANY

EXPORT DEPT.:
C. O. Brandes, Mgr., 4900 Euclid Ave., Cleveland 3, Ohio
IN CANADA:
Atlas Radio Corp., 560 King St. W., Toronto, Ontario

**Trade mark registered*

WARD *Magic Wand**

NEW NON-DIRECTIONAL TURNSTILE FOLDED DIPOLE AERIAL FOR FM

BY WARD . . . WORLD'S LARGEST PRODUCER OF AERIALS FOR CAR AND HOME

Model FMT-56
Non-Directional Dipole

as advertised in THE SATURDAY EVENING POST

NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

Television Camera (1)

GENERAL ELECTRIC CO., Syracuse, N. Y. The 56-pound television camera is ten inches wide, ten inches high and twenty inches long. Designed primarily for studios, it

is mounted on a mobile dolly and may be operated with fingertip control. Acceptable pictures can be obtained at 50 foot-candles and f/3.5.

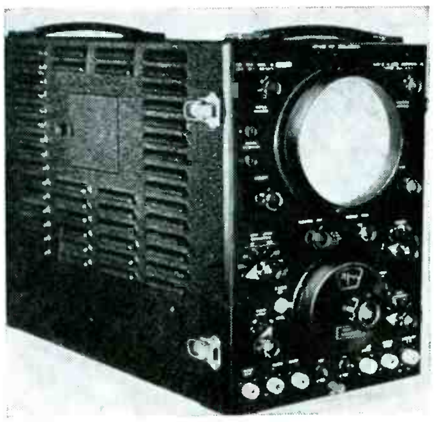
Sweep Calibrator (2)

BROWNING LABORATORIES, INC., Winchester, Mass. Model GL-22 sweep calibrator is a pulsed timing

marker oscillator designed for use with standard oscilloscopes for the accurate measurement of time intervals on either triggered or recurrent sweeps. Markers available are 0.1, 0.5, 1.0, 10, and 100 microseconds. Operation of the calibrator can be by use of external synchronizing triggers or from its own trigger generator.

Industrial CRO (3)

ALLEN B. DU MONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. The new type 256-D cathode-ray



USING THE NUMBERS

Readers desiring further details concerning any item listed in the New Products department can obtain the information by using the cards furnished as a stiff, colored insert elsewhere in this department.

Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet. Unnumbered items listed at the end should be procured direct from the manufacturer or publisher upon payment of the fee noted.

oscilloscope includes special features for various industrial and research applications. Provision is made for internal calibration of sweep circuits. Accelerating potential of 4,000 volts produces a clear trace. Sweep speeds from 4 to 4,500 microseconds can be selected in 6 ranges, while expanded and delayed portions of the above sweep are also available at speeds of 4, 10, or 25 microseconds. There are other special features.

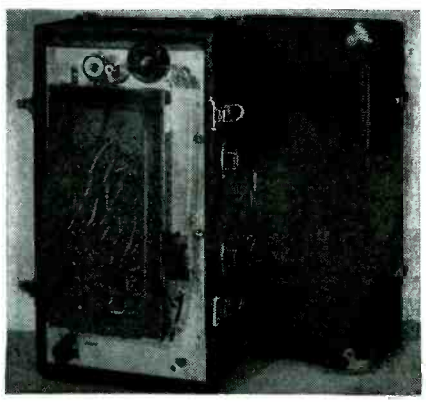
Noise Suppressor Amplifier (4)

FISHER RADIO CORP., 41 East 47th St., New York, N. Y. A new wide-range amplifier that embodies the

Scott dynamic noise suppressor shows only 1 percent distortion at 20 watts output, has less than 0.5 percent intermodulation distortion at 5 watts output, and exhibits uniform response within plus or minus 1 db from 20 to 20,000 cycles. The amplifier is priced at $254.50.

Talking Ads (5)

MAGNECORD, INC., 304 W. 63rd St., Chicago 21, Ill. AudiAd is a magnetic tape recorder that plays back a total of more than 60 seconds of speech or other sound, either continuously or in brief segments, after being tripped by a light-beam



This RAYTHEON Subminiature Tube...

Inside *this* Probe (actual size)...

Helps Make this WESTON High Frequency Electronic Analyzer, Model 769, An Extraordinarily Useful and Dependable Instrument

This WESTON Instrument, employing the small probe, pictured, provides a stable vacuum tube voltmeter with a range up to 300 megacycles. Combined with this in the one instrument is a volt-ohm-milliammeter and a high impedance electronic volt-ohmmeter.

The handy sized probe permits ready measurement of high frequency potentials in restricted spaces. Its convenience in use and the stability and broad frequency range of the Instrument may be attributed in part to the use of the Type *CK 606 BX* Raytheon Subminiature Tube.

Why WESTON and other manufacturers of high grade electronic equipment use RAYTHEON Subminiature Tubes.

1. **Reduced Product Size . . . Increased Product Salability.** Raytheon filamentary Subminiatures are *flat*. Batteries can be tiny because of extremely low filament drain.
2. **Plug Into Standard Sockets.** All Raytheon Subminiatures can either be soldered in or plugged into readily available sockets.
3. **Raytheon Reliability** — the result of unique precision methods and eight years continuous production of long-life Subminiature Tubes.
4. **Readily Available From Stock** — over half a million on tap at all times. Over 30 types. Standard throughout the world.
5. **At Your Local Distributor's** — over three hundred Raytheon Special Purpose Tube Distributors ready to serve you quickly and intelligently.

Write for Data Sheets on Raytheon Subminiature Tubes

RAYTHEON

Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY
SPECIAL TUBE SECTION
Newton 58, Massachusetts

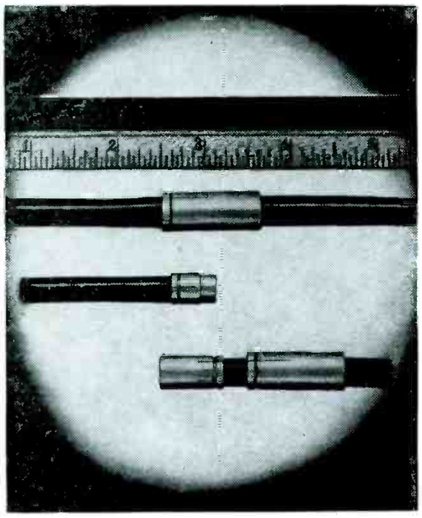
RADIO RECEIVING TUBES · SUBMINIATURE TUBES · SPECIAL PURPOSE TUBES · MICROWAVE TUBES or similar switch. Interchangeable magazines of magnetic tape can be recorded with advertising copy or the individual user can make his own recordings on the spot.

High Altitude Tube (6)

AMPEREX ELECTRONIC CORP., 25 Washington St., Brooklyn, N. Y. Developed for the Army Air Forces for use at high altitudes is a half-wave rectifier rated at 14,000 peak inverse volts. It delivers an average plate current of 125 ma and a peak current of 750 ma. The special tube-socket combination will handle voltages as high as 35,000 volts peak. Base of the tube is tapered and ground to fit the socket like a glass bottle stopper.

Miniature Connectors (7)

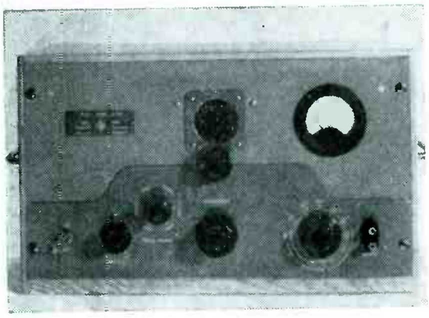
H. H. BUGGIE & Co., 2145 Madison Ave., Toledo 1, Ohio, manufacture a connector with an overall diam-



eter of 23/64 inch. It has a voltage rating of 500 volts peak with a low loss. The unit is solderless and requires minimum cable preparation.

Resistance-Tuned Oscillator (8)

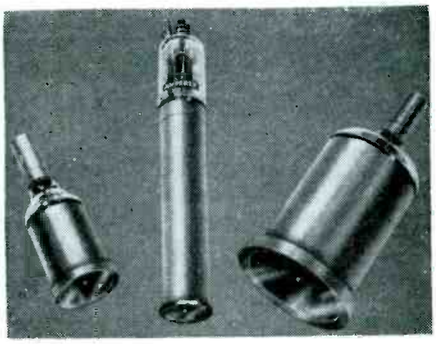
HEWLETT-PACKARD CO., 395 Page Mill Road, Palo Alto, Cal. Model 650A resistance-tuned oscillator is a wide-band precision instrument which provides output flat within



1 db from 10 cycles to 10 mc, and a voltage range of 0.00003 to 3 volts. Output impedance is 600 ohms or 6 ohms with output voltage divider.

G-M Counter Tubes (9)

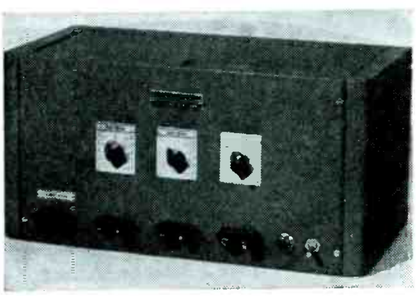
AMPEREX ELECTRONIC CORP., 25 Washington St., Brooklyn 1, N. Y. Physically redesigned for standard-



ized production the new series of Geiger tubes includes counter tubes for beta, gamma, and x-rays. Featured herein are direct bonds between mica and metal and mica and glass.

Multiple Power Supply (10)

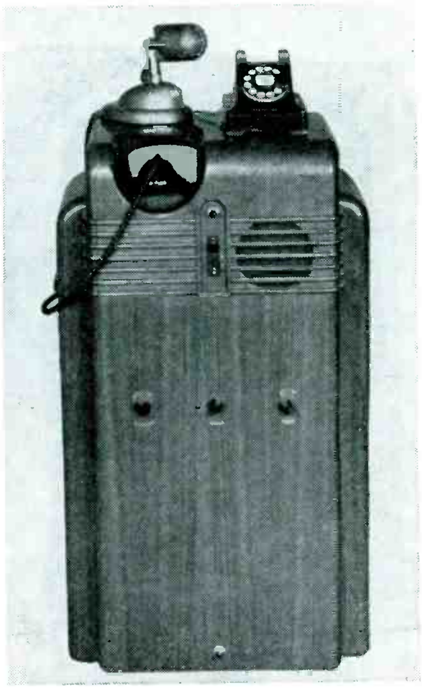
KEPCO LABORATORIES, INC., 142–45 Roosevelt Ave., Flushing, N. Y. Model 103 multiple power supply was developed to supply four commonly used voltages from a single compact unit. The power supply contains two continuously variable



B supplies delivering from 0 to 300 volts at currents up to 120 milliamperes, one variable C supply delivering from − 50 to + 50 v at 5 ma, and one heater supply delivering 6.3 volts at 5 amperes.

Group Telephone (11)

JORDANOFF AVIATION CORP., 595 Madison Ave., New York, N. Y. has begun limited production of the

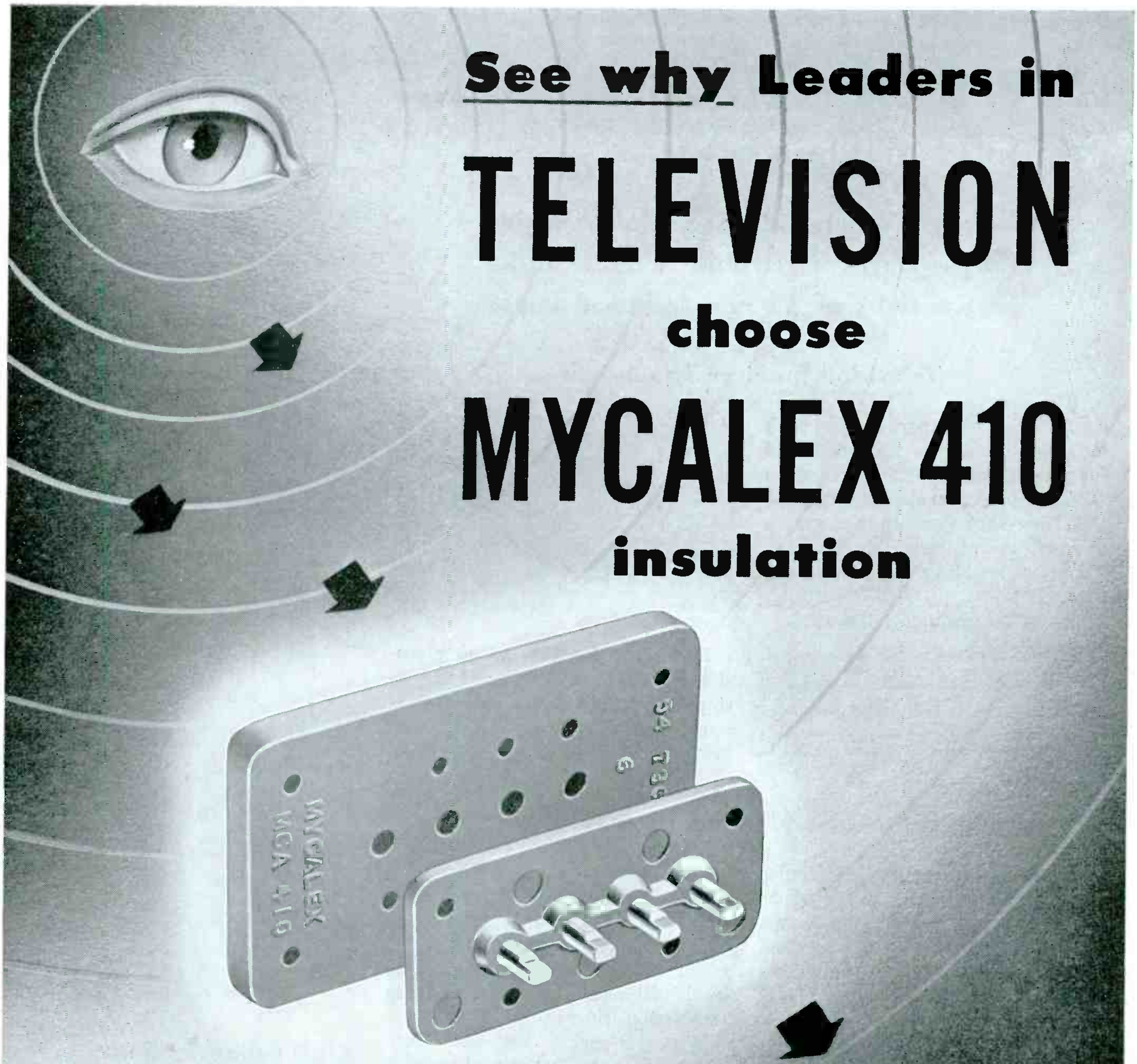


Jordaphone, a device which permits group telephone conversations without individual headsets. It consists of a regulation telephone, console cabinet and microphone. Impulses in the receiver are picked up by a coil in the console and amplified. In transmitting, the talker's voice is heard without amplification. A built-in receptacle cuts out all outside noises from both ends of the handset.

Well Sounder (12)

KEYSTONE DEVELOPMENT CORP., 2813 Westheimer Road, Houston, Texas. Sonolog is an instrument for the acoustic determination of the fluid level in the annular space between the casing and the tubing of an oil well. A small chamber attached to a casing at the surface

(continued on page 198)



In television seeing is believing . . . and big name makers of television sets are demonstrating by superior performance that MYCALEX 410 molded insulation contributes importantly to faithful television reception.

Stability in a television circuit is an absolute essential. In the station selector switch used in receivers of a leading manufacturer, the MYCALEX 410 molded parts (shown here) are used instead of inferior insulation in order to avoid drift in the natural frequency of the tuned circuits. The extremely low losses of MYCALEX at television frequencies and the stability of its properties over extremes in temperature and humidity result in dependability of performance which would otherwise be unattainable.

Whether in television, FM or other high frequency circuits, the most difficult insulating problems are being solved by MYCALEX 410 molded insulation...exclusive formulation and product of MYCALEX CORPORATION OF AMERICA. Our engineering staff is at your service.

Specify MYCALEX 410 for:

1. *Low dielectric loss*
2. *High dielectric strength*
3. *High arc resistance*
4. *Stability over wide humidity and temperature changes*
5. *Resistance to high temperatures*
6. *Mechanical precision*
7. *Mechanical strength*
8. *Metal inserts molded in place*
9. *Minimum service expense*
10. *Cooperation of MYCALEX engineering staff*

SINCE 1919 MYCALEX THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

MYCALEX CORP. OF AMERICA

"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J. *Executive Offices,* 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

New WWV time signal schedule; Marine Corps starts electronic warfare training; reviews of 11 new technical books

Television Receiver Symposium

EIGHT technical papers dealing with television receivers are scheduled for presentation Feb. 28, 1948 at an all-day symposium sponsored by the IRE New York Section, in the main auditorium of the Engineering Societies Building in New York City.

The program is as follows:

10:00 a.m.—Television Receiving Antennas, by Andrew Alford of Boston, Mass.
10:30 a.m.—Television Antenna and R-F Distribution Systems for Apartment Houses, by Heinz Kallman of New York City.
11:00 a.m.—Automatic Frequency Control of Television Sweep Circuits, by E. L. Clark of RCA Victor.
11:30 a.m.—Standards for Testing Television Receivers, by D. G. Fink of ELECTRONICS.
2:00 p.m.—Intermediate Frequencies for Television Receivers, by Paul F. G. Holst of Crosley Division, AVCO Mfg. Co.
2:30 p.m.—I-F Amplifiers for Intercarrier System of Sound Reception, by S. W. Seeley of RCA Laboratories.
3:00 p.m.—Television Tuners, by Alarico Valdettaro of Bloomington, Ind.
3:30 p.m.—Standardization of Transient Response of Television Transmitters and Receivers, by G. L. Fredendall of RCA Laboratories.

Moderator for the morning session is Arthur Loughren of Hazeltine Electronics Corp., and moderator for the afternoon session is Murray Crosby of Paul Godley Co.

Eta Kappa Nu Honors Young Electrical Engineers

ACTIVITIES in the field of electronics appear frequently in the biographical sketches of the six Eta Kappa Nu Recognition Award winners and the fifteen winners of honorable mention. Suspended during war years because security regulations prevented divulging the work of many candidates, the resumption of awards this year cites one outstanding young engineer and a number of honorable mentions for each of the years 1942 through 1947.

Achievements considered in making the selections stress cultural development and contributions to community, state, and national welfare as well as professional achievement. The name of each award winner is engraved on a bronze bowl displayed in AIEE headquarters in New York City and each winner is given a miniature replica of the bowl. Honorable mention winners received certificates.

Winners, with colleges from which they graduated and present business affiliations, are as follows:

RECOGNITION AWARDS

1942 John R. Pierce; California Institute of Technology, 1933; Bell Telephone Laboratories, Inc., New York, N. Y.

1943 Nathan I. Hall; West Virginia University; Hughes Aircraft Company, Culver City, Calif.

1944 Richard W. Porter; University of Kansas, 1934; General Electric Co., Schenectady, N. Y.

1945 James M. Wallace; University of Pittsburgh, 1935; Westinghouse Electric Corporation, Pittsburgh, Pa.

1946 Everard M. Williams; Yale University, 1936; Carnegie Institute of Technology, Pittsburgh, Pa.

1947 Richard R. Hough; Princeton University, 1939; Bell Telephone Laboratories, Inc., Whippany, N. J.

HONORABLE MENTIONS

1942 Gilbert D. McCann, Jr.; California Institute of Technology, 1934; California Institute of Technology, Pasadena, Calif.
David B. Smith; Massachusetts Institute of Technology, 1933; Philco Corporation, Philadelphia, Pa.

1943 Armig G. Kandoian; Harvard University, 1934; International Telephone and Telegraph Company, New York, N. Y.
James W. McRae; University of British Columbia, 1933; Bell Telephone Laboratories, Inc., New York, N. Y.

1944 William E. Ingerson; Hardin-Simmons University; Bell Telephone Laboratories, Inc., Murray Hill, N. J.
Ernst H. Krause; University of Wisconsin, 1934; Naval Research Laboratory, Washington, D. C.
Donald W. Pugsley; University of Utah, 1935; General Electric Company, Bridgeport, Conn.

1945 Wallace A. Depp; University of Illinois, 1936; Bell Telephone Laboratories, Inc., New York, N. Y.
Jack A. Morton; Wayne University, 1935; Bell Telephone Laboratories, Inc., New York, N. Y.
Edgar A. Post; University of Illinois, 1936; United Air Lines, Chicago, Ill.

1946 Benjamin B. Bauer; University of Cincinnati, 1937; Shure Brothers, Inc., Chicago, Ill.
Albert C. Hall; Agricultural and Mechanical College of Texas, 1936; Massachusetts Institute of Technology, Cambridge, Mass.
Donald L. Waidelich; Lehigh University, 1936; University of Missouri, Columbia, Mo.

1947 Marvin Camras; Illinois Institute of Technology, 1940; Armour Research Institute, Chicago, Ill.
Jerome B. Wiesner; University of Michigan, 1937; Massachusetts Institute of Technology, Cambridge, Mass.

AIEE Tube Conference

NEED for tubes having longer life and closer tolerances, for use in electronic instruments, has resulted in an AIEE tube conference to be held March 29 and 30 at the Benjamin Franklin Hotel in Philadelphia. Instrument and tube manufacturers, as well as engineers from industrial, commercial, and

1942
J. R. Pierce

1943
N. I. Hall

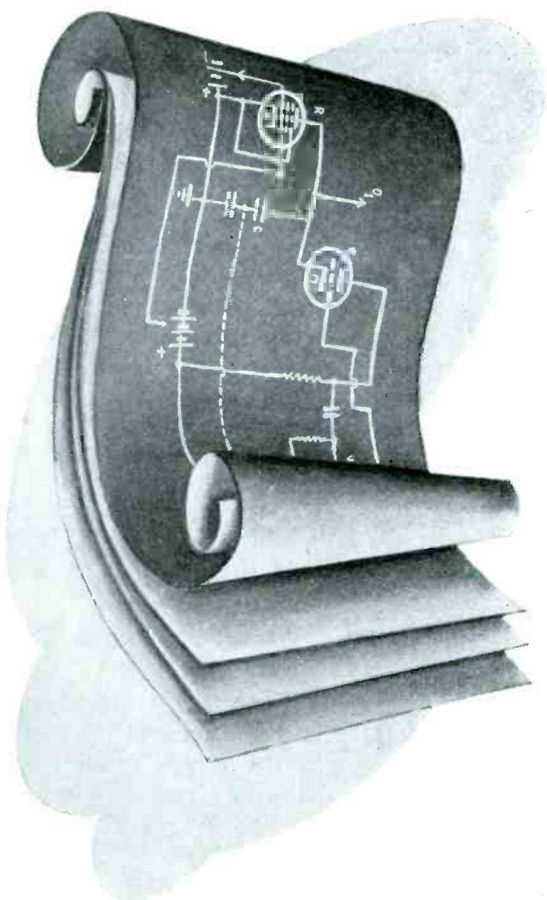
1944
R. W. Porter

1945
J. M. Wallace

1946
E. M. Williams

1947
R. R. Hough

Specialized Knowledge and Equipment for
UHF DESIGN



- The phenomena encountered in the UHF field are in many cases so decidedly different from those true of lower frequencies that many manufacturers find themselves in urgent need of specialized UHF knowledge, in order to develop equipment that will handle certain specific conditions.

- Since we are specialists in UHF engineering, we are equipped not only to render technical advice, but also to follow through in the actual production of equipment in our shops.

- If you are contemplating a new product, or have a problem involving ultra high frequency with present production, our specialized knowledge should be invaluable for quick, accurate, low unit cost. There is no cost or obligation involved in talking this over.

Lawvie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in the Development and Manufacture of UHF Equipment

university laboratories will convene. AIEE members will be admitted free, and the fee for nonmembers is $2.00. Requests for invitations should be addressed to C. C. Wilson, AIEE Headquarters, 33 W. 39th St., New York 18, N. Y.

Chicago Scientific Center

THE WESTERN Society of Engineers has signed an agreement with the John Crerar Library in Chicago, leasing three floors in the Taylor building, which adjoins the Library, and establishing a science and technical center for the use of professional persons, students, and others interested in the advancement of science. Included in the center is an auditorium seating 300.

The Western Society's 20,000-book collection is being coordinated with the 700,000-volume Crerar Library, largest free public library in the world devoted exclusively to science and technology.

Development of the new science center will cost the engineering society about $100,000.

New WWV Schedules

EFFECTIVE Jan. 30, 1948, time announcements from radio station WWV of the National Bureau of Standards were advanced one minute with respect to the former announcement scheme (see WWV Schedules, ELECTRONICS, p 87, May 1947). With the new system the audio frequencies are interrupted at precisely one minute before each hour and at each succeeding five-minute period, and are resumed precisely on the hour and each five minutes thereafter. The time announcement, in International Morse Code, refers to the end of the announcement interval (the instant when the audio tone frequencies are resumed), as indicated by the accompanying clock-face diagram.

These time signals are now broadcast continuously day and night on all of the eight carrier frequencies in use: 2.5, 5, 10, 15, 20, 25, 30, and 35 mc. A 440-cycle audio tone is transmitted on 2.5, 5, and 30 mc along with pulses at intervals of precisely one second. Both 440 and 4,000 cycle tones are transmitted on 10, 15, 20, and 25 mc along with the time ticks. Further details of WWV broadcast services are given in bulletin LC886, available on request from the National Bureau of Standards, Washington 25, D. C.

MEETINGS

FEB. 28: IRE Television Receiver Symposium, sponsored by New York Section; main auditorium, Engineering Societies Bldg., technical papers all day, starting at 10:00 a.m.

MARCH 22-24: Chicago Technical Conference, Stevens Hotel; meetings and exhibits; sponsored by 51 societies, including IRE, SMPE, and AIEE.

MARCH 22-25: IRE Convention and Radio Engineering Show, Hotel Commodore and Grand Central Palace, New York City.

MARCH 29-30: AIEE conference on electron tubes for instrumentation and industry, Benjamin Franklin Hotel, Philadelphia, Pa.

APRIL 1-3: AIEE Great Lakes District Meeting, Des Moines, Iowa.

APRIL 7-9; Midwest Power Conference, Sheraton Hotel, Chicago, Illinois. Three papers on supervisory control and telemetering at 2 p.m. April 9.

APRIL 17: IRE Engineering Conference, Chicago Section, Illinois Institute of Technology, Chicago.

APRIL 24: Spring Technical Conference of IRE Cincinnati Section, featuring television papers, at Engineering Society Headquarters.

APRIL 26-28: IRE-RMA spring meeting on transmitters, Syracuse Hotel, Syracuse, N. Y.

APRIL 28-30: AIEE North Eastern District Meeting, New Haven, Conn.

MAY 3-5: URSI-IRE joint meeting, Washington, D. C.

MAY 9-14: 1948 Radio Parts Show, Hotel Stevens, Chicago.

MAY 11-16: Engineering Progress Show, Franklin Institute, Philadelphia, Pa.: exhibits and two evening lectures.

JUNE 21-25: AIEE Summer General Meeting, Mexico City, Mexico.

AUG. 24-27: AIEE Pacific General Meeting, Spokane, Wash.

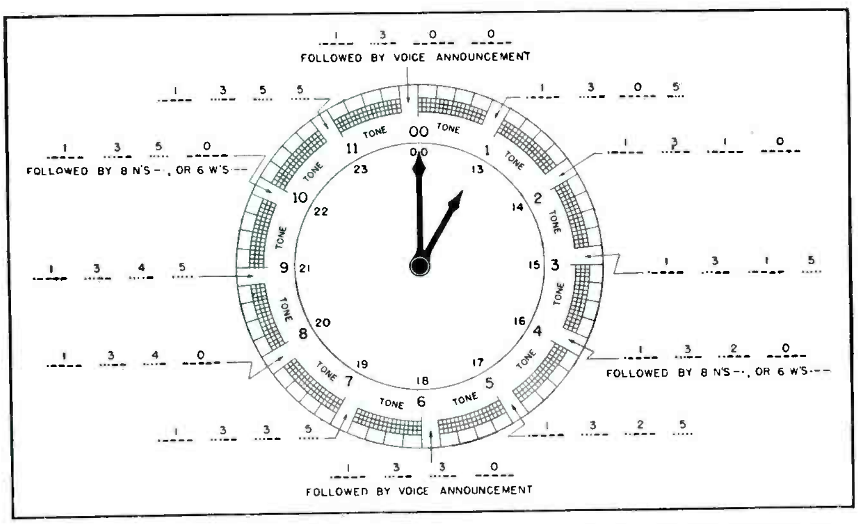
SEPT. 13-17: Third Instrument Conference and Exhibit, Convention Hall, Philadelphia, Pa.

SEPT. 27-Oct. 2: Third National Plastics Exposition, Grand Central Palace, New York City.

SEPT. 30-Oct. 2: Pacific Electronic Exhibition and IRE west coast Annual Convention, Biltmore Hotel, Los Angeles, Calif.

OCT. 5-7: AIEE Middle Eastern District Meeting, Washington, D. C.

OCT. 11-12: FM Association Second Annual Convention, Sheraton Hotel, Chicago.



Example illustrating new schedule of time announcements by station WWV. Hour illustrated is 1 to 2 p. m., or 1300 to 1400 in 24-hour time for Eastern Standard Time

Other Time Signal Services

The Naval Observatory, U. S. Navy Department, broadcasts time signals at regular intervals on the following frequencies: NSS (Annapolis, Md.)—122, 4,390, 9,425, and 12,630 kc; NPG (Mare Island, Calif.)—115, 9,255, 12,540 kc; NPM (Pearl Harbor, Hawaii)—16.68, 56, 4,525, 9,050, 13,575, 17,370 kc; NBA (Balboa, Canal Zone)—148, 5,005, 11,080 kc. Detailed information

(continued on p 246)

SIX SOLUTIONS TO YOUR D-C POWER PROBLEMS

Federal Selenium Rectifier Equipments

HERE'S FEDERAL'S line of standard D-C Power Supplies which offer you a convenient, economical and always *dependable* source of direct current for a wide range of industrial and laboratory applications.

These attractively styled, compact and efficient units are completely self contained—ready to connect to your a-c power supply—ready to supply d-c power wherever and whenever you want it. Because they are powered by Federal's long-life Selenium Rectifiers, their service life is practically unlimited—with no expendable parts which require frequent replacement. These equipments are conservatively rated, using the new heavy-duty stacks which assure a wide margin of safety to withstand momentary heavy overloads.

For complete information on these new d-c power supplies, write to Federal today—Dept. E 313.

Available for *IMMEDIATE DELIVERY*

1	**FTR 3300-DS**	D-C Output—2-32 volts, 50 amperes A-C Input—115 volts, 1-phase, 60 cycles
2	**FTR 3339-BS**	D-C Output—6-24 volts, 18 amperes A-C Input—115/230 volts, 1-phase, 50/60 cycles
3	**FTR 3128-BS**	D-C Output—22-30 volts, 10 amperes (filtered and regulated) A-C Input—115 volts, 1-phase, 60 cycles
4	**FTR 3341-AS**	D-C Output—28 volts, 5 amperes A-C Input—115 volts, 1-phase, 50/60 cycles
5	**FTR 3246-BS**	D-C Output—6 volts, 10 amperes (filtered) A-C Input—115 volts, 1-phase, 60 cycles
6	**FTR 1342-AS**	D-C Output—6 volts, 4 amperes (3 cells 6-3 amperes) A-C Input—115 volts, 1-phase, 50/60 cycles

FTR
An IT&T Associate

Federal Telephone and Radio Corporation

SELENIUM and INTELIN DIVISION, 900 Passaic Ave., East Newark, New Jersey

KEEPING FEDERAL YEARS AHEAD...is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N. Y.

TUBES AT WORK
(continued from p 136)

the same method, with printer light values and values of gamma of the negatives only a small amount greater or smaller than those previously found most satisfactory.

High-Frequency Crystal Voltmeter

By B. F. Tyson
Hazeltine Electronics Corporation Little Neck, N. Y.

A CRYSTAL voltmeter is useful in measuring the gain and response characteristics of the r-f and i-f circuits in f-m and television receivers. Such an instrument is physically small, and when built in probe form can be easily connected to the point of measurement. Inherently, it has high sensitivity and when used with a 10-microampere meter will indicate r-f voltages as low as 0.05 volt.

The voltmeter described here uses a type 1N28 crystal rectifier connected as shown in the circuit diagram of Fig. 1. Other crystals such as types 1N21 or 1N25 can also be used. On the input side, load resistor R_1 and a ceramic d-c blocking capacitor C_1 are built into the probe. On the output side, the r-f components of the rectified current are bypassed to ground through a button mica capacitor C_2 and the direct current to the microammeter is filtered by resistor R_2 and a button mica capacitor C_3.

The physical arrangement of the various parts is shown in the cross-section assembly view of Fig. 2. The smaller diameter half of the probe has the ground and high potential input tabs and contains the blocking capacitor and load resistor. The shielded microammeter lead is brought out of the other half which houses the button-type bypass and filter capacitors and the filter resistor. Note that the large end of cylinder B is made to slide fit into cylinder A and a clip from

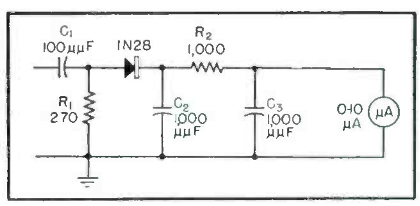
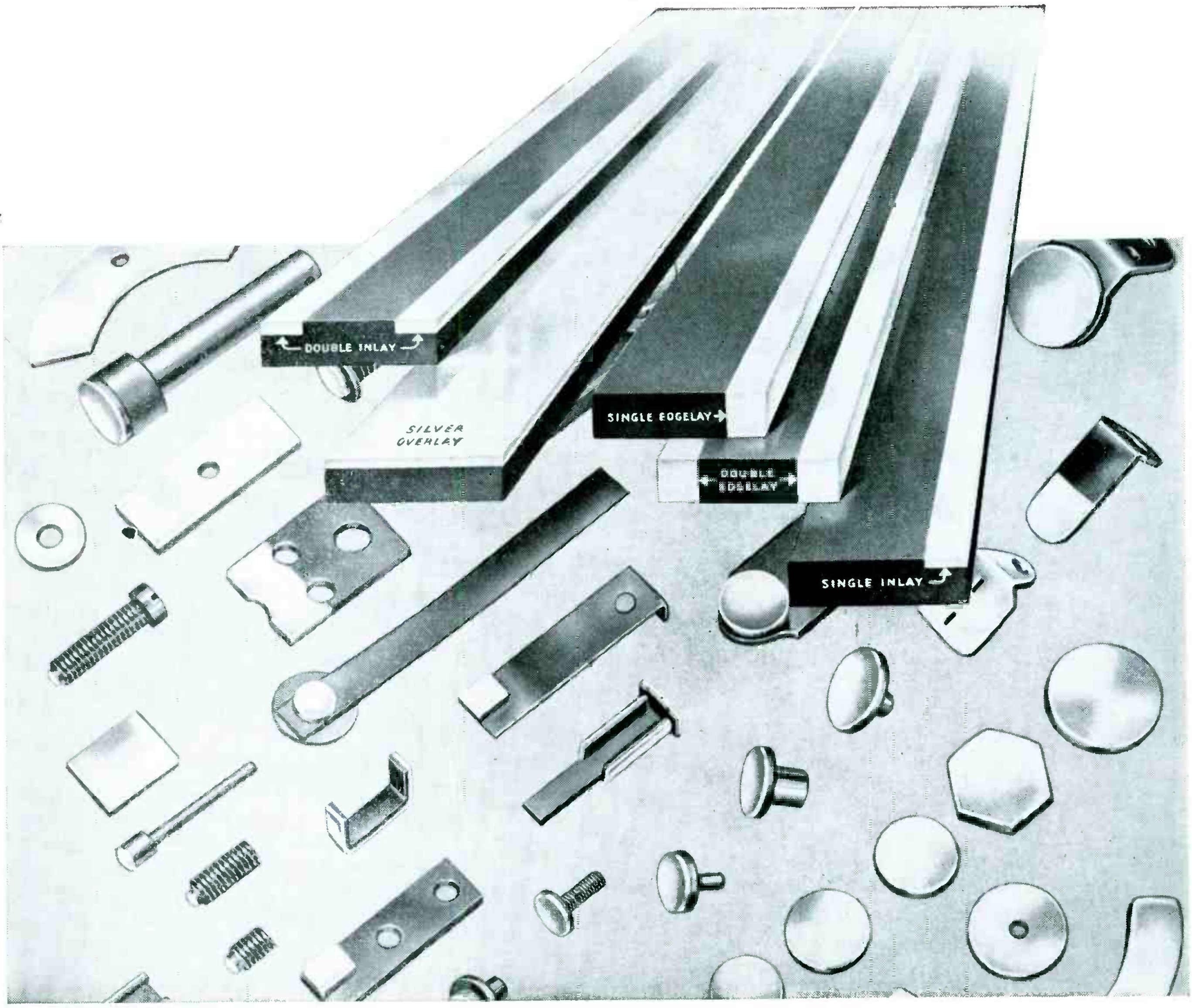


FIG. 1—Circuit diagram of crystal voltmeter



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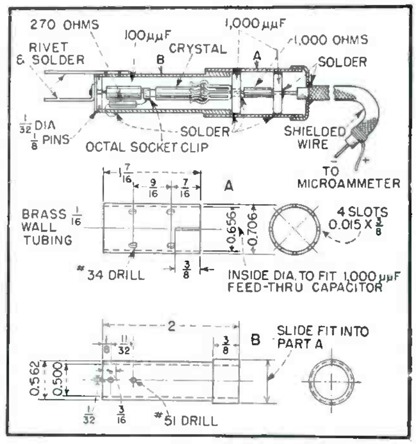


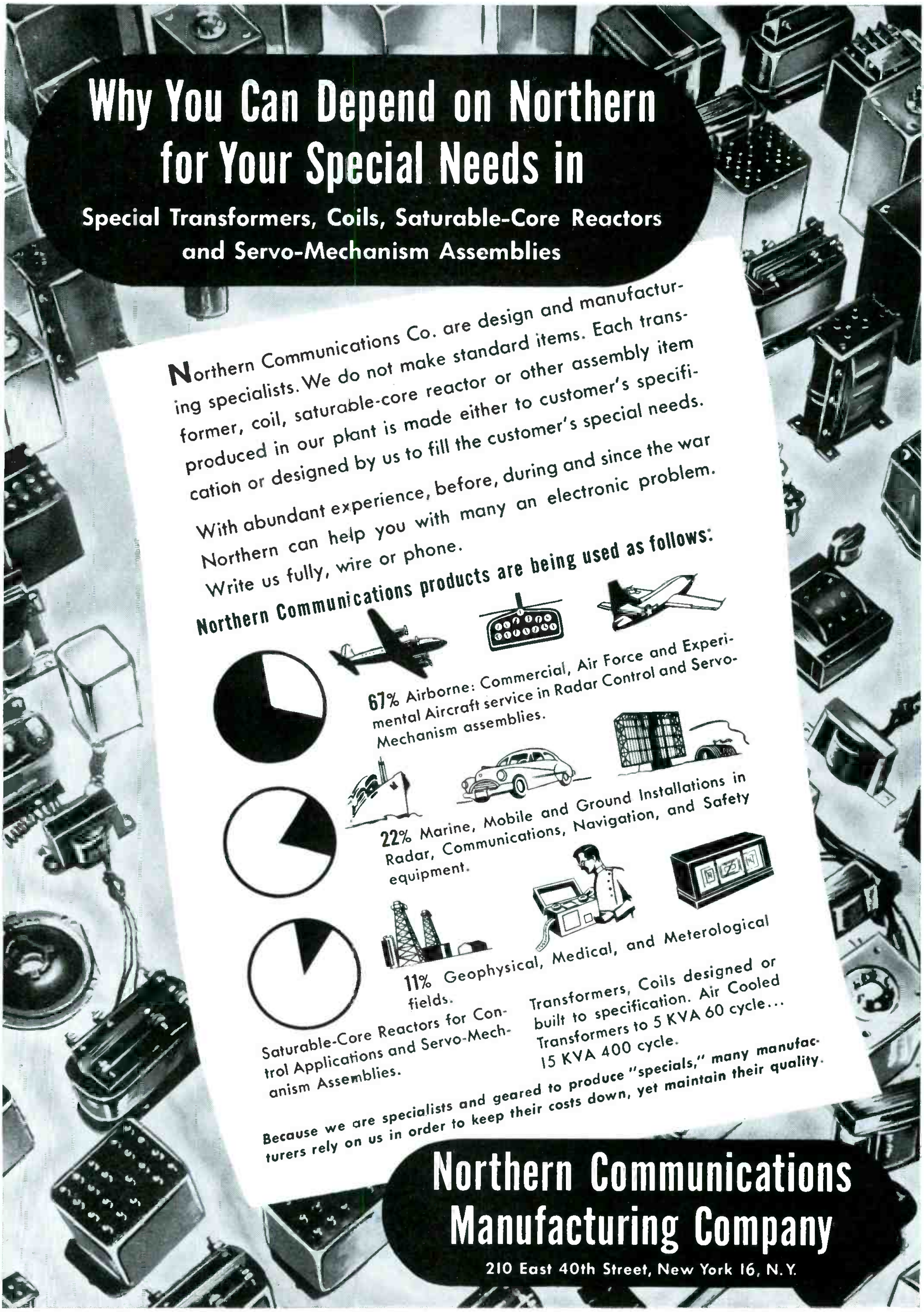
FIG. 2—Crystal probe assembly consists of two cylinders machined so the end of one slides inside the other for rapid replacement of crystal cartridge

an octal socket is soldered to the end of the 100-μμf Ceramicon capacitor to receive the contact of the crystal. The larger, probe end of the crystal is held firmly by a finger contactor. Thus, the entire probe is separable near its center for easy insertion of the crystal cartridge.

Fig. 3 is a typical calibration curve of the crystal voltmeter using a 1N28 crystal. Measured characteristics of several 1N28 crystals indicate that their sensitivities are in the order of 700 to 1,200 microamperes per volt squared and that they have square-low input-output characteristics only for inputs up to approximately 0.1 volt. The compact construction of the probe, minimizes lead inductances and stray capacitances, and the low value of load resistance, 270 ohms, serve to maintain an input-output characteristic substantially independent of frequency from 50 mc to at least 250 mc. At frequencies below 50 mc, the response falls off gradually.

The crystal voltmeter has been checked for susceptibility to burnout. Peak surges of 500 volts d-c or 130 volts, 60-cycle a-c have shown no effect on the calibration. Likewise, it has been determined that the crystal can withstand r-f voltages to produce approximately 1 ma of direct current, without effect on calibration. Higher r-f voltages, or mechanical shocks may, of course, cause a change in calibration or permanent damage.

The crystal voltmeter is intended for observation of r-f voltage across low impedances such as the output terminals of a signal generator or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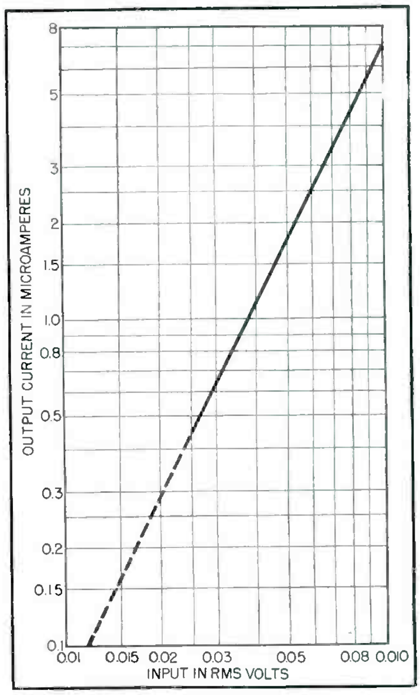


FIG. 3—Typical calibration curve of the crystal voltmeter using a 1N28 crystal

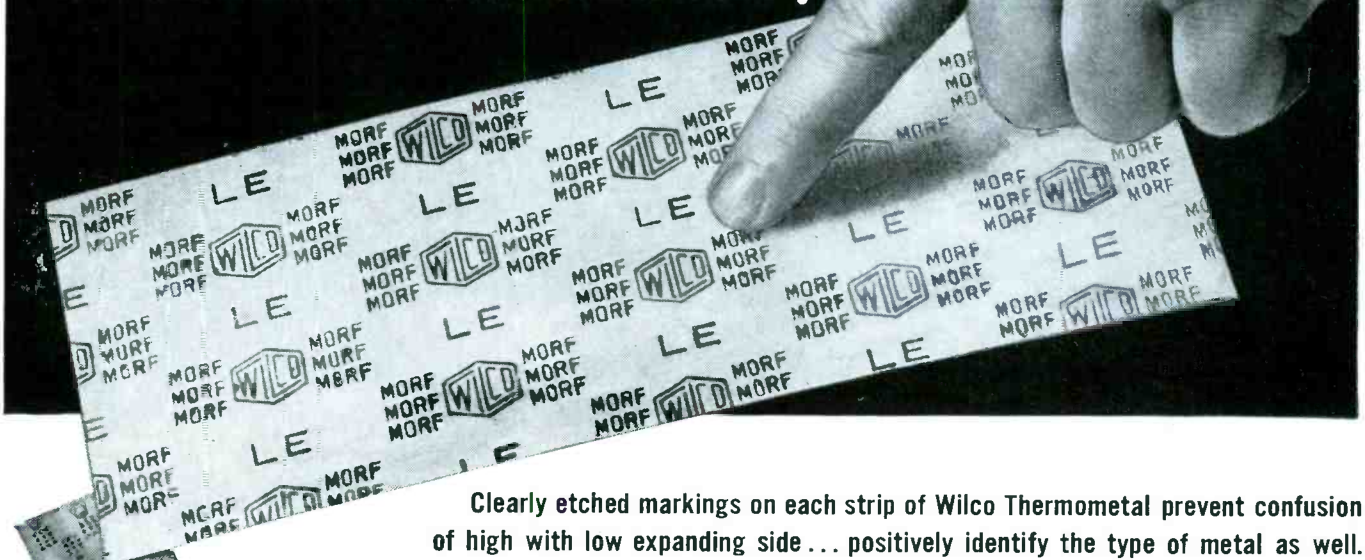
a low-resistance plate load of an amplifier tube. Care should be exercised in connecting the probe for high radio-frequency measurements to avoid excessive lead length and the addition of stray capacitance. When making measurements at low frequencies, say below 50 mc, it should be remembered that the 100-$\mu\mu$f d-c blocking capacitor has appreciable series reactance. It will be observed that the action of the microameter needle is somewhat sluggish due to damping by the crystal resistance. A short time should therefore be allowed for the needle to come to rest before reading the meter.

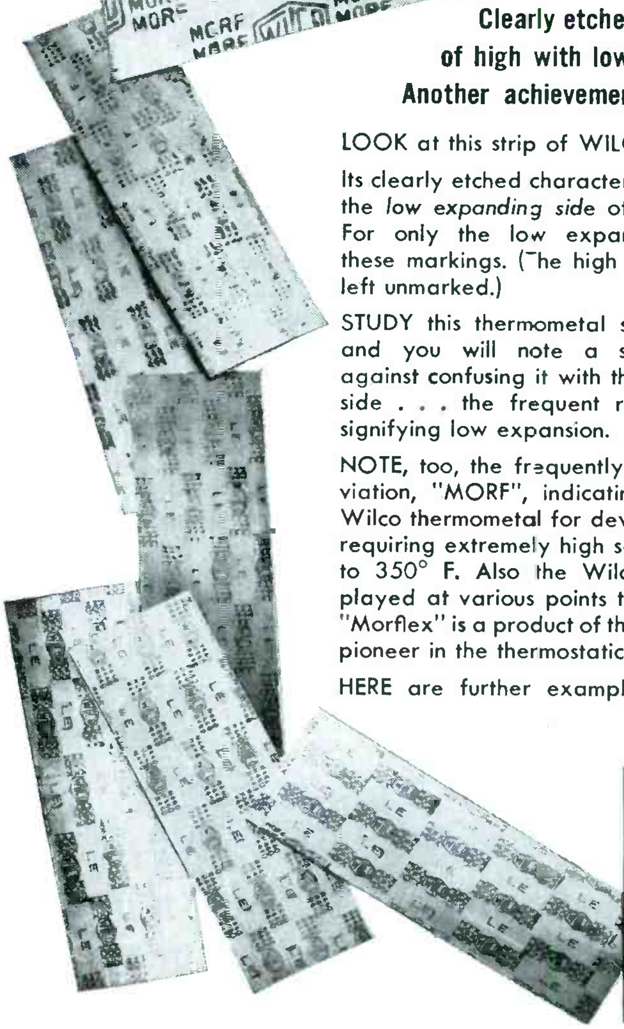
X-Ray Thickness Gage

GAGING without physical contact with the material under test, and access to areas never before gaged, are features of a new x-ray technique that consists of irradiating the material and measuring the drop in intensity through that material. Designed by Westinghouse engineer W. N. Lundahl for measuring the thickness of cold-rolled steel sheet and cold-rolled copper, the instrument should also prove applicable for use on hot materials like metal and glass sheet, and fragile materials like foil and paper. Readings are unaffected by

Wilco Announces

A new and positive method of bimetal identification!





Clearly etched markings on each strip of Wilco Thermometal prevent confusion of high with low expanding side... positively identify the type of metal as well. Another achievement by a leading pioneer in thermostatic bimetal developments.

LOOK at this strip of WILCO "Morflex."

Its clearly etched characters instantly identify the *low expanding side* of the thermometal. For only the low expanding side shows these markings. (The high expanding side is left unmarked.)

STUDY this thermometal strip more closely, and you will note a second safeguard against confusing it with the high expanding side . . . the frequent repetition of "LE", signifying low expansion.

NOTE, too, the frequently repeated abbreviation, "MORF", indicating "Morflex", the Wilco thermometal for devices or instruments requiring extremely high sensitivity from 50° to 350° F. Also the Wilco trademark displayed at various points to remind you that "Morflex" is a product of the H. A. Wilson Co., pioneer in the thermostatic bimetal field.

HERE are further examples that show the consistency with which Wilco carries this clear-cut method of identification throughout the entire line of 29 Wilco Thermometals, precluding any possibility of mistaking one type for another.

Another Wilco pioneering achievement

The H. A. Wilson Company is an American pioneer in the design and development of thermostatic bimetals. WILCO supplies these materials as sheet or strip, in partly or completely fabricated form, and as parts of assemblies for thousands of applications. All temperature ranges, deflection rates and electrical resistivities.

Now Wilco—which for 34 years has *majored* in the development and widespread application of thermostatic bimetals—pioneers again with an etching process that will help to make these Wilco products more than ever *precision products*.

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The gage consists of two x-ray sources and one phototube pickup. Relative to the two x-ray sources, the pickup is actually at the apex of a right angle but is illustrated for simplicity in Fig. 1 as being aligned vertically with the two x-ray sources. Radiation from the lower source is directed up through the sheet being gaged so that the transmitted rays will strike the pickup. Rays from the upper source are directed horizontally through a

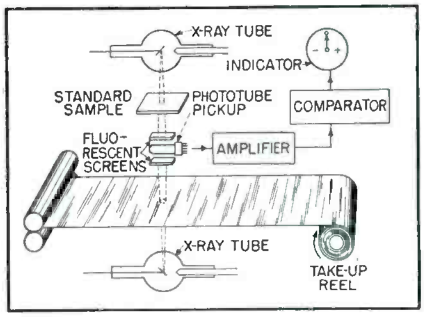

FIG. 1—Simplified schematic showing arrangement of units so that two x-ray beams strike the phototube pickup for comparison

standard sample of correct thickness to the same pickup. Radiations are emitted 180 degrees out of phase so that the rays alternate in striking the pickup and are compared in intensity after a large part of their radiation has been absorbed in the standard sample or test sheet.

Difference in the intensities of the rays is registered on the indicator instrument. At full deflection of the indicator needle a red light on the instrument goes on and a throw-out or other mechanism is actuated through electronic circuits.

Measures Glass Thickness

Equipment has recently been constructed for measuring the wall thickness of glass containers. In this system, the pickup is inserted within the container as shown in Fig. 2. It consists of a brass tube with one end opening to a housing containing the phototube and the other end cut on a 60-degree angle axially with respect to the tube. This diagonal cut has a fluorescent screen mounted in its plane. Thus the phototube looks down through the tube at the fluorescent screen.

A mechanical system brings the

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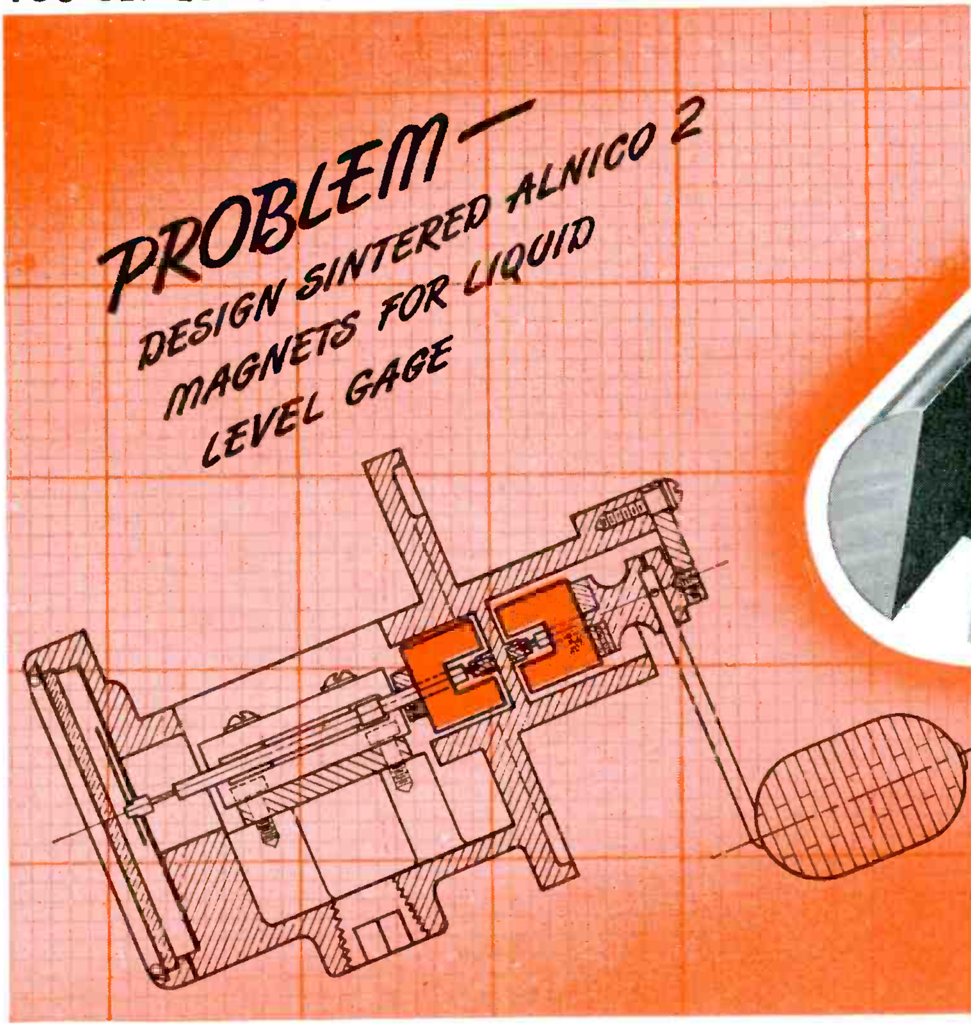
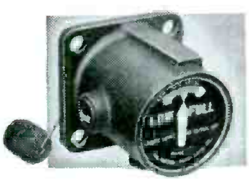


Here's another outstanding application for one of the many G-E permanent magnet materials—the magnetic liquid level gage manufactured by The Boston Auto Gage Company.

The Magnets that Guard your Transformer



Two G-E sintered ALNICO permanent magnets, separated by an aluminum diaphragm, function as a leakproof magnetic coupling in this gage to accurately indicate the level of the insulating liquid in transformers. The rise or fall of the float actuates the dial pointer by means of the coupling.

In addition to the large group of sintered and cast ALNICO permanent magnets, General Electric now offers you greater flexibility of magnet design with the ductile alloys CUNICO, CUNIFE and SILMANAL and the lightweight, non-metallic VECTOLITE. Be assured of receiving magnets of the highest uniform quality resulting from precise G-E production methods, accurate testing and rigid inspection.

Let us help you with your magnet application problems. General Electric engineers, backed by years of research and magnet design experience, are at your service. *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

SEND FOR our new bulletin, CDM-1, "G-E Permanent Magnets", specifically designed to help you with your permanent magnet problems.
This bulletin contains information about the characteristics and properties of G-E permanent magnet materials, their application and design.

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GENERAL ELECTRIC COMPANY
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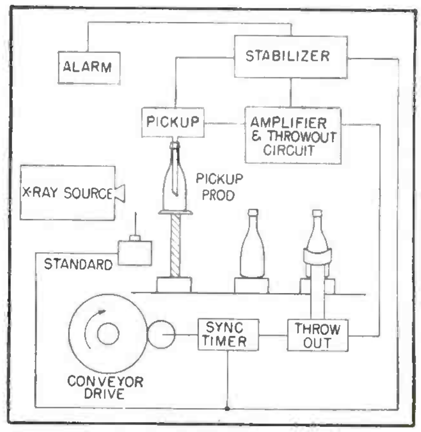

FIG. 2—A method of using the x-ray gage for measuring the thickness of a glass bottle

glass container up around the pickup tube, rotating the bottle at the same time. Thus a point on the container describes a helix and the bottle wall is effectively scanned. If the wall thickness at any point is less than a predetermined minimum value, the gaging circuits operate to discard the defective container.

The phototube pickup consists of a photomultiplier surrounded by a fluorescent screen and enclosed in a light-proof cover. Absorption of x-radiation in the fluorescent screen excites the compound of the screen to visible luminescence which is picked up by the phototube and converted into current pulses. The latter vary in amplitude according to the thickness of the material.

Gage Circuits

The gage circuit (see Fig. 3) consists essentially of a 6SJ7 amplifier, a 6H6 clipper and base line restorer, a 6AC7 saw-tooth converter, and a pair of 6AG7's used in a comparator circuit. A 6AC7 photomultiplier stabilizer, a 6AC7 amplifier for a cathode-ray indicator, and a 6H6 duplex diode rectifier for a bias supply are also located in the gage chassis.

The output signal obtained from the anode of the 931A photomultiplier is applied to the control grid of the 6SJ7 through conventional capacitive coupling. The photomultiplier anode is maintained approximately 255 volts d-c above ground through 1.5 megohms resistance from the power supply of the gage circuit. The amplified signal from the 6SJ7 is then applied to the 6H6 clipper. The anode of this clipper is maintained at a

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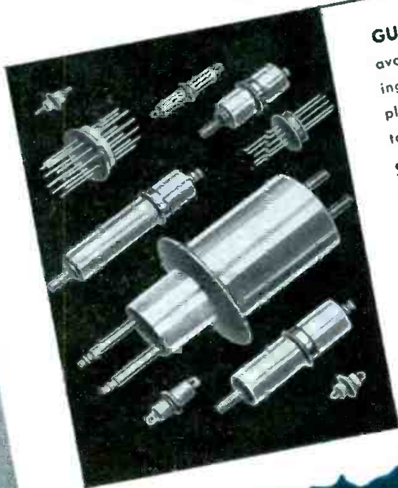

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GENERAL TOLERANCES: Unglazed surfaces, ±1% of the dimension involved but not less than ±.005". Glazed surfaces, ±2% of the dimension involved but not less than ±.010". Thickness dimensions are normally held to ±.012", unless otherwise specified.

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—AT ANY FREQUENCY

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negative potential with respect to the cathode. Thus, a positive pulse for the 6SJ7 will not be conducted across the 6H6 unless the pulse amplitude overcomes the bias between the elements on the clipper. Thus, by varying this d-c bias, the amplitude of the pulse as it may be applied to the next stage can be controlled.

The action of this tube also protects the indicating instrument in the event of thickness differentials

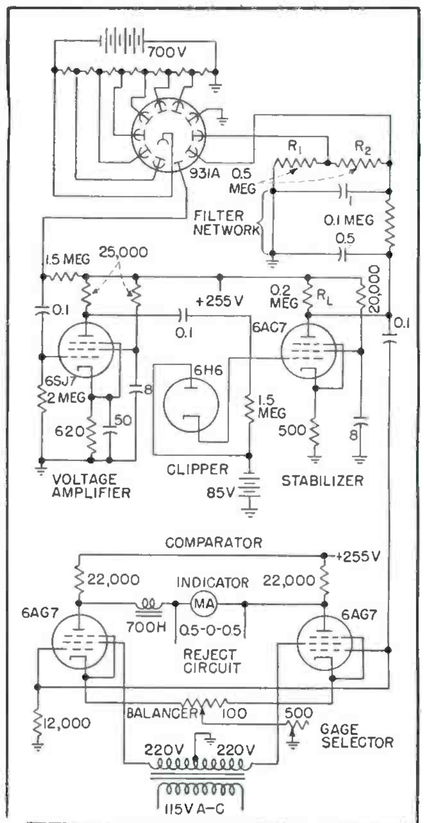
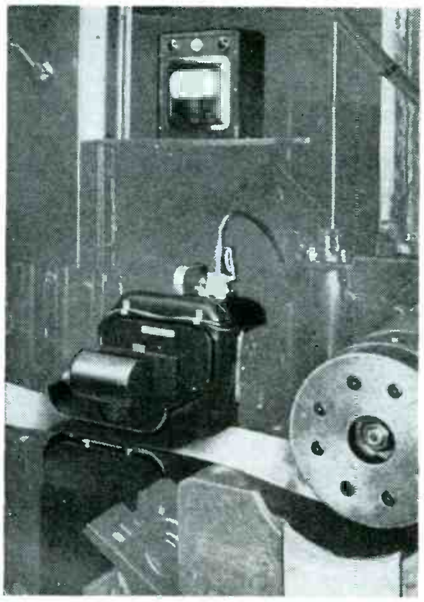


FIG. 3—Values of components and stages of the gaging circuit. The 6AC7 stabilizes the 931A photomultiplier

greater than 150 percent or complete removal of the test sheet. In either event one pulse becomes too small to pass the diode, and thus the pulse differential on the comparator is no longer proportional to the actual thickness difference. The indicating instrument will consequently never be subjected to much more than 150 percent of rated current.

The cathode of the 6H6 clipper is coupled to the control grid of the following 6AC7, which is a saw-tooth converter. This stage in effect adds area to the pulses. This effect is accomplished by shunting the tube with a 1-μf capacitor.

The control grids of the two



Setup of the x-ray thickness gage for checking copper strip in a cold reduction mill

tubes in the comparator circuit of Fig. 3 are in parallel. The cathodes are grounded through a potentiometer balancer and a gage-selector rheostat located on the control panel. The screen grids are connected to the transformer so that the applied potentials are 180 degrees out of phase. Each tube thus conducts only when its screen grid is positive. The magnitude of the plate current during conduction depends on the magnitude of the pulse applied to the grid by the x-ray tube channel that is operating during that same half cycle. For equal pulse amplitudes on both half cycles, as occurs when sample and unknown are equal in thickness, the voltage drops across the two 22,000-ohm plate load resistors will be equal and there will be no voltage acting on the meter. For differences in thickness, the zero-center meter will indicate the deviation in thickness by deflecting in the proper direction. The high-reactance choke prevents a-c voltage from acting on the meter.

Photomultiplier Stabilizer

Phototube output is held constant despite inherent drift of secondary-emission tubes by automatically controlling the dynode potentials and in effect controlling the amplification of the phototube. The output pulse due to visible light emitted by the fluorescent screen is amplified by the phototube and by the 6SJ7. The amplified pulse is

Where Collins Serves the Airlines

The chart above indicates main routes of airlines using Collins radio communication equipment in the air, on the ground, or both. This tremendous acceptance had its beginning in the middle thirties, and is the result of early and never-ending Collins research and development in the field of aviation communications.

The airlines whose routes are shown include Air France, All American Aviation, American, American Overseas, Braniff, British Overseas, Chicago & Southern, Colonial Airlines, Eastern Air Lines, FAMA (Argentine Republic), Hawaiian, Northwest, Panagra (Pan American-Grace), Pan American World Airways System (Latin American division, Atlantic division, Pacific-Alaska division), Pennsylvania-Central, Peruvian International, Quantas (Australia), Royal Dutch, Sabena (Belgium), SILA — SAS — ABA (Scandinavian Air Carriers), South African, TACA Airways Agency (Irish), Trans-Australia, Transcontinental and Western, United, and Western.

Our own planes are in constant use, testing equipment of advanced Collins design for Government and commercial aviation. A recent and notable example of accomplishment is the Collins 51R VHF airborne receiver and attendant instrumentation, which equip an airplane for navigational use of the new omnidirectional range system. This equipment was designed and thoroughly tested in 1946, and was demonstrated to the airlines throughout 1947. As a result, Collins has been awarded the majority of the contracts which have been let to the time this announcement is written.

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applied to the grid of the 6AC7 stabilizer which is biased far beyond cutoff and will not conduct unless the signal pulse amplitude nearly equals the d-c bias. If the stabilizer tube plate current increases due to an increase in pulse amplitude, the average drop across R_L increases and the drop across R_1 and R_2 decreases. This lowers the voltage on photomultiplier dynodes 8 and 9 sufficiently to counteract the increase in signal pulse amplitude due to drift.

Operating Conditions

At times, signal amplitude increases to quite high values due to thin test material or complete removal of the test material. The diode serves to clip off the lower portion of the signal, reducing the average a-c value and preventing excessive positive grid swings that might damage the stabilizer tube.

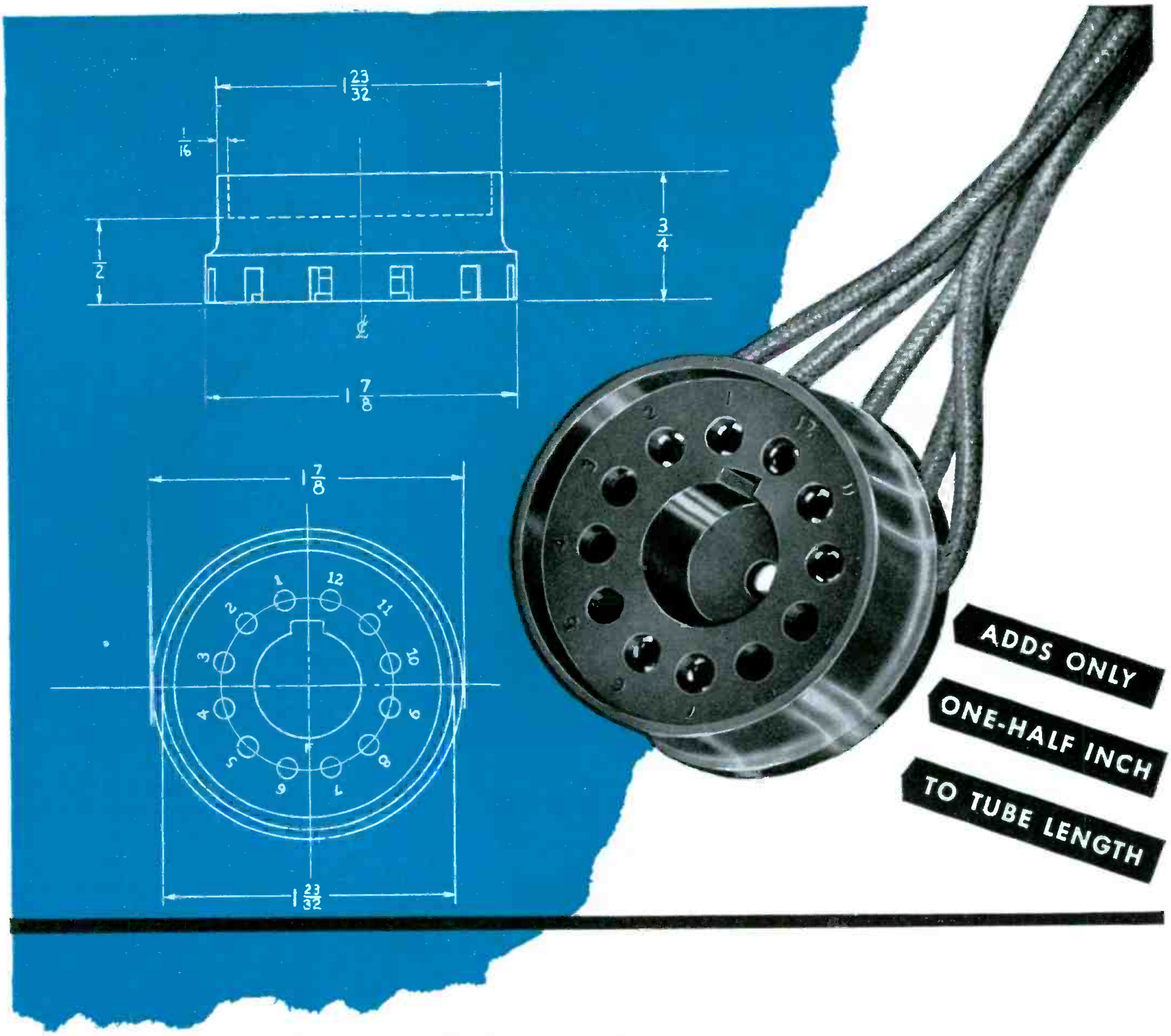
Signal input to the phototube is set originally so that an optimum signal current flows through the stabilizer tube. This sets the voltage across R_1 and R_2 at its midvalue, as required for drift compensation in either direction.

The operator may select the gage of stock to be run by making a simple adjustment of a calibrated rheostat connected in the cathode circuit of the comparator and located at the remote control panel.

Optimum conditions include use of a fluorescent screen causing highest photomultiplier response, restriction of the x-ray beam to that small area on the fluorescent screen most effective in causing photomultiplier response, use of x-ray wavelengths for which absorption in the fluorescent screen is nearly complete, and use of a refined 931A phototube for maximum light sensitivity.

X-Ray Tube Stabilizer

Operation of the x-ray sources without stabilization results in undependable gage indication. X-ray tube current is dependent upon filament temperature. If tube currents in the two heads are originally set at equal values, it is unlikely that they will still be equal an hour later. To maintain automatically identical current magnitudes at all times, the tandem milliampere stabilizer circuit shown in Fig. 4 is



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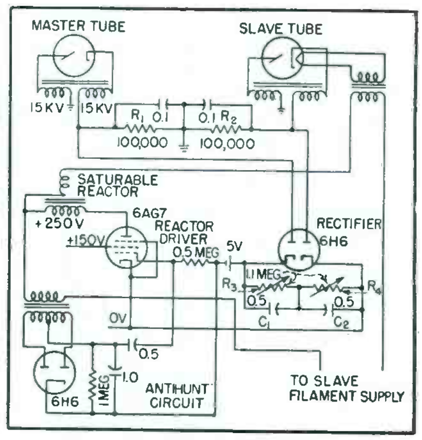

FIG. 4—In the x-ray tube stabilizer, the anode current of the master tube controls the filament current of the slave tube

provided. This circuit uses current of one tube (the master) as reference and makes the current of the slave tube follow it.

The cathode currents of the x-ray tubes cause voltage drops across resistors R_1 and R_2 and these are applied to a 6H6, charging C_1 and C_2 to voltages proportional to the respective x-ray tube anode currents.

Rheostats R_3 and R_4 adjust the time constants of the two R-C circuits, enabling the operator to vary the magnitude of the slave current. The bias on the control grid of the 6AG7 pentode is the algebraic sum of the two capacitor voltages and the bias battery voltage. Plate current of the pentode flows through the d-c winding of a saturable reactor. The greater the plate current, the smaller the a-c voltage drop across the reactor and the higher is the filament current in the slave tube, and vice versa. An antihunt arrangement using a feedback transformer and a duplex-diode rectifier, capacitance-coupled to the grid circuit, prevents oscillation that might otherwise result from high sensitivity and quick response.

Other Applications

Applications for an x-ray thickness gage include measurement of the thickness of linoleum, laminated plastics, sheet glass, many types of sheet metal, and paper and cardboard. One interesting application that wouldn't work was counting of bundles of banknotes to determine exactly how many bills above and below the standard number (100, 500, or 1,000) were in a given bundle. It sounded simple, until a trial showed the thicknesses of in-

dividual bills varied as much as 10 percent.

The photograph illustrated on page 162 shows the instrument as it is installed in a cold reduction mill. The Westinghouse x-ray thickness gage checks copper strip as it passes to the take-up mandrel at right. Mounting the x-ray generators as shown (below the moving strip and above and to the rear) permits the necessary right-angle relation with respect to the phototube pickup in the cylinder above the strip.

Ultraviolet Flame Detector

IN DEVELOPING counter tubes to measure the intensity of soft x-rays, physicists at the Naval Research Laboratory observed that these tubes were sufficiently sensitive to ultraviolet radiation to make practical the construction of a counter, highly sensitive to ultraviolet radiation from an open flame, and thus having advantages for fire alarm equipment.

The basic Geiger-Muller counter tube, of which this unit is a variation, consists of a cylindrical cathode and a centered anode wire all enclosed in a glass envelope as shown in Fig. 1. The tube is filled

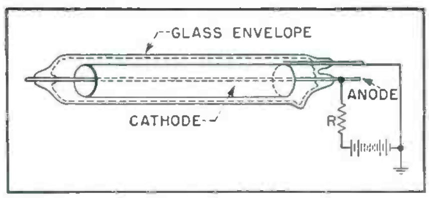

FIG. 1—Construction of basic Geiger-Muller counter tube. To sensitize tube to ultraviolet, surface of copper cathode is slightly oxidized and tube is filled with mixture of argon and alcohol vapor at low pressure. Quartz window in the glass envelope admits ultraviolet radiation

with a single gas or a combination of gases at low pressure, and a potential of the order of 1,000 volts is applied across the two electrodes. This voltage is carefully adjusted so that the tube is operating just below the point where self-sustained discharge can occur. Under these conditions, when a single electron is introduced into the tube, a momentary discharge is triggered. Proper design of the counter and its associated circuit permits the discharge to be rapidly quenched. The elec-

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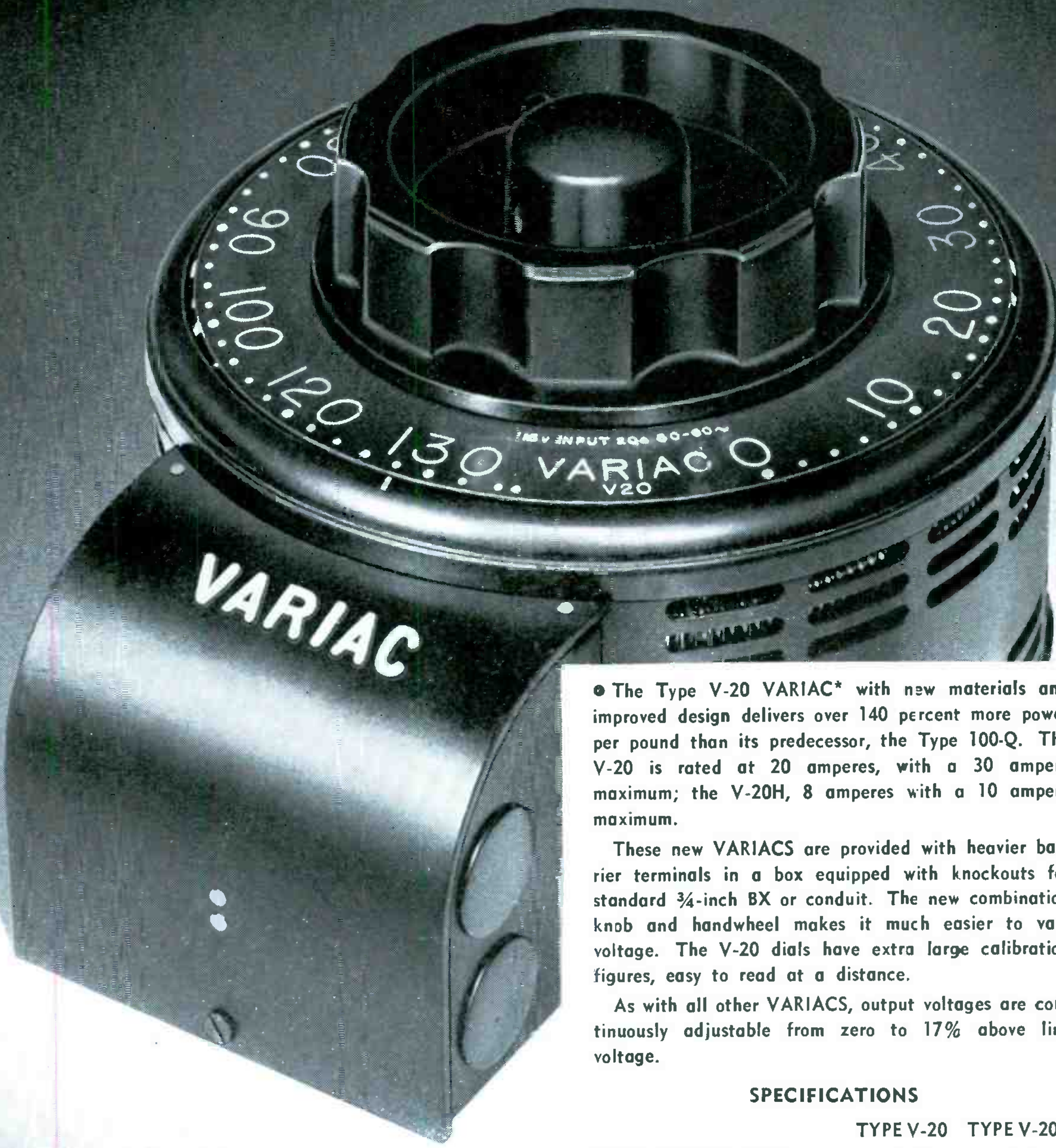

● The Type V-20 VARIAC* with new materials and improved design delivers over 140 percent more power per pound than its predecessor, the Type 100-Q. The V-20 is rated at 20 amperes, with a 30 ampere maximum; the V-20H, 8 amperes with a 10 ampere maximum.

These new VARIACS are provided with heavier barrier terminals in a box equipped with knockouts for standard ¾-inch BX or conduit. The new combination knob and handwheel makes it much easier to vary voltage. The V-20 dials have extra large calibration figures, easy to read at a distance.

As with all other VARIACS, output voltages are continuously adjustable from zero to 17% above line voltage.

SPECIFICATIONS

	TYPE V-20	TYPE V-20H
LOAD RATING (KVA)	3.45	2.3
Input Voltage	115	230 or 115
Output Voltage	Zero to 115 or 135	270 or 230
Rated Current (Amperes)	20	8
Maximum Current (Amperes)	30	10
PRICE	$55.00	$55.00

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*The trade name VARIAC is registered at the U. S. Patent Office. VARIACS are manufactured and sold under Patent No. 2,009,013.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

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trons causing the discharges can originate as the result of various forms of radiation. In a light-actuated counter, they originate as a result of photoelectric emission from the cathode.

To permit the use of the counter in a lighted place, it is necessary that it be particularly sensitive to those components of the spectrum that are produced by radiation from a flame, and that it be relatively insensitive to the spectral components of sunlight. For this purpose, the counter must have a threshold of sensitivity less than 2,900 angstroms. A counter tube having a copper cathode surface will meet this requirement provided that this surface is oxidized slightly. The introduction of a small amount of alcohol vapor in the counter tube also helps to reduce the wavelength at which the sensitivity threshold occurs.

Construction of Counter

Based on the principles outlined, an ultraviolet counter tube was constructed with a copper cathode having a slightly oxidized surface, and a 5-mil tungsten wire anode. The anode was centered by means of two punched mica discs. A quartz window cemented in the glass wall with Glyptal admits ultraviolet radiation. The tube was filled with a mixture of alcohol vapor at 4 mm and argon at 4 cm (mercury-pressure).

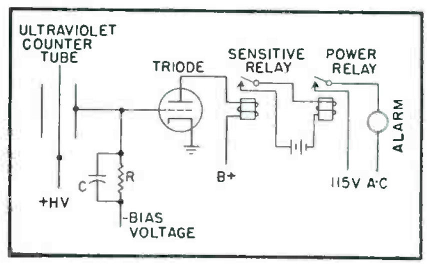
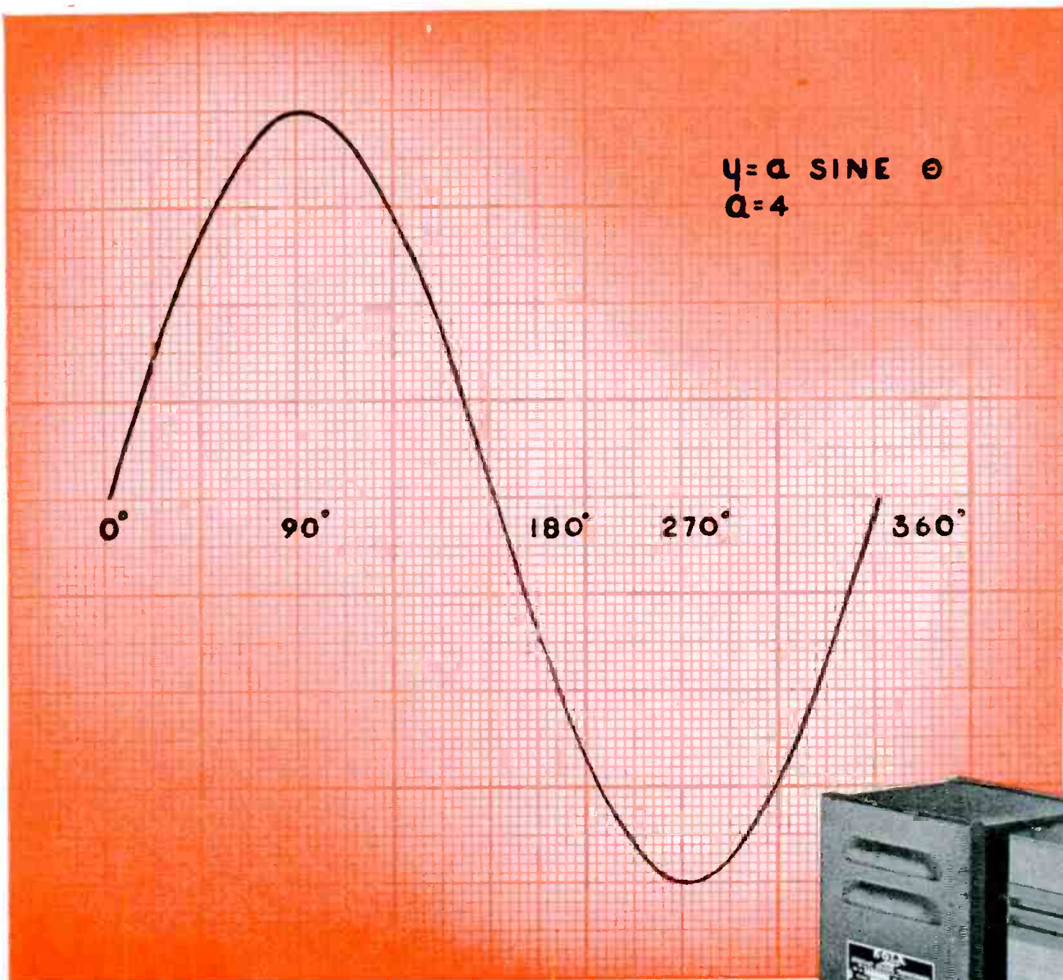
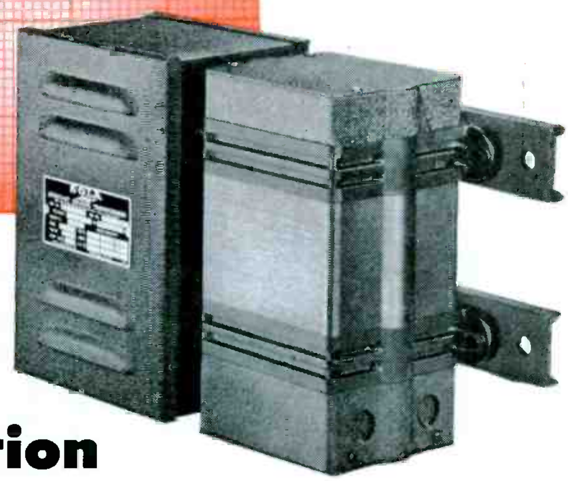


FIG. 2—Simple ultraviolet counter fire-alarm circuit

The counter tube was connected as shown in Fig. 2 to the input of an amplifier. The R-C input circuit was chosen to have a time constant of about five seconds. Thus, infrequent aperiodic discharges of the counter, occurring for small intensities of radiation, are smoothed out to produce steady currents. With the time constant so chosen,





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Manufactured under license by: ENDURANCE ELECTRIC CO., Concord West, N. S. W., Australia • ADVANCE COMPONENTS LTD., Walthamstow, E., England UCOA RADIO S.A., Buenos Aires, Argentina • M. C. B. & VERITABLE ALTER, Courbevoie (Seine), France the relay operated when the input current exceeded 10 photoelectrons per second. An alternative circuit arrangement using a thyratron is shown in Fig. 3.

If it is desired to operate the device from the 110-volt a-c line, a transformer and voltage doubler can furnish the required high voltage. Stabilized voltage can be picked off a bank of ¼-watt neon lamps connected in series across the d-c output. Alternatively, with an amplifier using a low-current triode such as the 1G4-G, a pack of miniature aircraft B batteries can be used to produce the necessary voltage.

Performance

In a one-minute run, the counter described can detect a photocurrent of only five electrons per minute against the normal background count inherent in the device. This small electron flow corresponds to a current of the order of 10^{-20} ampere. The most sensitive type of photocell can measure photocurrents of the order of 10^{-16} ampere.

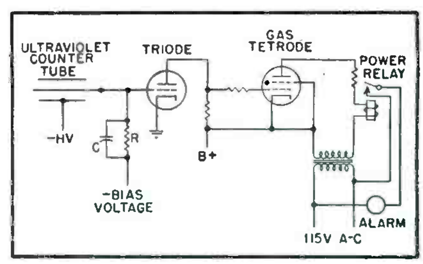
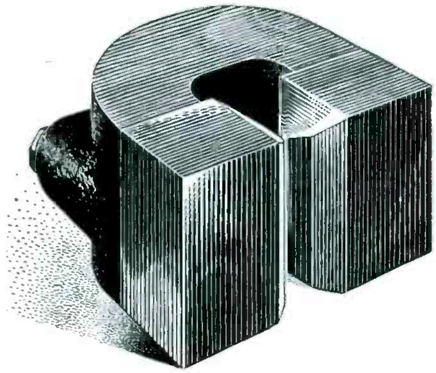


FIG. 3—Sensitive relay required in circuit of Fig. 2 is eliminated by use of thyratron

In testing thermal alarms, the Bureau of Standards has used a standard flame obtained by igniting five square feet of alcohol in a flat pan. In one series of tests, this source was ignited in a room measuring roughly 13 feet high and having about 2,000 square feet of floor space. With detector elements on the ceiling and the fire pan on the floor in the center of the room, it generally required more than a minute to actuate the alarm. With a similar source, the ultraviolet counter triggers the alarm in a few seconds when mounted 200 feet from the fire pan. Its response is independent of room shape or ventilation and is limited only by the cone of vision.



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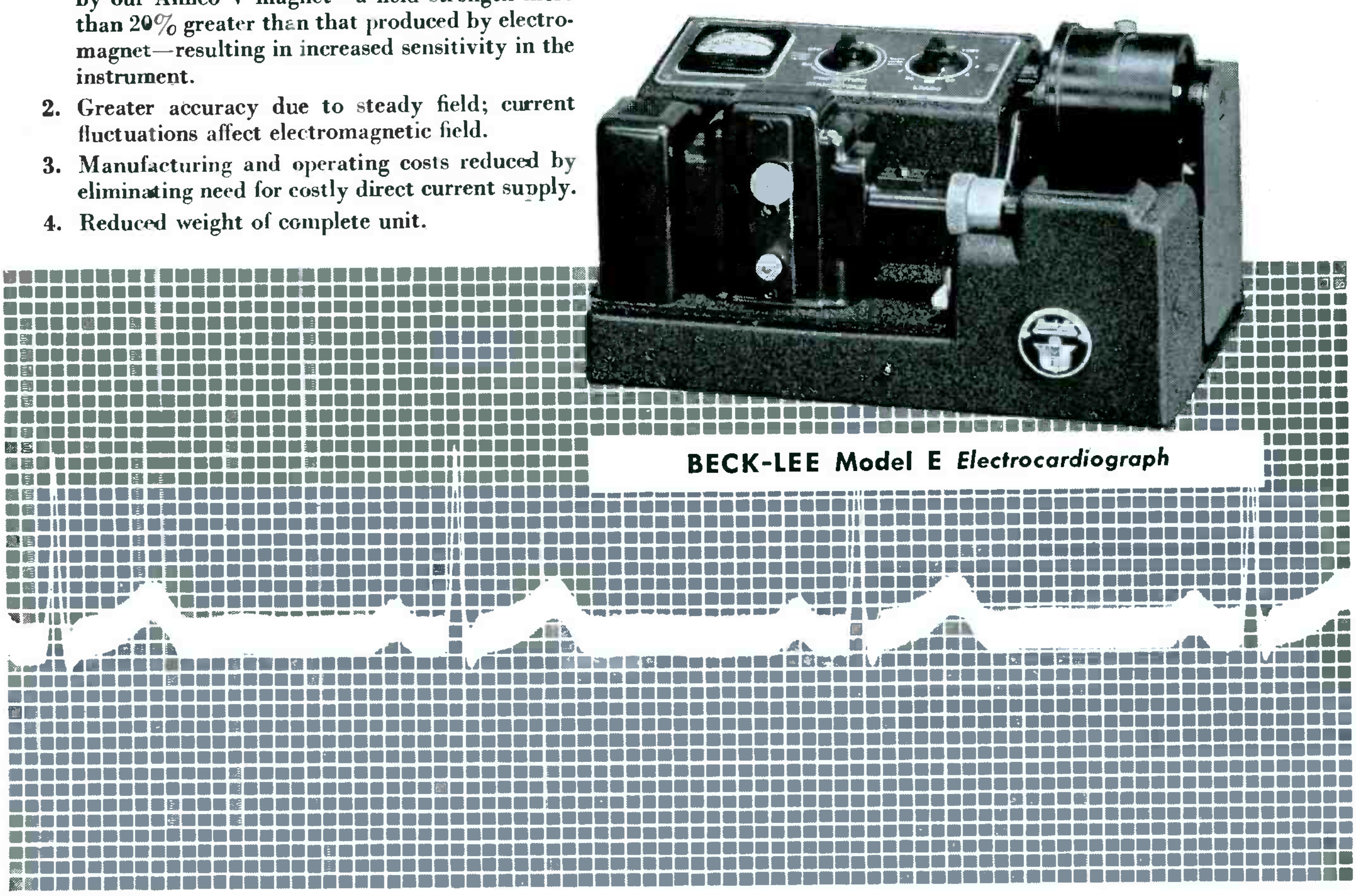

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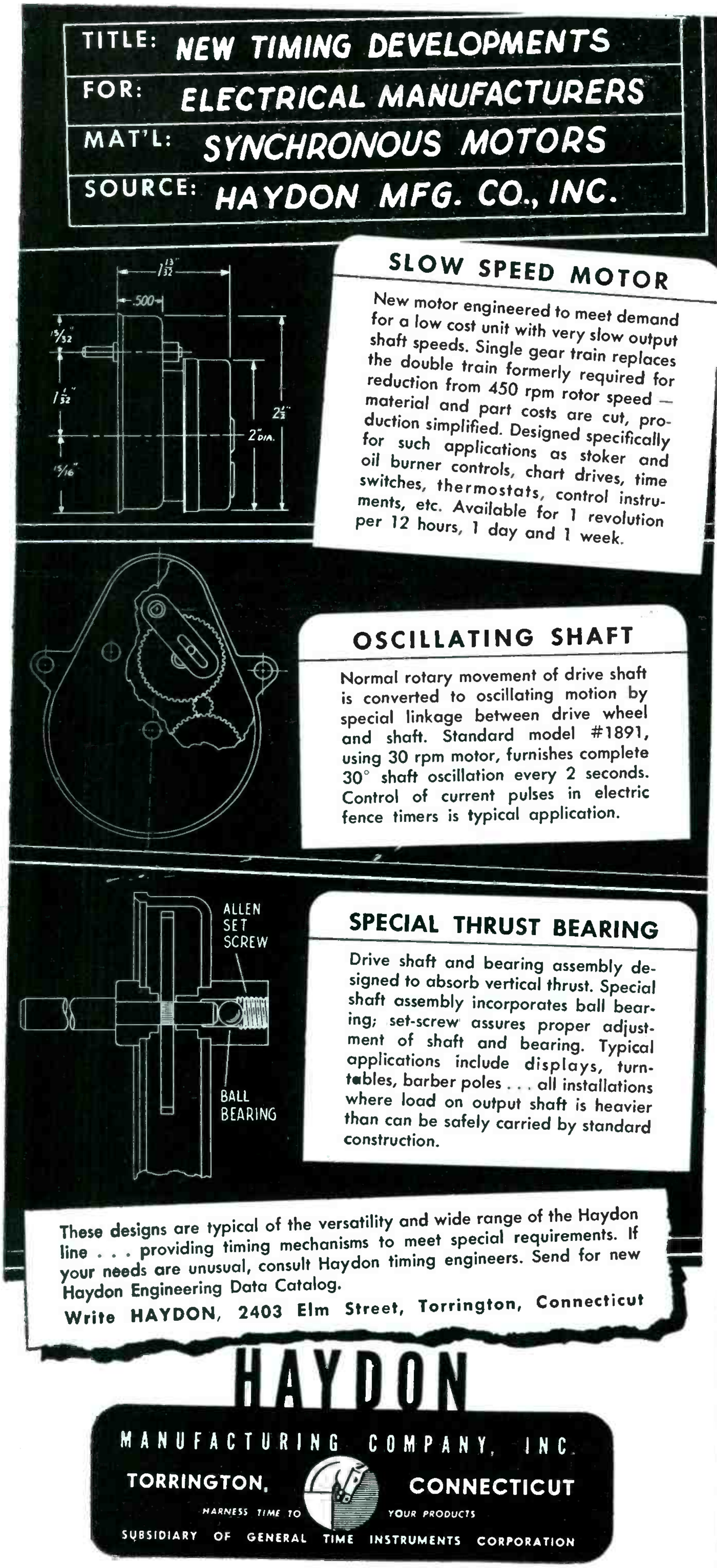

(continued from p 140)

dividual slits are arranged on tracks along the focal curve. The receivers can be positioned as necessary on tracks to monitor lines from elements of interest. Each receiver of the Quantometer built by the Applied Research Lab. consists of a photomultiplier tube (supplied from a single high-voltage rectifier in common with the other receivers) and an integrating amplifier (with individual power supply). A separate, multiple-channel recording console punches tapes from which, after calibration, the chemical percentage of each element can be read. Once set up, the meter determination has an average deviation of only 0.012 percent.

Development and Applications of the Skiatron

By G. WIKKENHAUSER
Technical Director, Schophony Ltd. Wells, Somerset, England

DISLOCATION of electrons in or from their atoms in crystal lattices usually results in coloration. This effect, recently utilized in x-ray treatment and inspection of gems, is used to produce the visible image

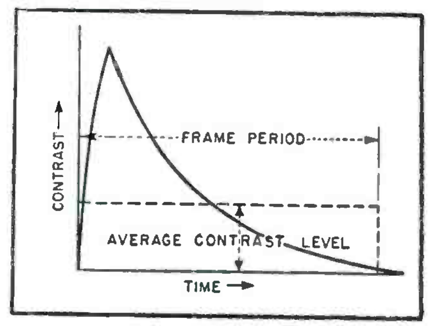

FIG. 1—Density-time characteristic of electron opacity phenomena

in the Skiatron type cathode-ray tube. Although experimentally developed for use in television, this tube offers several advantages for radar indicators, especially its long persistence with concomitant discrimination against noise by signal integration.

Development and Characteristics

Intense coloring of various alkali halide crystals that results from cathode-ray bombardment, discovered in 1894 by E. Goldstein, and further studied by Pohl, Mott, and Gurney, is used to produce opacity in the tube screen. When a thin layer of these crystals is so bom-

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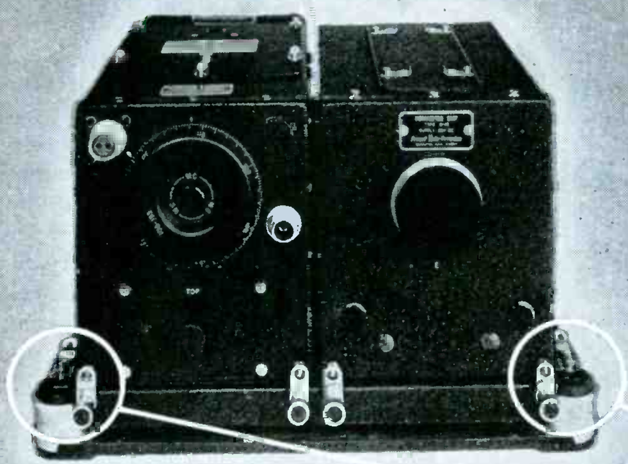

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FIG. 2—Large-screen plan position indicator used by British Admiralty

barded, some electrons are displaced from the halides and occupy positions in the faults of the crystal lattice where they vibrate at characteristic frequencies. Because the frequency of vibration lies in the visible spectrum, and because these displaced electrons can absorb light at their characteristic frequencies, a dark pattern is produced on the originally semitransparent crystal layer. The color of the pattern is the complementary color of the absorption.

The most commonly used material is potassium chloride whose absorption is in the green region of the spectrum, thus the dark pattern appears magenta. In potassium bromide the absorption is in the bluish range, so that the pattern is brownish; sodium chloride gives an orange trace. As the electrons absorb further energy either from light or heat rays they return to their stable positions and the dark trace disappears.

This phenomenon was applied to television tubes by A. H. Rosenthal in 1938, but, although he obtained television images on Skiatrons of the BBC 405-line interlaced transmission, it was realized that much work was required to perfect the technique. The images lacked sufficient contrast because of the relatively long persistence of the trace. Time required for a trace to disappear is a function of the degree of discoloration, dark traces dissolving most slowly. To obtain fast enough decay for reproducing 25 pictures per second, the darkening had to be limited to very faint traces. Figure 1 shows a typical buildup-decay characteristic. De-


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Type	Cathode voltage	Cathode current	Anode peak voltage	Anode peak current	Anode avg current
GL-866-A	2.5 v	5 amp	10,000 v	1 amp	0.25 amp
GL-8008	5 v	7.5 amp	10,000 v	5 amp	1.25 amp
GL-673	5 v	10 amp	15,000 v	6 amp	1.5 amp
GL-869-B	5 v	18 amp	20,000 v (*15,000 v)	10 amp	2.5 amp (*5 amp)
GL-857-B	5 v	30 amp	22,000 v	20 amp (*40 amp)	5 amp (*10 amp)

(* Quadrature operation)

spite these limitations, the fact that the tube could be used as a light valve, controlling an auxiliary light source, recommended it for use in projection systems for producing large television images.

Application to Radar Indicators

In applications other than television, where the trace could remain for some time, the characteristic of the Skiatron screen is desirable. One such application is to ppi instruments, especially the projection type of Fig. 2, on which shore lines and other fixed objects build up to high contrast and paths of aircraft and ships are shown. To cancel the trace the screen is irradiated with heat and light.

Parallel developments were made by several German firms including Lorenz and Telefunken. To cancel the trace on these tubes, heat was applied directly. The halide screen was formed on a thin sheet of mica on which was also a tungsten film thin enough to be transparent to visible light but yet electrically conductive. When the trace was to be erased, current was passed through the tungsten film producing a sufficiently high temperature to dissolve even a very dark trace in from 5 to 10 seconds. The metal

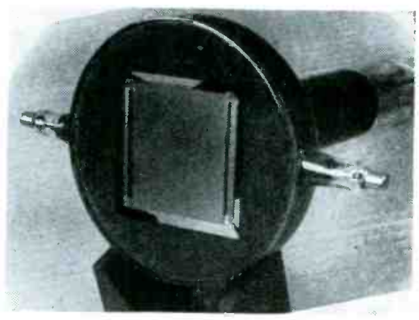

FIG. 3—Dark-trace tube developed in Germany contains erasing heater

caps at the sides of the tube shown in Fig. 3 provide connection to the tungsten film.

Other applications utilizing the long persistence characteristic of the Skiatron have been made. To track every plane within a 50-mile radius of the All-Weather Flying Center, Wilmington, Ohio, such a tube is being used. The transient recording oscillograph made by Scophony produces a persistent trace that can be studied or photographed without need for precise synchroni-

Truarc inverted rings align shafts, save 20 minutes . . . . $1.00 per unit

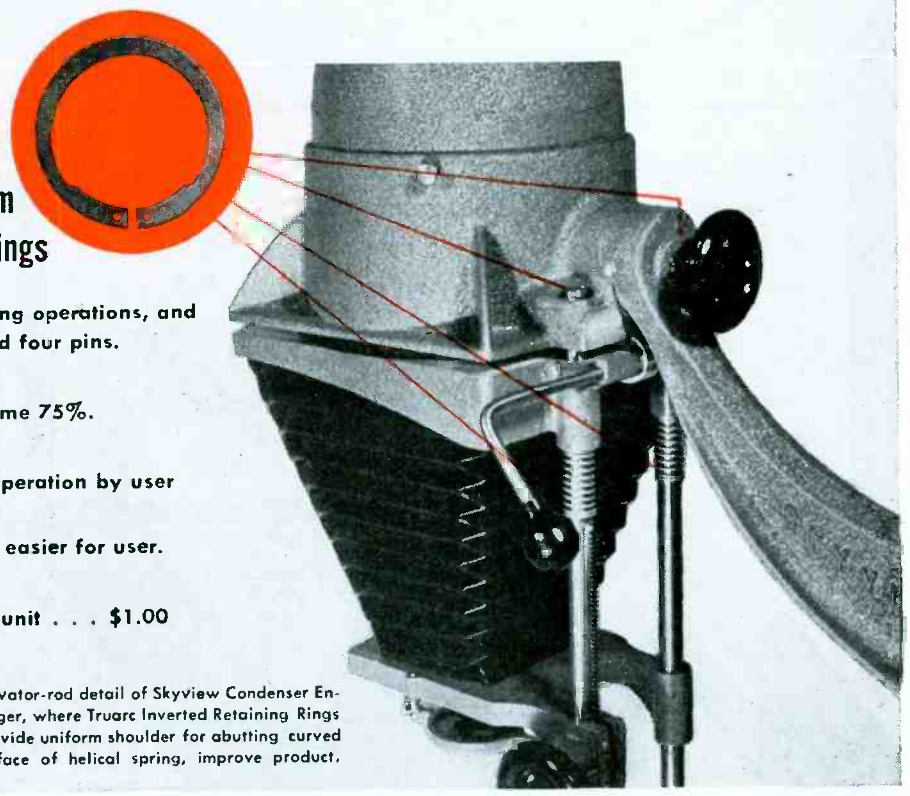

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FIG. 4—Dark trace persistence is such that trace remains after tube is unplugged

zation with the occurrence to be recorded. Figure 4 is a rather unique photograph of a British tube on which a damped 25-cps wave was recorded; the tube was then removed from the associated equipment and the photograph made, the trace still remaining on the screen. The British Services Electronic Research Laboratories have demonstrated a facsimile transmission and reception system in which a 500-line picture, scanned over a period of one second, is reproduced by this electron opacity technique.

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(1) British Patents 513,776; 514,155; and 514, 776; also United Kingdom Trade Mark register No. 640,179 in the name of Schophony Ltd.
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(3) R. W. Pohl, Electron Conductivity and Photochemical Processes in Alkali-halide Crystals, *Proc. Phys. Soc.* (London), p 3, Aug, 1937.
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(5) Skiatron, ELECTRONICS, p 216, Oct, 1946.

Measuring R-F Power with a Thermopile

By GUY P. WALKER
Naval Research Laboratory
Navy Department
Washington, D. C.

DETERMINATION of radio-frequency power produced by an oscillating vacuum tube or lost within it or its associated circuit is difficult. Closely coupling measuring equipment to the circuit may change the operating conditions. Although the optical pyrometer method does not disturb the tube or circuit, it is subject to error from the nonuniform distribution of temperature over the anode during calibration (calibration usually being done with d-c in

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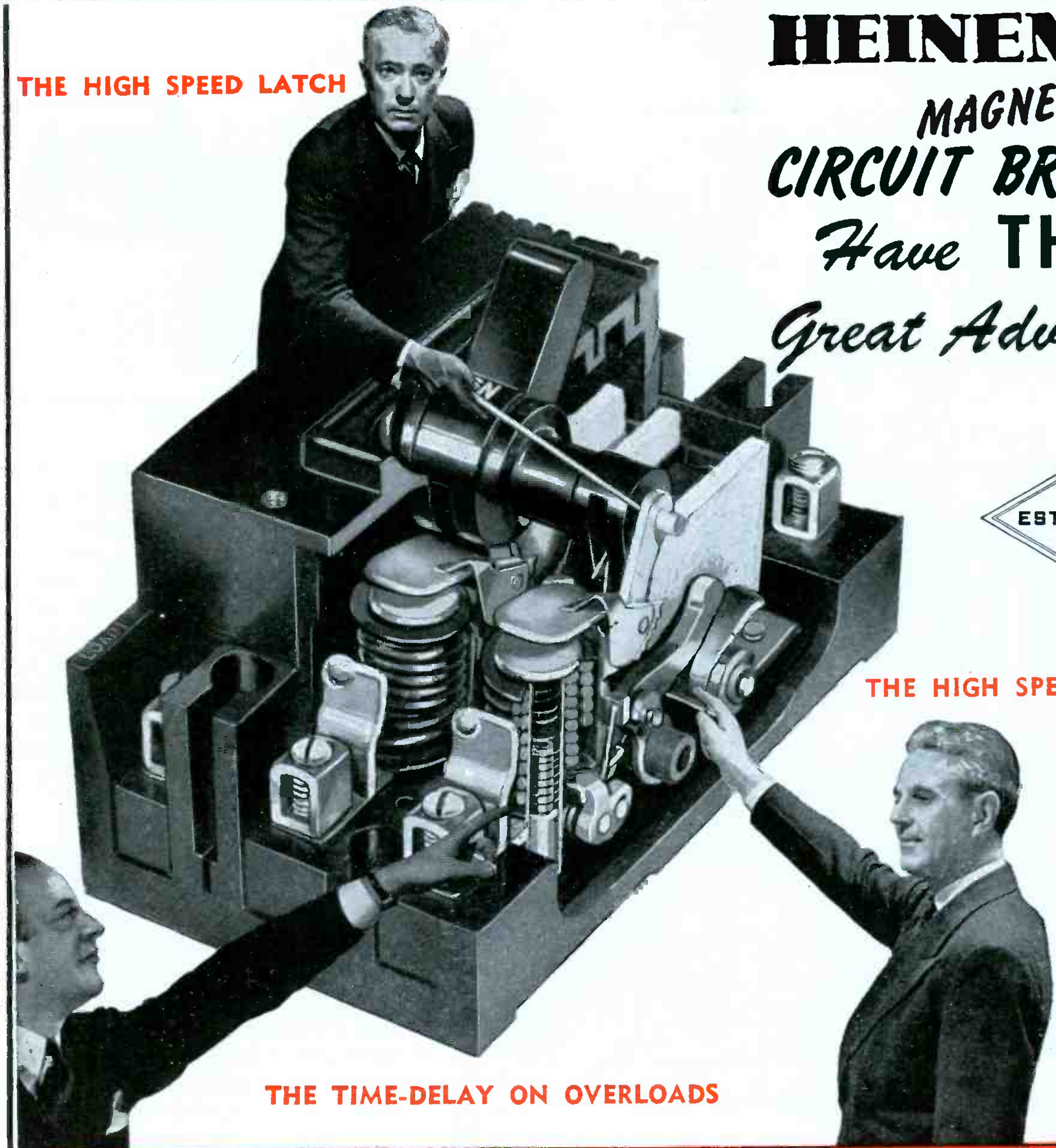

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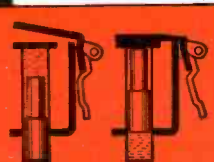
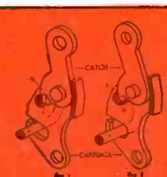
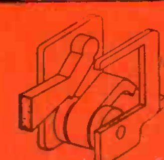


Above sketch shows the action of the Time Delay Tube, which prevents the breaker from opening on sudden inrush current, but allows it to open on sustained overloads. This is done by means of the plunger action in the liquid-filled tube. The speed with which the plunger is drawn toward the magnetized pole piece depends on the viscosity of the liquid. (At left—plunger in normal position. At right—after overload has attracted plunger to pole piece, opening contacts).



The Latch Mechanism performs two functions: (1) It opens the breaker with the least mechanical delay, and (2) It opens the breaker independent of handle operation. Of all known latches, this mechanism operates with the least amount of friction and with the greatest speed. The latch collapses only under overload or short circuit conditions—and it does that even if the handle is held in the "on" position.



Speed is added to the arc interruption by means of the High Speed Blowout shown above. Magnetic blowout contacts are mounted in individual arcing chambers, carefully insulated from each other. These add speed to the arc interruption. As the value of the current to be interrupted increases, the quenching effect becomes greater, due to the intensified magnetic blowout field.

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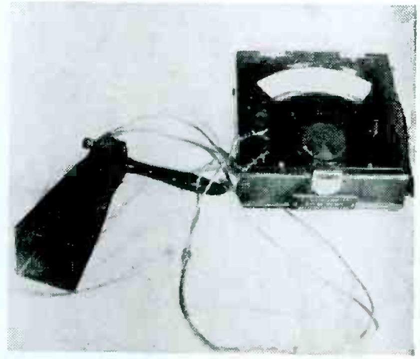

FIG. 1—Thermopile in horn operates indicating meter

which case the grid shadows on the anode are well defined; during operation, when the grid voltage is swinging, these shadows are less defined). Furthermore, the optical pyrometer can only be used with tubes whose anodes show color during operation. The thermopile, by measuring radiated heat rather than light, is free from these limitations, and retains the advantage of not disturbing the circuit.

Method of Use

In a self-excited oscillator, d-c input power to the tube is consumed in (1) tube losses, (2) circuit losses, and (3) useful power output. Circuit losses and useful power output taken together make up the total r-f power output. Because d-c input power to the tube is readily obtained, if tube loss can be measured, subtracting this loss from d-c input power gives total r-f power output. A lumped value of the various circuit losses can be obtained if both tube loss and useful power output are measured and the useful power output subtracted from total r-f power output.

A sensitive but rugged and inexpensive thermopile located at the focus of a horn whose interior is highly polished has been found to be sufficiently directional to respond to the heat radiated from a given tube toward which it is aimed and to exclude small quantities of heat radiated from sources outside the area seen by the orifice of the horn. However, the horn covers a large enough area of the anode not to make the equipment sensitive to localized temperatures. Figure 1 is a photograph of this equipment and its associated meter. The horn and shielded meter leads prevent interference from r-f fields produced by

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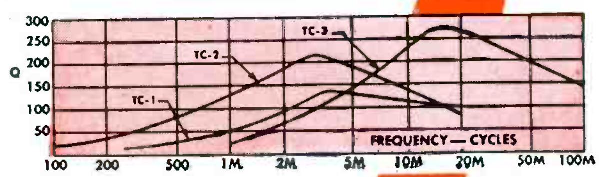
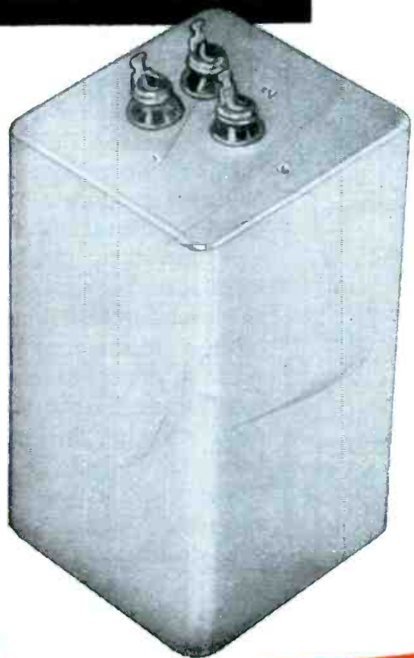
TC-3	Any Ind. up to	350	MHYS

Be sure to state desired inductance.



TOROIDAL COIL FILTERS



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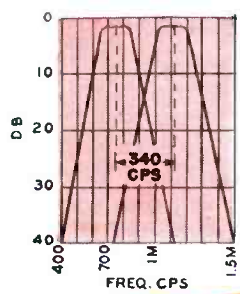

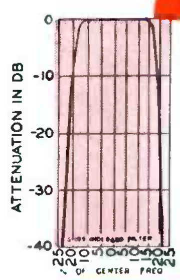

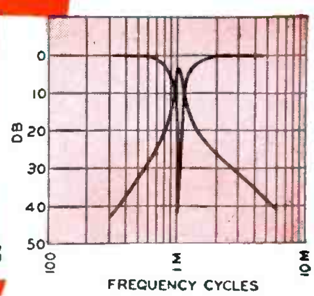

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the circuit under test. The meter used with the thermopile is a sensitive d-c microammeter whose resistance should be such as to produce a reading of at least half scale under the prevailing conditions of radiation being received by the thermopile.

A calibration curve is made of d-c input power vs thermopile reading with the tube operating statically. As would be expected, current from

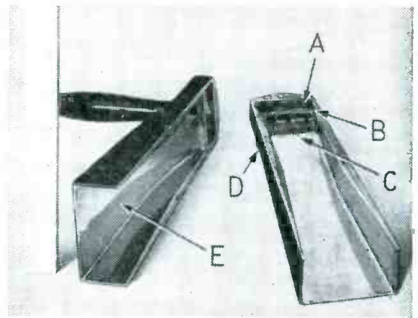

FIG. 2—Open horn shows internal shape and location of thermal junctions. There are 19 cold junctions (A) and 19 hot ones (C), the later being blackened and located along the focus of the horn. The Thermopile is insulated (B) from the polished aluminum horn (E) and leads brought out to terminal posts (D). The equipment is available through Central Scientific Co., Chicago

the thermopile varies linearly with respect to the power dissipated within the tube. During calibration the tube dissipation is considered to be the sum of the plate and screen input powers. Filament power is neglected because it is considered to be constant throughout calibration and operation, its only effect being to produce a finite intercept of the calibration curve. Control grid power for most tubes is negligible during calibration and in self-excited oscillators is furnished by the anode supply. After calibration, the tube circuit is adjusted for the oscillating condition without disturbing the distance between tube and thermopile or their positional relationship. However, the same thermopile and meter can be used to measure a wide range of power by varying the distance between thermopile and radiating tube, making suitable calibrations at these distances.

With the tube oscillating, a thermopile reading is obtained and, by reference to the calibration curve the power dissipated within the tube is determined. As indicated above, subtraction of this value

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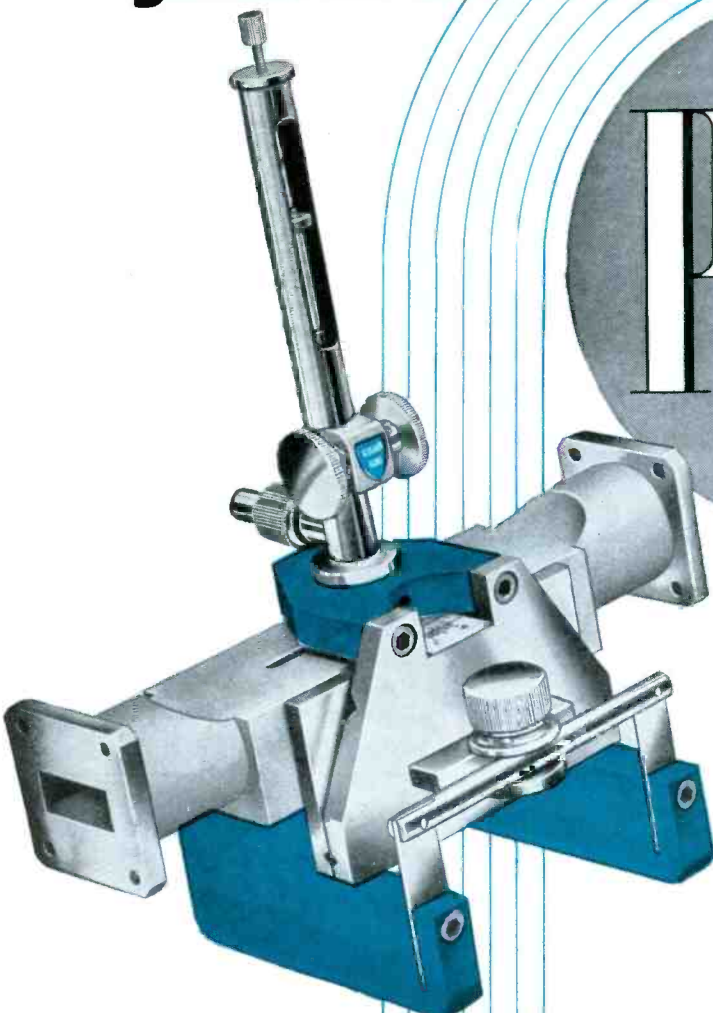

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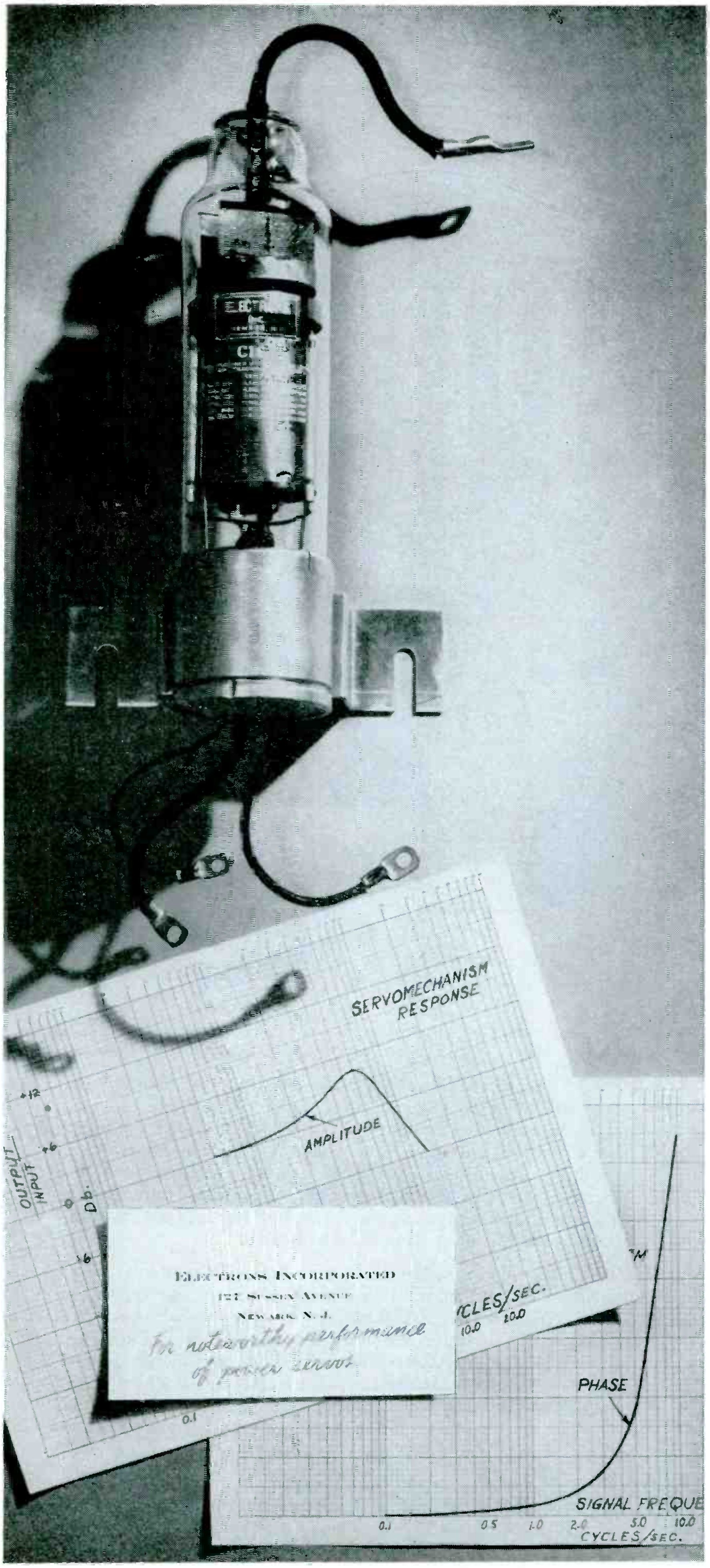


from the d-c input power gives the total r-f output or, in other words, gives the sum of circuit losses and useful power output. Measurement of the useful power output by a lamp and photocell or by a lamp or other load and the thermopile enables one to arrive at a lumped value of circuit losses. By supporting the thermopile on a pivot, it can be rotated to aim it at either the tube to measure tube loss or at the load to measure useful power output. Separate calibration curves are necessary because of the dissimilarity in the two sources of radiation. Figure 2 shows constructional features of the horn and thermopile.

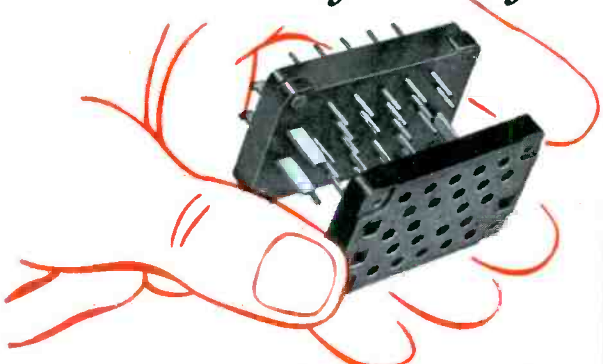
Accuracy of Technique

Using a 4E27, which has a tantalum anode, the relationships of watts dissipated within the tube to thermopile current and optical pyrometer reading in degrees centigrade were simultaneously determined. Then, with the tube oscillating, readings were taken on both instruments as a check of one method against the other to give the following tabulation

Optical Pyrometer	*Thermopile*
Tube loss in watts	
37	44
49	51
57	52
80	79
Total r-f power in watts	
117	110
138	136
168	173
220	221
Circuit losses in watts	
21	14
20	18
30	35
29	30

In general, the readings agree with each other within a few percent. However, scattered readings are in considerable disagreement. The fact that the disagreements are not consistently in the same direction indicates that the personal element may be an important factor. Because matching colors of a small area of the tube anode and of a heated filament within the optical pyrometer is more difficult than

Multiples of these paired Plastic Plugs ingeniously



connect the electrical circuits of the **WURLITZER ORGAN**

Above photograph, by courtesy of The Rudolph Wurlitzer Company, indicates the position of referred-to plastic plugs in the Wurlitzer Organ. Arrangement facilitates inspection and ready access for disassembly of the interior Wurlitzer Organ parts.

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PRODUCT DEVELOPMENT • MOLD DESIGN • MOLD CONSTRUCTION • PLUNGER MOLDING • TRANSFER MOLDING • INJECTION MOLDING • COMPRESSION MOLDING reading a 5-in. meter scale, the disagreements in readings are most likely due to inaccuracies in reading the optical pyrometer than to errors in the thermopile. Therefore the thermopile is at least as accurate as other commonly used equipment for measuring r-f power.

Because tubes warm up slowly, approaching their stable temperatures asymptotically, readings cannot be taken quickly. A 50-watt tube requires about 8 minutes to reach a point where reasonably accurate readings can be taken. When making readings with the thermopile, ambient temperature should not change widely. Changes in direction or velocity of air currents near the tube or thermopile can introduce errors. However, as the data presented indicates, the thermopile with its directive horn is a very useful instrument, especially in the laboratory where tubes can be held at equilibrium long enough for the reading to have meaning.

Directly Coupled Phase Inverter

By E. Johnson
Brooklyn, N. Y.

Direct-current symmetry and stability of output are obtained from the phase inverter shown in the accompanying diagram. Because of these properties, the circuit is useful in handling flat-topped pulses, low frequencies and the like. The indicated values of the components, although considered optimum for the specific application for which this circuit was developed, should be taken as suggestions rather than absolutes.

Operating Conditions

The upper half of the inverter is recognizable as a cathode-coupled amplifier[1,2]. The output of this half is in phase with the inverter input.

The lower half is the same as the upper half but with its grids interchanged. With respect to quiescent conditions, the lower half of the circuit behaves identically to the upper half. However, the output of the lower half is 180 degrees out of phase with the inverter input. The inherent gain

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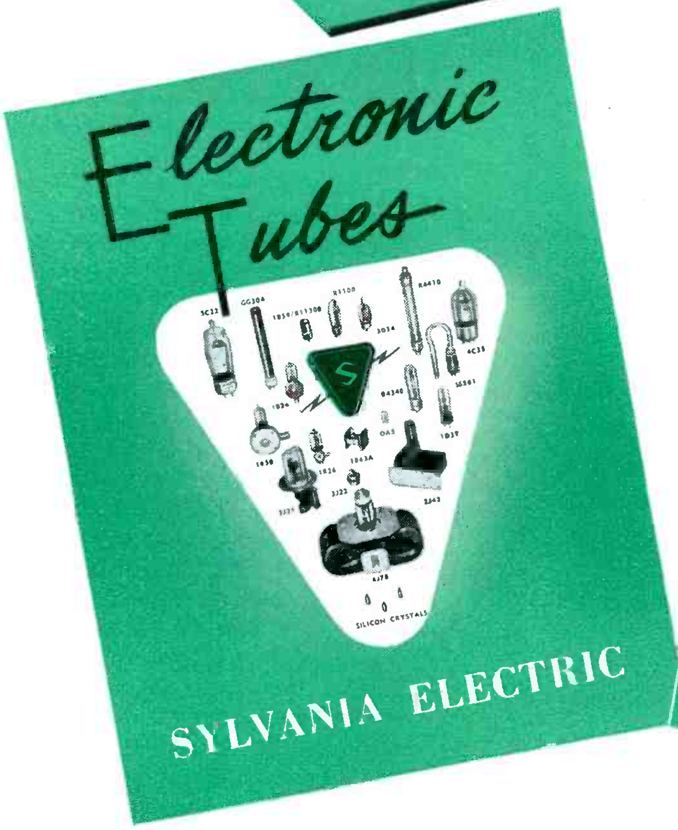

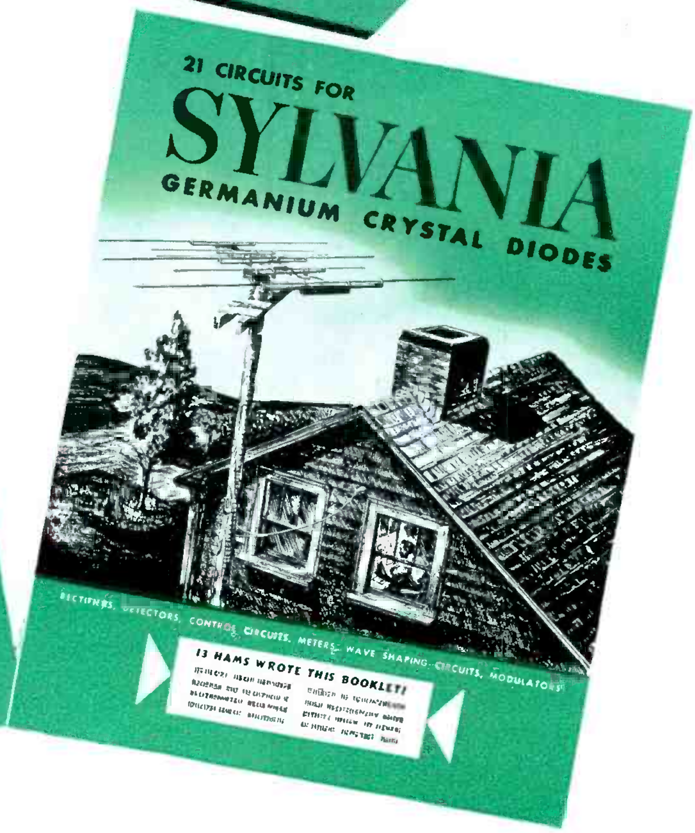

Sylvania's revised catalog, "Electronic Tubes," lists ratings, characteristics and typical applications of more than 75 special tubes and devices, including: Semi-conductors, Microwave Tubes, Industrial Electronic Tubes, Radioactivity Detection Tubes, Special Purpose Tubes. Catalog gives cross-references to detailed literature available from Sylvania on each type.

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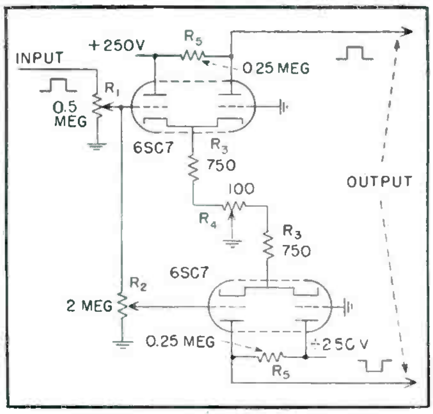

Phase inverter is directly coupled

of the lower half is about half that of the upper half so that an adjustment of the potentiometer R_2 is necessary to equalize the outputs of the two halves. Overall gain of the inverter is controlled by R_1.

Potentiometer R_4 is adjusted to make the d-c output voltage of each half of the circuit equal, the adjustment being made in the absence of signal and before R_2 is adjusted. The subsequent adjustment of R_2 does not necessitate any further adjustment of R_4, making the circuit very easy to balance. Essentially, each half of the circuit operates independently of the other half so that there is no tendency towards regenerative drifting and critical adjustment that characterize many comparable circuits.

With the typical values of components as shown, the circuit has a voltage gain of about 20 and handles inputs up to two volts without appreciable distortion. Use of 6SN7's would have reduced the gain to about seven. Graphical analysis offers a convenient means of investigating the performance of the circuit and provides a guide for selecting the components[3]

REFERENCES

(1) G. C. Sziklai and A. C. Schroeder, Cathode-Coupled Wide-Band Amplifiers, *Proc IRE*, p 701, Oct. 1945.
(2) K. A. Pullen, The Cathode-Coupled Amplifier, *Proc IRE*, p 402, June 1946.
(3) M. S. Rifkin, A Graphical Analysis of the Cathode-Coupled Amplifier, *Communications*, p 16, Dec. 1946

SURVEY OF NEW TECHNIQUES

NBS CASTING RESIN, whose properties were described (ELECTRONICS, p 136, July 1947), is being commercially produced by The Mathieson Alkali Works. Because of its low shrinkage upon polymerization and its electrical and dimensional

stability, it is used as a potting compound to protect and stabilize electronic circuits.

AUTOMATIC electronically controlled machinery for high vacuum thermal evaporation of metallic salts and metals on optics, as in the production of front surfaced television projection mirrors, has been devel-

Electronically controlled high vacuum evaporation equipment for coating lenses and for plating mirrors

oped by National Research Corp. Glass to be coated passes on a conveyer through a series of locks to the vacuum coating chamber and then through another series returning to atmospheric pressure. The application of automatic control to high vacuum processing greatly extends its industrial significance.

UNIVERSAL capacitor microphone principles, details of crystal filters for communication systems, and sound recorders and reproducers developed in Germany are described in three reports available through the Office of Technical Services, Dept. of Commerce.

The capacitor microphone, used for broadcast pickups, can be constructed to have either a unidirectional, bidirectional, or nondirectional response. The microphone operates on the gradient of the sound pressure and the diaphragm is resistance controlled so that the response is independent of frequency (PB-79584, mimeograph \$0.25).

Information based on an interview with Dr. Krambeer, chief filter designer of Siemens Halske Labs.,

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and contained in an exchange report prepared by the British Intelligence Objectives Sub-Committee describes methods of designing channel, narrow band, and low and high pass crystal filters (PB-80572, microfilm $1.00).

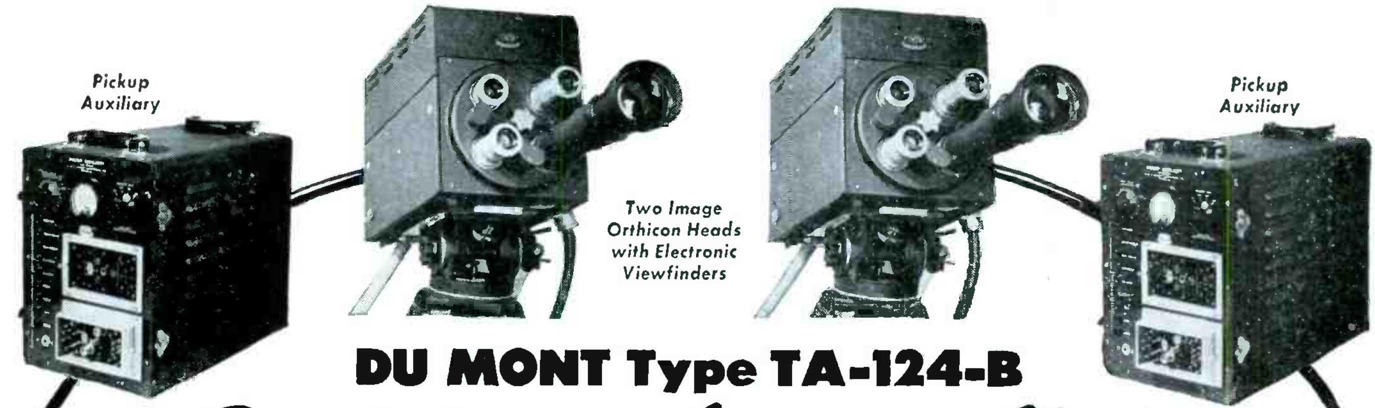
Electroacoustic measurements can be logarithmically recorded by techniques used in the Neumann damping recorder. The method is suitable for determining voltage differences in sound frequency generators such as receivers and microphones (PB-69125, microfilm $1.00).

CONCENTRATED ARC LAMP (ELECTRONICS, p 202, Feb. 1947) is used as a point source in projecting a wide angle beam capable of covering the large spherical mirrors used in projection television receivers.

Optical laboratory instrument paves the way for production inspection of television projection mirrors

The technique is used at North American Philips Labs. to determine means for improving quality of mirrors. The image formed is examined by the same lens system that projects the light beam.

VERY DILUTE CONCENTRATIONS of colloids and bacteria can be compared in a pulse type penetrometer developed under OSRD and Army Service Forces contracts at Northwestern University by F. T. Gucker, Jr., H. B. Pickard, C. T. O'Konski, and J. N. Pitts, Jr. The penetrometer consists of a cell through which the stream (gas or liquid)



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Sync Generator: Smallest and lightest portable unit extant. Better rise time of pulses and freedom from adjustments than most studio type sync generators.

Distribution Amplifier: Equipment set up to handle up to four cameras without use of junction boxes.

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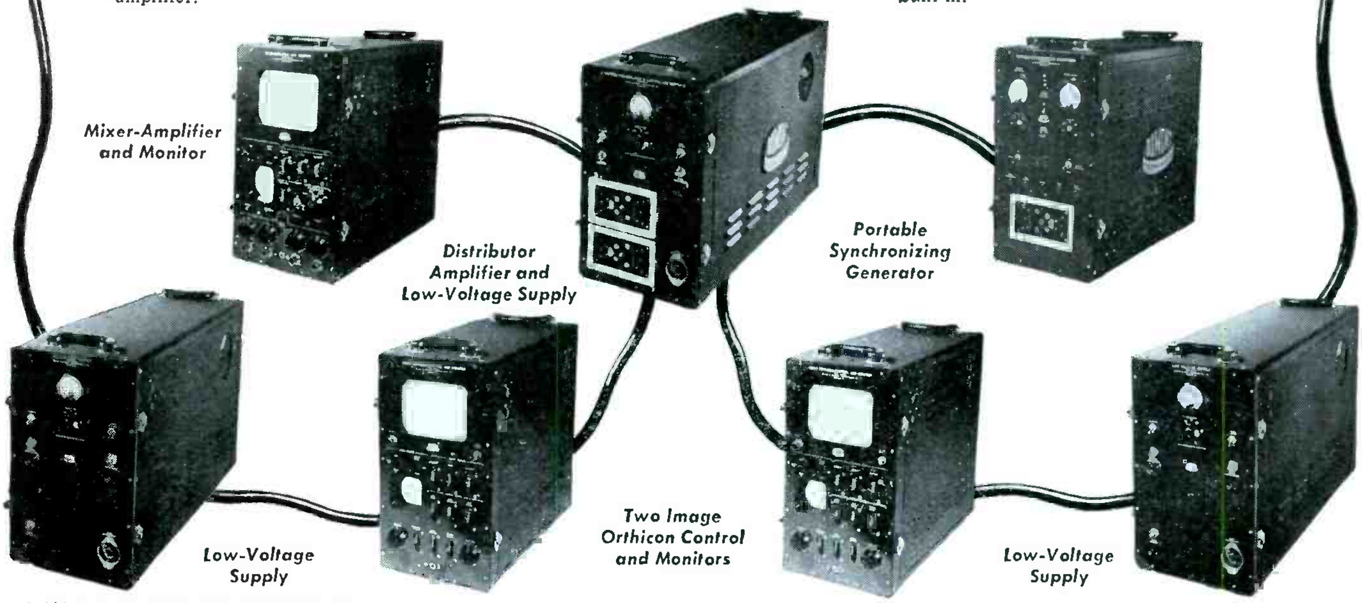

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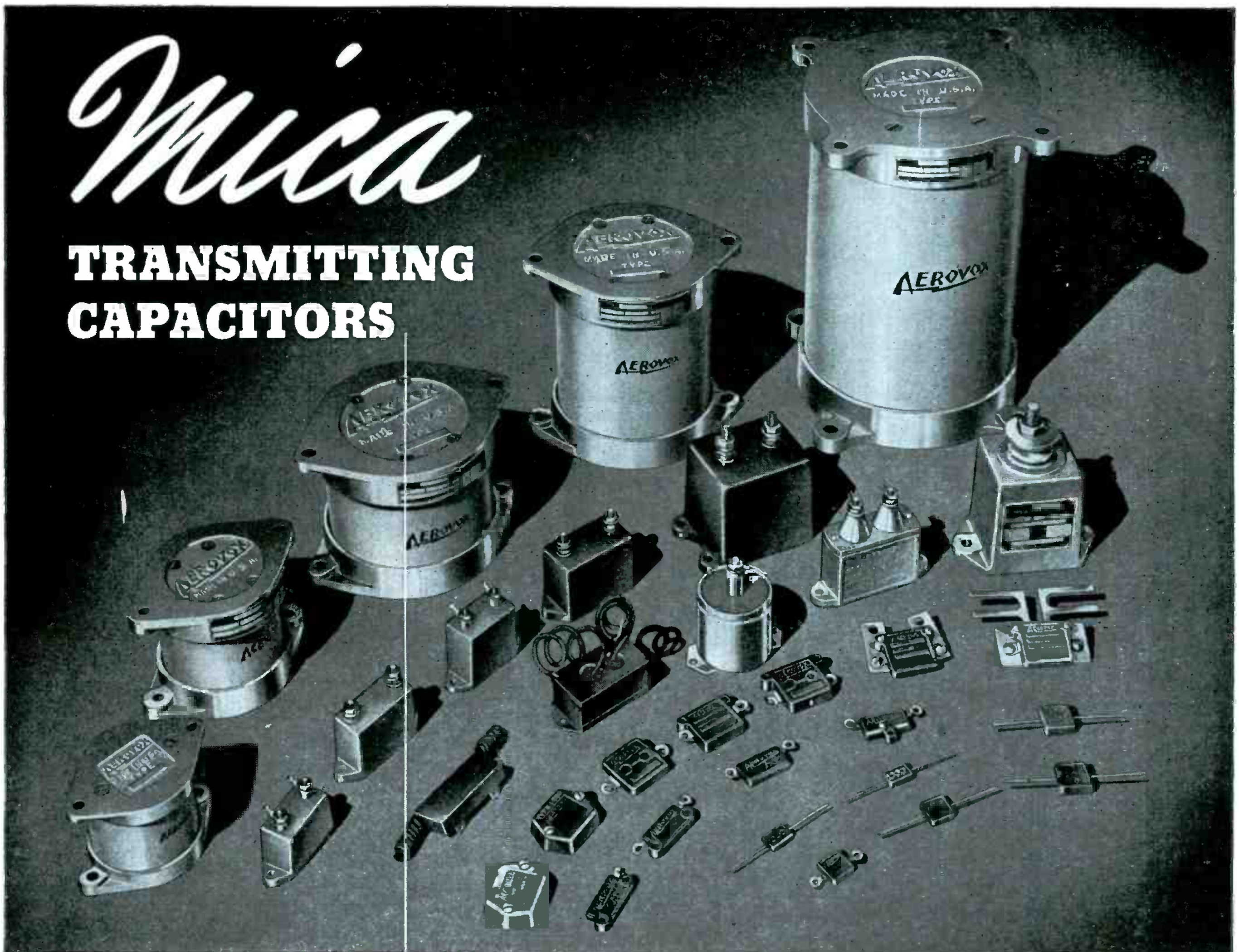
bearing the very dilute concentration to be measured passes an intense light-beam. Particles in the stream scatter light to a thalofide cell or photomultiplier tube which feeds an amplifier having a maximum voltage gain of 300,000. As a particle passes the beam, it scatters light to the photocell for about three milliseconds. A thyratron in the amplifier output is thus operated to actuate a mechanical counter. The count over a measured time interval is indicative of the particle concentration (PB-79150, microfilm $1.).

STANDARD OF LENGTH might be made the green radiation of mercury 198, an isotope transmuted from gold by neutron bombardment. Because the human eye is more sensitive to this green line than to the red line of cadmium, used as a standard because of its greater stability and precision than the standard platinum-iridium meter bar, adjustment of interferometers with which lengths are measured is more readily done. Also this green line is stable, reproducible, sharp, and easily maintained, according to Dr. W. F. Meggers of the National Bureau of Standards.

CAPACITOR paper having densities from 1.25 to 1.30 were manufactured in Germany; highest density attained in America is 1.00. The high density paper is the result of using high-grade Finnish pulp, slow-speed paper making machines, carefully controlled wetting of the paper, and especially the final supercalendering on fine mechanical machines (mimeographed copies of 15 page PB 80394, "Supercalendering of Condenser Paper", are available from Office of Technical Services at $0.50 each.)

VOLTAGE on power lines varies—In the District of Columbia, voltages at substations vary about 4 percent, according to National Bureau of Standards measurements. Considering the greater amount of heavy industry in other districts of the country, voltage drops in mains, distribution transformers, and plant wiring, the Bureau estimates that voltages in factories vary about 11 percent.



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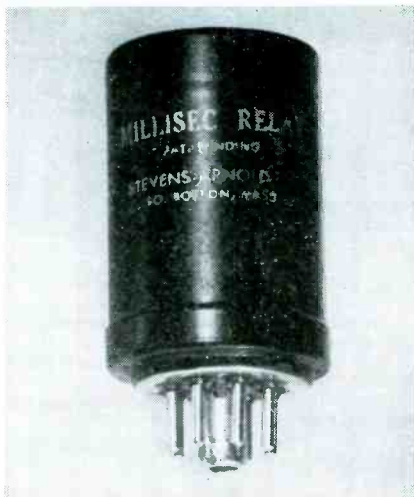
(continued from p 144)

contains a microphone and a blank-cartridge gun. Sound of the initial explosion as well as the reflected pulses are picked up, amplified, and recorded.

High-Speed Relay (13)

STEVENS-ARNOLD INC., 22 Elkins St., South Boston, Mass. The new Millisec d-c relay has an operating



time as short as $\frac{1}{3}$ millisecond. It is assembled in an hermetically sealed container, with an 8-prong octal base, and made in two sizes, either single-pole, double-throw, or double-pole, double-throw.

Sync Signal Generator (14)

ALLEN B. DU MONT LABORATORIES, INC., 42 Harding Avenue, Clifton, N. J. Model TA-107 A/B synchronizing signal generator furnishes horizontal and vertical driving pulses, blanking signals, and composite synchronizing signals required by studio and film cameras, camera control units, monitors

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CHATHAM 2051 THYRATRON

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CHATHAM 2050 THYRATRON

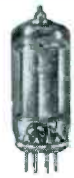
A Xenon filled shield grid thyratron for grid controlled rectifier service. Permits use of high resistance in grid current. Heater 6.3 volts, 0.6 amp. . . . Peak inverse plate voltage 1300 volts, average anode current 100 MA.

CHATHAM 884 THYRATRON

An Argon filled thyratron for use as a sweep circuit oscillator in cathode ray tube circuits. Stable oscillator. Heater 6.3 volts, 0.6 amp. . . . Peak forward plate voltage 300 volts, 75 ma. average plate current.

CHATHAM 4B32 RECTIFIER

A rugged half wave Xenon filled rectifier. Operates in any position throughout an ambient temperature range of —75° C to + 90° C Fil. 5 volts, 7.5 amp. . . . Inverse peak anode voltage 10,000 volts, 1.25 amp. average anode current.



CHATHAM 2D21 THYRATRON

A Xenon filled shield grid thyratron for grid controlled rectifier service. Permits use of high resistance in the grid circuit. Heater 6.3 volts .6 amp. . . . Inverse peak plate voltage 1300 volts, 100 ma. average plate current.

CHATHAM 5594 THYRATRON

Xenon filled thyratron. Operates through ambient temperatures from —55°C to +90° C without auxiliary equipment to maintain bulb temperature. Fil. 2.5 volts, 5.0 amperes. Peak inverse 5000 volts, anode current 0.5 amps, average, 2.0 amps peak.

CHATHAM 872-A RECTIFIER

A half wave Mercury Vapor rectifier to withstand high peak inverse voltages. Heavy duty filament. Fil. 5 volts, 7.5 amp. . . . Peak inverse anode voltage 10,000 volts, 1.25 amp. average anode current.

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An Argon filled thyratron for use as a sweep circuit oscillator in cathode ray tube circuits. Stable oscillator. Heater 2.5 volts, 1.4 amp. . . . Peak forward plate voltage 300 volts, 75 ma. average plate current.

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A Mercury Vapor thyratron for grid controlled rectifier and general application . . . rugged filamentary cathode. Fil. 2.5 volts, 5.0 amp . . . Peak inverse anode voltage 5,000 volts, 0.5 amp. average anode current.

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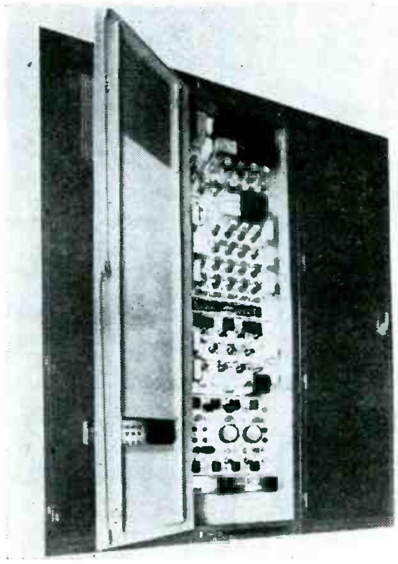
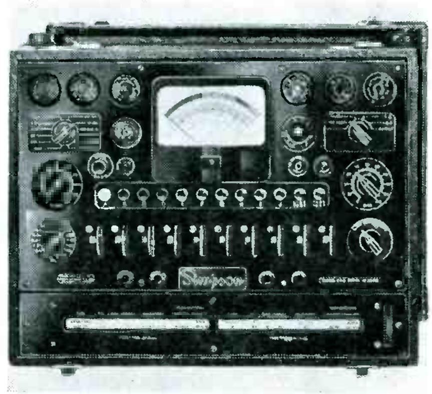


and other telecasting station equipment. Power consumption is 680 watts. Equipment conforms to all RMA and FCC specifications.

Tube and Set Tester (15)

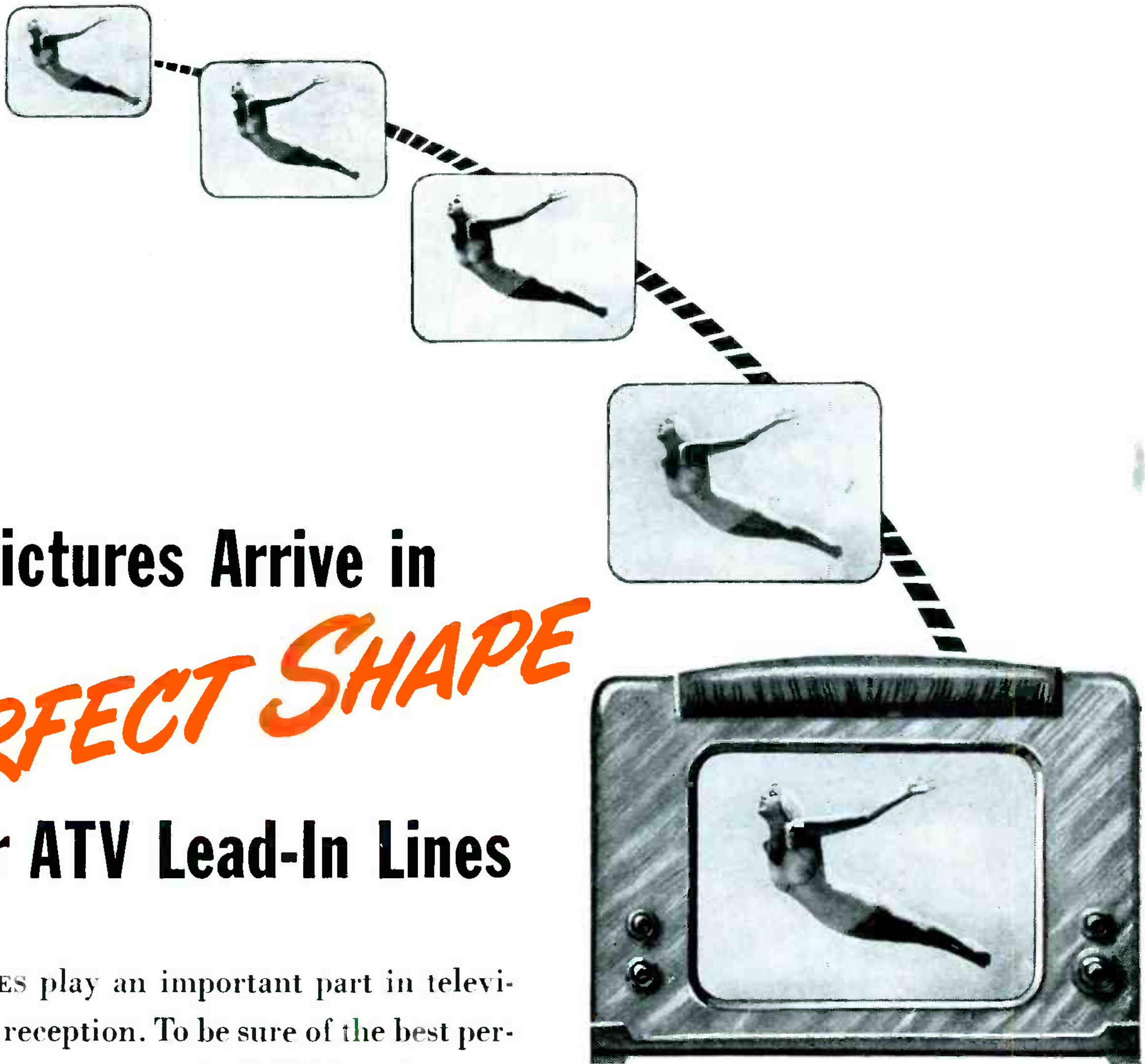
SIMPSON ELECTRIC CO., Chicago, Ill. A new tube and set tester model 445 incorporates the well-known model 260 meter. The tube tester is the plate conductance type



with an automatic reset mechanism that returns all switches to normal at the end of each test. Sockets for all types of tubes are provided.

X-Ray Tube (16)

WESTINGHOUSE ELECTRIC CORP., Bloomfield, N. J. A small x-ray tube designed for application in selfcontained dental, portable and mobile oil-filled equipments for low current high detail radiographic work features a hooded anode and a getter. A relatively thin x-ray



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LEAD-IN LINES play an important part in television and FM reception. To be sure of the best performance of your set, specify ATV* lines for your set.

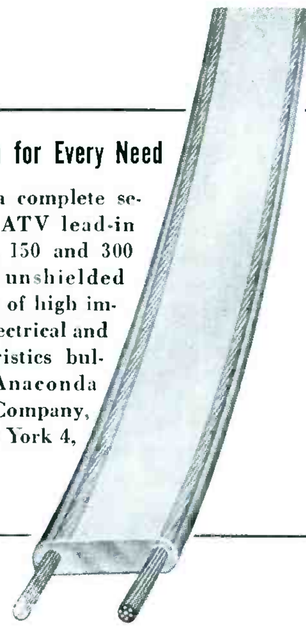
The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV lead-in lines.

The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest development in coaxial cables.

48147

A Type ATV Lead-In for Every Need

Anaconda offers a complete selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and shielded lines of high impedance. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.



*An Anaconda Trade-Mark

ANACONDA from mine to consumer

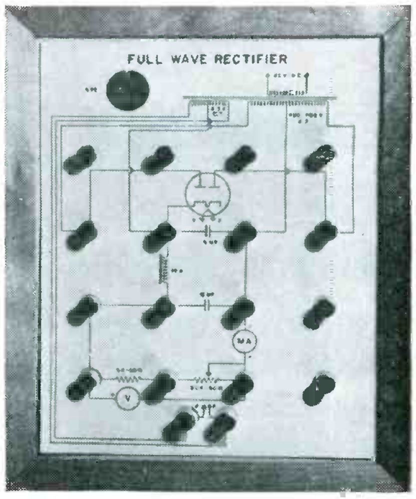
Anaconda Wire and Cable Co.

25 Broadway, New York 4, N. Y.

window can be used because the hooded anode reduces the electron bombardment of the envelope. Information is available on several tubes that make up this new line.

Circuit Panel (17)

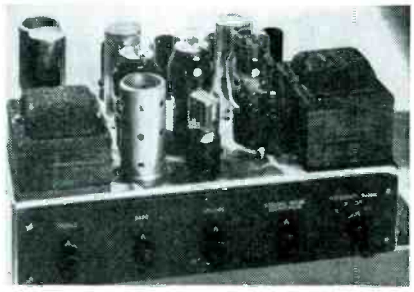
KEPCO LABORATORIES, INC., 142-45 Roosevelt Ave., Flushing, N. Y. Model 104 electronic circuit panel,



designed for fundamental laboratory experiments, aids in investigating the characteristics of vacuum and gas-filled tubes as well as the circuits using these tubes. It contains three octal tube sockets and eighteen binding posts mounted on a panel. Supplied with the unit are 23 keyed circuit diagrams and 3 master charts.

Lab Amplifier-Suppressor (18)

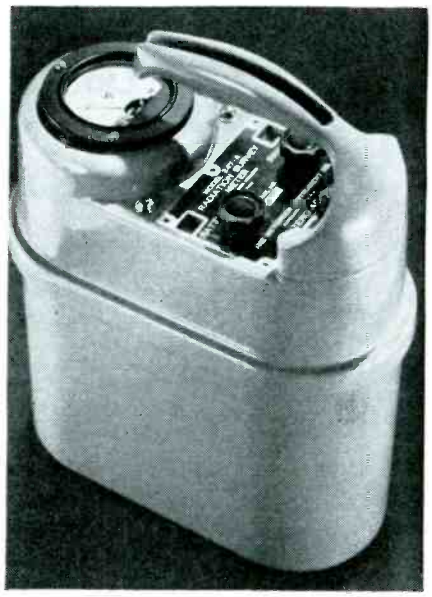
HERMON HOSMER SCOTT, INC., 385 Putnam Ave., Cambridge, Mass. Type 210-A laboratory amplifier is supplied with a matched variable reluctance pickup cartridge. The amplifier has less than 2 percent distortion at 20 watts output. Below 8 watts distortion falls to under 0.5 percent. Frequency range



exceeds 20,000 cycles and with dynamic noise suppressor response is flat to 10,000 cycles. Bass and treble tone controls are provided. For a-m reception a whistle filter can be switched in.

Radiation Meter (19)

VICTOREEN INSTRUMENT CO., 5806 Hough Ave., Cleveland 3, Ohio. The portable 247A gamma ray survey meter is the ionization chamber



type that is hermetically sealed and watertight. Four ranges of sensitivity are provided to allow full-scale readings of 2.5, 25, 250, and 2,500 milliroentgens per hour. Total weight of the rugged instrument is 11¾ pounds.

Wire-Wound Resistors (20)

CLAROSTAT MFG. CO., INC., 130 Clinton St., Brooklyn, N. Y. announces the Greenohm Juniors, ceramic-cased midget wire-wound resistors for small spaces and for facilitating point-to-point wiring. Standard type C7GJ is rated at 7 watts,

LISTED UNDER REEXAMINATION SERVICE
UL
UNDERWRITERS' LABORATORIES, INC.

...mean 105°C continuous operating temperature

A NEW HIGH FOR EXTRUDED VINYL TUBING

Natvar 400 now has "four ridges equally spaced around the circumference, and running the length of the tubing." This marking was specified by Underwriters' Laboratories to distinguish it from tubings limited to lower temperatures.

It may now be safely used in many applications instead of varnished sleeving, with great savings in material and labor costs and reduced waste.

More and more users of extruded tubing are standardizing on Natvar 400 because, in addition to its remarkable heat and oil resistance, it is well balanced in other properties. E. T. L. and Underwriters' reports are available on request.

Natvar

Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing
- Extruded vinyl identification markers

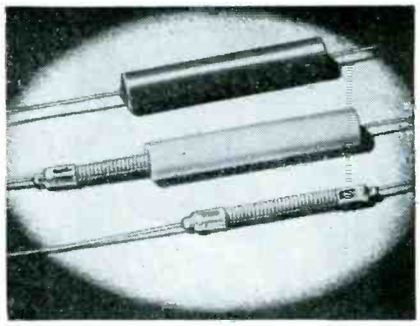
Ask for Catalog No. 21

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE
RAHWAY 7-2171

CABLE ADDRESS
NATVAR: RAHWAY, N. J.

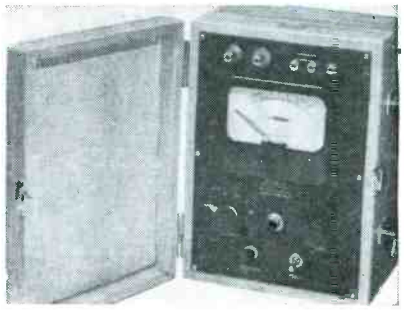
201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY



and is available in values from practically zero to 5,000 ohms maximum; smaller type C4GJ is rated at 4 watts, with maximum resistance of 1,000 ohms.

Log Scale Megohmmeter (21)

MACLEOD & HANOPOL, Charlestown 29, Mass. Logarithmic scale dis-



tribution of this direct-reading megohmmeter gives the same accuracy over the whole range of 1 to 100,000 megohms, covered by six decade steps. Range can also be extended to 1,000,000 megohms.

Projection Television Components (22)

SPELLMAN TELEVISION CO., 2898 Jerome Ave., New York 58, N. Y. The 30 kv r-f power supply illustrated has a low voltage supply separate from the high voltage pack. Voltage can be varied from

Funny Numbers?

. . . perhaps, but they are more evidence of SPRAGUE LEADERSHIP!

New Phenolic-Molded Sprague Tubular Capacitors Produced in Decade Ranges and Color-Coded!

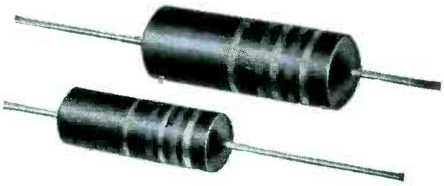
With the recent introduction of its sensational new *molded* tubular capacitors, Sprague now announces standardized capacities, and color-coding for ready identification of these new units. For example, starting with the number 1, the next numbers in the 20% tolerance decade are 1.5, 2.2, 3.3, 4.7, 6.8 and on back to 10.

Established decade ranges and color-coding have proved their efficiency and acceptability in the resistor industry over a period of years. Now, for the first time, this same practice will allow capacitor manufacturers the many advantages of standardized production—advantages which we feel will be cumulative through the years.

In the firm conviction that these steps toward standardization will prove mutually beneficial, Sprague Electric Company solicits your co-operation and invites your inquiries for information, samples and application data concerning the new SPRAGUE MOLDED TUBULAR CAPACITORS. WRITE FOR ENGINEERING BULLETIN NO. 210A.

THE FIRST TRULY PRACTICAL PHENOLIC-MOLDED PAPER TUBULAR!

Highly heat- and moisture-resistant • Non-inflammable • Conservatively rated for —40°C. to 85°C. operation • Small in size Completely insulated • Mechanically rugged Moderately priced.



SPRAGUE MOLDED TUBULAR CAPACITOR COLOR CODE

			Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White
1st BAND	Capacity in MMFD	First Significant Number	0	1	2	3	4	5	6	7	8	9
2nd BAND		Second Significant Number	0	1	2	3	4	5	6	7	8	9
3rd BAND		Decimal Multiplier			100	1000	10.000	100.000				
4th BAND	TOLERANCE		±20%			±30%	±40%	±5%				±10%
5th BAND	RESERVED FOR ARMED SERVICES											
6th BAND	Voltage in Hundreds (x 100)	First Significant Number	0	1	2	3	4	5	6	7	8	9
7th BAND		Second Significant Number	0	1	2	3	4	5	6	7	8	9

SPRAGUE ELECTRIC COMPANY North Adams, Mass.

CAPACITORS **SPRAGUE** *KOOLOHM RESISTORS

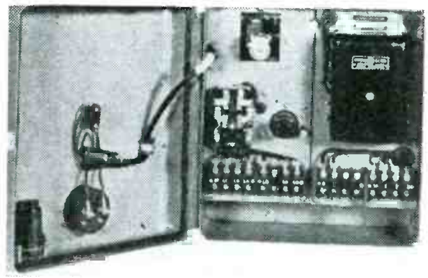
*Trademark reg. U. S. Pat. Off.

PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

12 to 40 kv. A focus control is provided for use with type 5TP4 projection tube. Other components include projection lens, movable stand for equipment, and a number of screens.

Combustion Control (23)

GENERAL ELECTRIC Co., Schenectady 5, N. Y. A new photoelectric



combustion control system for commercial oil burners comprises master, phototube, and electrode units. The system shuts off fuel flow immediately if oil fails to ignite or if the flame is extinguished after successful ignition. Write for bulletin GEA 4779.

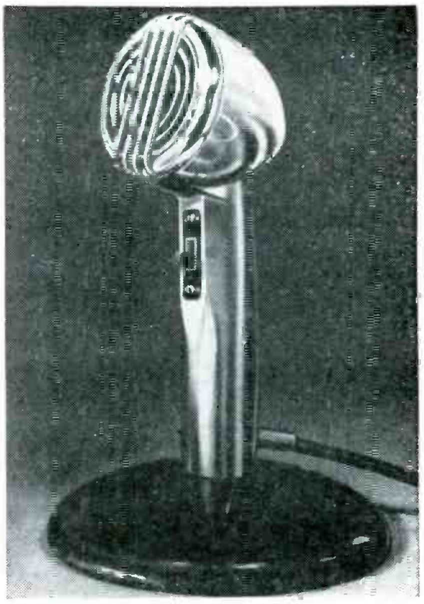
Voltage Reference Tube (24)

RADIO CORP. OF AMERICA, Harrison, N. J. Type 5651 miniature glow-discharge tube maintains a d-c operating voltage of 87 volts, and has an operating current range of 1.5 to 3.5 milliamperes. Operating

characteristics are essentially independent of ambient temperature. Complete information is contained in a reference sheet.

Hand-Desk Mike (25)

ASTATIC CORP., Conneaut, Ohio. Model 200 crystal microphone has a smooth frequency response from 30 to 10,000 cycles; model 241 is similar in range but with a rising characteristic between 1,500 and



5,500 cycles. Either model supplied with or without switch has a quick-lock base so that it can be used as hand or desk mike or mounted on a floor stand.

10-Kw R-F Generator (26)

WESTINGHOUSE ELECTRIC CORP., 306 Fourth Ave., Pittsburgh 30, Pa. Designed specifically for the woodworking industry, the new 10-kw r-f generator operates semi-automatically. A single front panel control allows adjustment for large changes in electrode size. The generator is available in 5 and 13.6-mc units that operate on 230 or 460 volts, three-phase, 60-cycle current.

Modulator Unit (27)

BEE-BEE ELECTRONIC CO., 2692 W. Pico Blvd., Los Angeles 6, Calif. The model 500 narrow-band f-m modulator unit is a reactance type designed for direct coupling to the

MEASURE SONIC FREQUENCIES . . .

INSTANTLY . . . ACCURATELY . . . VISUALLY

WITH *Stroboconn*

Used effectively in industrial laboratories for checking the speed of rotating objects and for calibrating or checking tachometers, measuring natural frequencies, and calibrating oscillators, impulse generators and similar equipment. With the Stroboconn, you can speed up the job with full assurance of accurate results.

A Notable Achievement in Sonic Research

The Stroboconn is essentially a logarithmic frequency meter of the Stroboscopic type, having an accuracy of frequency determination of 0.05%, in the continuous range of 32 to 4070 cycles per second. Ultra-sonic frequencies may be reduced to Stroboconn range by use of a frequency divider. The logarithmic scale is particularly advantageous in measuring ratios of two frequencies, with or without regard to the actual frequencies involved.

In use, the quantity to be measured is converted into an audio signal, amplified and fed to a discharge tube that produces flashes of light at the audio rate involved. A dial reading indicates the frequency of the input signal. Send for *free* folder and further information concerning the Stroboconn's adaptability to your particular problem.

PROVED PERFORMANCE

Among Stroboconn users are Harvard University, Bell Aircraft Corp., and Hamilton Standard Propellers. During the War, this instrument was used as a standard for checking equipment in the Army Air Forces Power Plant Laboratory, at Wright Field.

★ ★ ★

Send for Free Folder

Gives more complete information about operation and application of this amazing precision instrument. No obligation.

CONN BAND INSTRUMENT DIVISION

C. G. CONN LTD., DEPT. 312
ELKHART, INDIANA

Stroboconn

vfo or crystal socket of a conventional crystal-controlled pentode or triode oscillator.

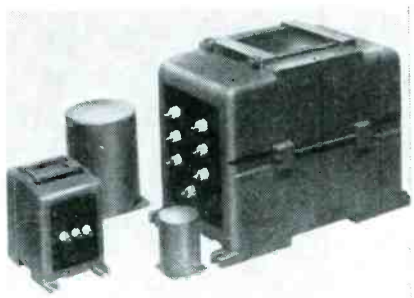
Multi-Purpose Tester (28)

SIMPSON ELECTRIC CO., Chicago, Ill., announces the new model 1005 Electrical Laboratory, a test unit combining the functions of over 60

separate instruments. It is adaptable for testing all electrical appliances, small motors, circuits, radio sets and the like. Size is approximately 34 × 17 × 9 inches; and weight, 37 lb.

Transformers (29)

UNITED TRANSFORMER CORP., 150 Varick St., New York 13, N. Y. A



new series of commercial grade transformers includes audio components, input transformers, modulation, power, and filament transformers. They are fully described in catalog PS-408.

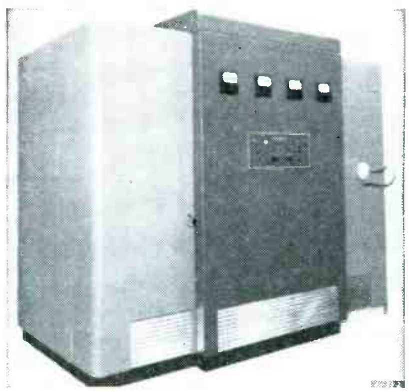
Dielectric Heater (30)

SHERMAN INDUSTRIAL ELECTRONICS CO., INC., 503 Washington Ave., Belleville 9, N. J. Sieco heater type SD-15 for heating plastic preforms, drying cloth, or setting glue has a

continuous output of 15 kw and features pushbutton operation. No tuning or other manual adjustments are required. Frequency of operation is 27 mc.

50-kw Heater (31)

WESTINGHOUSE INDUSTRIAL ELECTRONICS DIVISION, Plant 4, Baltimore 3, Md. A 50-kw 450-kc r-f



generator and two-position work table are available for production heating jobs such as hardening gears and automotive parts. The generator operates on 230/460 volt 3-phase, 60-cycle current.

Variable Speed Motor (32)

GUERNET ELECTRICAL MACHINERY, INC., Box 196, Meriden, Conn. Designed to maintain constant maximum torque at all speeds, a new motor with ⅓ hp rating is variable from 1,500 to 6,000 rpm. A lever at the side of the motor stops and starts the motor and mechanically

controls a pair of centrifugal vibrating contacts that accomplish the speed variation.

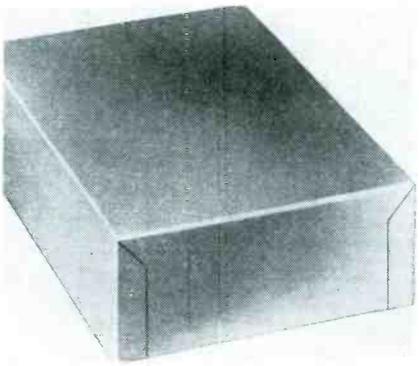
Control Unit (33)

GENERAL ELECTRIC CO., Schenectady 5, N. Y. A new packaged amplidyne control unit for applications

where speed, current, or voltage regulation are required is now available. Indicating instruments are provided for ease in adjustment.

New Chassis (34)

E. F. JOHNSON CO., Waseca, Minn. A new line of chassis is so formed that no overlaps occur at the cor-



ners. The feature permits locating holes for volume controls and toggle switches all the way up to the corners. Rigidity is insured by welded tie bars on the inside of the turned under bottom edge.

Servicing CRO (35)

HICKOK ELECTRICAL INSTRUMENT Co., 10527 Dupont Ave., Cleveland

PLASTICON HIVOLT SUPPLIES

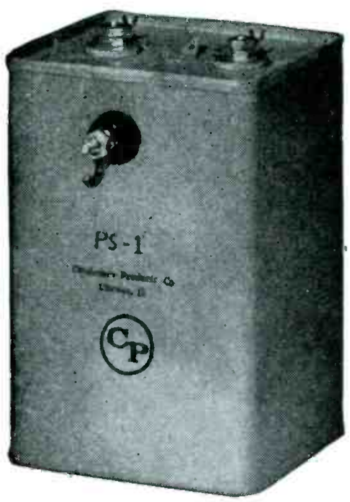
High Voltage - Low Current DC Power Supplies

for

Television—Radiation Counters—Photoflash Devices—Electrostatic Precipitators—Spectrographic Analysers, Oscilloscopes, Etc.

HiVolt Supplies are self-contained in hermetically sealed metal containers. They are designed to transform low voltage AC to high voltage - low current DC.

HiVolt PS-1



Specifications:

Volts Input: 118 VAC, 60 cycles.
Volts Output: 2400 VDC (capacitor load)
Current Output: .006 Amps., half-wave DC.
Max. Watts Input: 15 watts.
Type of Filter: Not filtered.
Terminals: 8-32 screw and nuts.
Insulation: 118 VAC—2 bakelite washers;
2400 VDC—1 porcelain standoff;
2400 VDC—lug spotwelded to case.
Container: Terne plate steel—gray lacquer finish.
Size: 3¾" x 3 3/16" x 5½".
Weight: 2.2 lbs.

List Price $18.95 F. O. B. Chicago

NOTE: The PS-1 is designed to charge a parallel-wired bank of not more than 15 AOCOE-22C3 Plasticon Energy Storage Capacitors (48 mfd.).

HiVolt PS-2

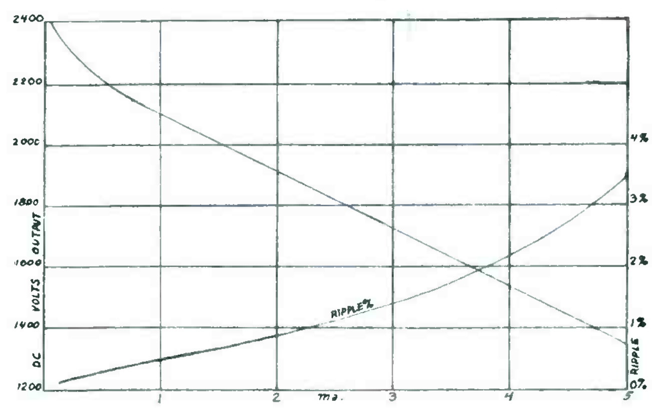
Specifications:

Volts Input: 1,8 VAC, 60 cycles.
Volts Output: 2400 VDC, maximum.
Current Output: .005 Amps. DC. maximum.
Max. Watts Input: 10 watts.
Type of Filter: R. C. Filter: 50,000 ohms, 2x.1 mfds.
Terminals: 8-32 screw and nut.
Insulators 118 VAC—2 bakelite washers;
2400 VDC—2 porcelain standoffs;
container neutral.
Container: Terne plate steel—gray lacquer finish.
Size: 3¾" x 3 3/16" x 5½".
Weight: 2.5 lbs.

List Price $25.75 F. O. B. Chicago

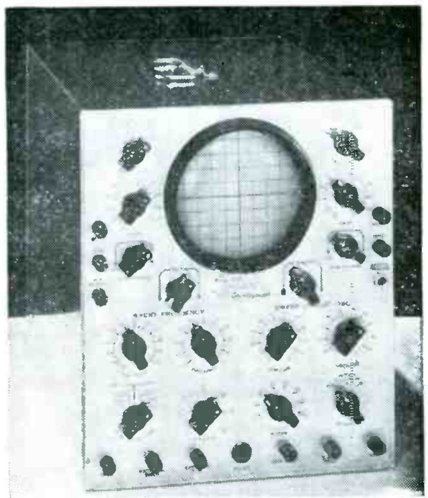
NOTE: The PS-2 is similar in appearance to the PS-1 except that all four terminals are on the recessed top of the container.

Regulation and Ripple Curves



Condenser Products Company

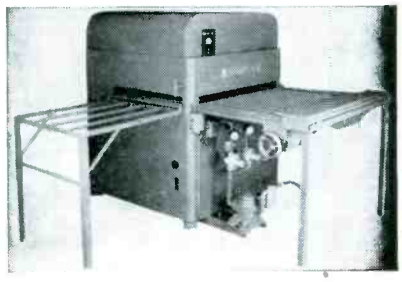
1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS



8, Ohio. Model 505 cathode-ray oscilloscope has been designed for the visual analysis of receiver circuits and the signal-tracing technique in trouble shooting. The equipment generates an f-m signal so that it can be used for aligning i-f and r-f transformers and discriminator circuits.

H-F Gluing Machine (36)

ELECTRONIC HEATING ASSOCIATES, 75 Jefferson St., Newton 58, Mass. The new high-frequency glueing



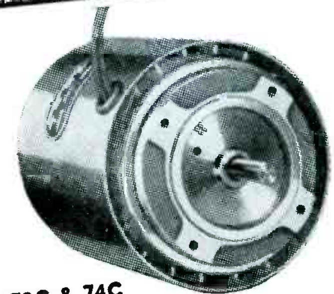
machine for woodworking, called Raybond, has a capacity from 400 to more than 1,200 square feet of edge-bonded blanks an hour. It requires only one operator and accommodates stock in thicknesses from ⅜ inch to 2 inches with adjustable pressure as required. Average complete work cycle takes from 20 seconds to one minute. Several models are available.

Time Switch (37)

PALO-MYERS, INC., 81-83 Reade St., New York 7, N. Y. The new time switch for laboratory and industrial uses is a selfcontained unit incorporating equipment for turn-

EAD

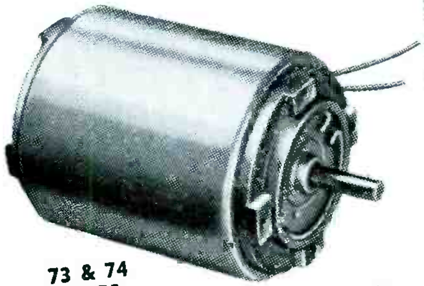
FRACTIONAL H.P. MOTORS — BLOWER UNITS — CONTROL COMPONENTS



73C & 74C SERIES

115-220 Volts—50, 60 and 400 cycles . . . Continuous duty. Sleeve Bearing . . . Fan Cooled . . . Totally Enclosed. Outside Diam. 3⅞".

TYPE	H. P.	R.P.M. 60 Cy.
Capacitor	1/15, 1/20, 1/30	1600 & 3200
Shaded Pole	1/30, 1/50, 1/100	1500
Synchronous	1/50, 1/100	1800 & 3600



73 & 74 SERIES

115-200 Volts—50, 60 cycles. Fan or Intermittent duty . . . Sleeve Bearing . . . Totally Enclosed. Outside Diam. 3-5/16".

TYPE	H.P.	R.P.M. 60 Cy.
Capacitor	1/20, 1/30, 1/50	1600 & 3200
Shaded Pole	1/30, 1/50, 1/100	1500
Synchronous	1/50, 1/100, 1/200	1800 & 3600

71 SERIES

115-200 Volts—50, 60, 400 Cycles Continuous duty. Sealed Ball Bearings. Totally enclosed. Outside Diam. 3-5/16"—3⅞".

TYPE	H. P.	R.P.M. 60 Cy.
Capacitor	1/15, 1/20, 1/30, 1/50, 1/100	1600 & 3200
Shaded Pole	1/30, 1/50, 1/100	1500
Synchronous	1/50, 1/100, 1/200	1800 & 3600

49 SERIES

115 Volts—50, 60 and 400 Cycles. Continuous duty . . . Ball Bearing. Totally enclosed. Outside Diam. 1¾".

TYPE	H.P.	R.P.M. 60 Cy.
Capacitor	1/100*, 1/250	2800 & 3100
Torque	5 Oz. In.	45°Only

*Intermittent Duty Only

31 SERIES

115 Volts, 400 cycles, 1/25 to 1/100 H. P. Weight of units 15 oz. Diam. 1 15/16. Length 2 29/32.

36 SERIES

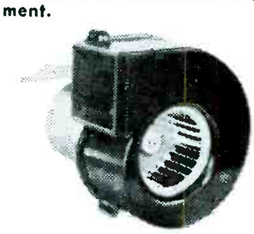
D.C. Voltage Generators for Control and Tachometer applications . . 2 Volts per hundred R. P. M. Permanent magnet field . . . weight, 20 oz. Diameter 2¼". Length 3".

ALTERNATORS

Special Alternators designed for any application. 20 to 1000 cycles up to 50 watts. Specialists in permanent magnet designs.

AXIAL FLOW BLOWERS

Numerous types for 50, 60 and 400 Cycle application. 170 to 800 C.F.M. (NEMA Code). 65 to 300 C.F.M. (NAFM Code). Designed for use in electronic or industrial equipment.



CENTRIFUGAL BLOWERS

Numerous Types for 50, 60 and 400 Cycle application. 60 to 110 C.F.M. For use in electronic or industrial equipment.

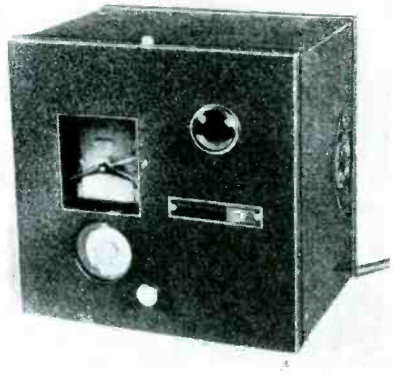
TYPICAL APPLICATIONS

Cameras and Projectors
Chart Recorders
Floor Fans
Dispensing Machines
Timing Apparatus
Turntables
Air Conditioning

Eastern Air Devices' units embody all of the important advances in design and construction made during the war. Included are such features as: replaceable "capsule" bearings, snap ring construction for easy disassembly, radically improved cooling means, insuring long life with minimum size and weight, etc. Let us fit an E. A. D. unit to your application.

EASTERN AIR DEVICES, INC.

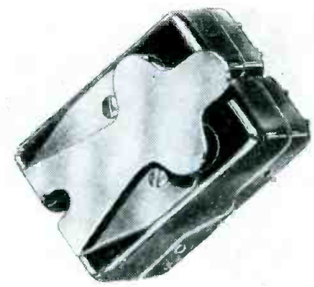
585 Dean Street - Brooklyn 17, N. Y. Tel. Sterling 3-3408
EAD Foreign Dept.-70 Pine St., N.Y.C. Tel Whitehall 4-8729



ing apparatus on and off at a predetermined time schedule. Operating at 110 volts a-c, the cycle repeats day after day as long as the clock is not disconnected.

Snap Switch (38)

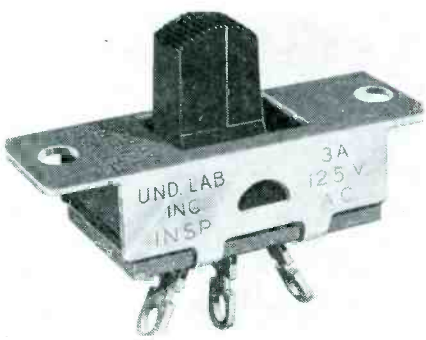
UNIMAX SWITCH CORP., 460 West 34th St., New York 1, N. Y. Type



SA-1 double-pole snap-action switch can be obtained in either double- or single-throw and is made up of two switches joined by an Adaptaplate. The switch is rated at 15 amperes 125 volts.

Snap-Slide Switch (39)

ELPAR CO., Bank & Marlton Ave., Camden, N. J. Type RS Underwriters' approved 3-ampere 125-volt a-c snap action slide switch has a low contact resistance. Max-



imum travel is 0.16 inch, and the switch is selfactuating beyond the center of throw. Two mounting holes are required.

Ferrule Resistor (40)

MILWAUKEE RESISTOR CO., 700 West Virginia St., Milwaukee, Wis. A new ferrule-type line of resistors

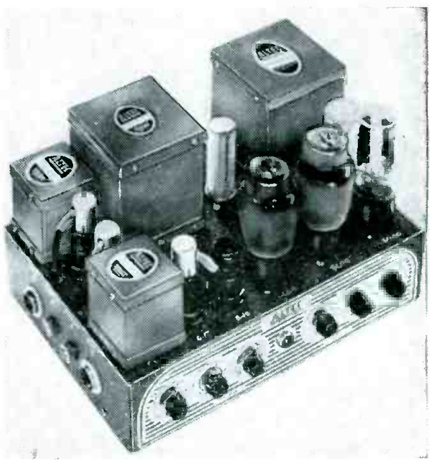
that eliminates separate tips by a technique in which the ends of the resistor core are copper coated substantially reduces production costs over conventional models.
ament.

Television Camera Tube (41)

RADIO CORP. OF AMERICA, Harrison, N. J. The new image orthicon, 5655, is especially recommended for studio use. It differs from the 2P23 in that its photocathode has practically no infrared sensitivity, and it has better resolution, signal-to-noise ratio, and more natural response to halftones.

Portable P-A Amplifier (42)

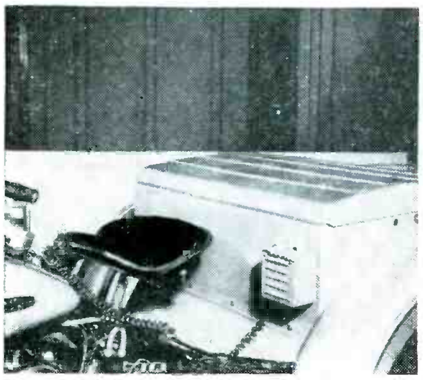
ALTEC LANSING CORP., 250 West 57th St., New York 19, N. Y. A new portable public address amplifier model A-324 is rated at 15 watts with an overall frequency response



flat within 1 db from 20 to 20,000 cycles. Four inputs are provided, two low impedance with 95-db gain and the other two with 72-db gain at high impedance. Variable controls are available for both bass and treble.

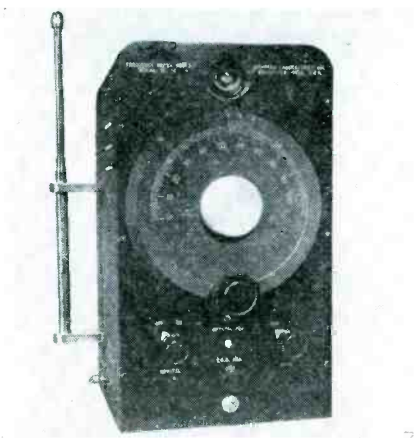
Motorcycle Dispatcher (43)

MOTOROLA INC., 4545 W. Augusta, Chicago 51, Ill. Designed for the 152-162 mc band, the new Dispatcher unit is a compact mobile radiotelephone transmitter and receiver for motorcycle use with a power output of 7 to 10 watts. The crystal drift is held to less than $\pm$ 0.002 percent over a temperature range of $-$ 20 to $+$ 80C.



Mobile Frequency Meter (44)

BROWNING LABORATORIES, INC., Winchester, Mass. Model S-7 frequency meter is particularly useful for measurements in the 72–76 and 152–162 mc bands. Accuracy of 0.005 percent is easily obtained, and with special precautions in the measurement technique, better than 0.0025 percent is possible. A whip



electronics READER SERVICE . . .

LITERATURE and NEW PRODUCTS

Manufacturers' Literature as well as further information on New Products described in this issue are important "working tools" for design and production departments. To make it easy to keep up to date, ELECTRONICS will request manufacturers to send readers the literature in which they are interested. Just fill out card as shown in the filled-in sample *(right), being particularly careful to write out in full all the information called for in each section of each card that is used.*

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Your Company Name Jones Mfg. Co.
Address 3217 Lewis Ave.
Chicago 13, Ill.
Your Name Geo. Smith
Your Title Chief Engineer
ELECTRONICS, 330 W. 42nd St., N. Y. 18

Write in circle number of item describing one item wanted → 32
Your Company Name Jones Mfg. Co.
Address 3217 Lewis Ave.
Chicago 13, Ill.
Your Name Geo. Smith
Your Title Chief Engineer
ELECTRONICS, 330 W. 42nd St., N. Y. 18

Write in circle number of item describing one item wanted → 37
Your Company Name Jones Mfg. Co.
Address 3217 Lewis Ave.
Chicago 13 Ill.
Your Name Geo. Smith
Your Title Chief Engineer
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Write in circle number of item describing one item wanted → 49
Your Company Name Jones Mfg. Co.
Address 3217 Lewis Ave.
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Your Name H. S. Towne
Your Title Adv. Mgr.
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SAMPLE CARD SHOWING CORRECT FILL-IN ←

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HOW TO ORDER:

1. There are two postcards, each divided into four parts. Each of the four parts contains a ◯. You must write in this ◯ the number that appears in this issue over the literature or new product item in which you are interested. Place one number only in each circle.

2. Fill out completely (name, address, etc.) for each piece of literature or new product information you desire.

Do not say "same" in lieu of writing out full information called for when requesting more than one item.

3. This service applies only to literature and new product items in this issue. It does not apply to advertisements. Write directly to the company for information on its advertisements.

PLEASE NOTE: Requests for unnumbered items must be made direct to the manufacturer.

In the event this copy of ELECTRONICS is passed along to other members of your company, please leave this sheet in for their convenience. This assures everyone in your plant the opportunity to fill in their requests. When the round is completed, cards can then be detached along perforated lines and dropped in the mail. Each individual request will be mailed by us to the company offering the information and for that reason must be completely filled out.

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An electronics service designed for
READERS and MANUFACTURERS

FOR THE READER . . . ELECTRONICS fundamental policy has always been to supply its readers with all the pertinent and timely industry news. The ELECTRONICS Reader Service supplements this policy by offering the reader an easy and effective means of obtaining complete, up to the minute data on new products and of maintaining at his fingertips comprehensive, practicable information on "who's doing what" in the industry.

In every issue of ELECTRONICS there's complete coverage of the month by month development by manufacturers of new materials, components and equipment, as well as brief mention of all the important, new, manufacturers' technical pamphlets and catalogs. Some of these items will be of particular interest to specific design and plant engineers, buyers, executives and others of our readers. They will want to make further inquiry concerning the new products described or they will want to read and make a permanent part of their industrial library some of the manufacturers' literature and catalogs. ELECTRONICS Reader Service makes it easy for them to obtain in readily accessible and usable form the information they desire.

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FOR THE MANUFACTURER . . .

ELECTRONICS Reader Service will also be welcomed by manufacturers who are desirous of placing the complete news of their product developments as well as their technical bulletins and catalogs in the hands of those members of the electronic industry . . . including design, electrical and production engineers, researchers, physicists, executives, and buyers —who have a particular interest in, or represent a potential buying power for, their products.

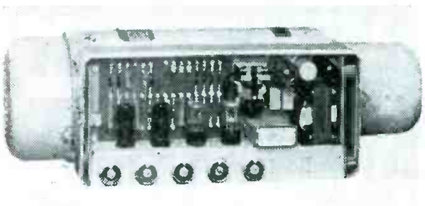
SUGGESTIONS FOR THE IMPROVEMENT OF OUR READERS' SERVICE ARE INVITED

ELECTRONICS is constantly seeking new and improved ways of providing its readers with the news and information they want and need, and of assisting the manufacturer in effectively delivering his message to electronic markets. If you have any ideas for us, send them along. They will receive prompt consideration.

antenna furnishes coupling to the transmitter. Operation is from 117 volts either a-c or d-c.

Electronic Amplidyne (45)

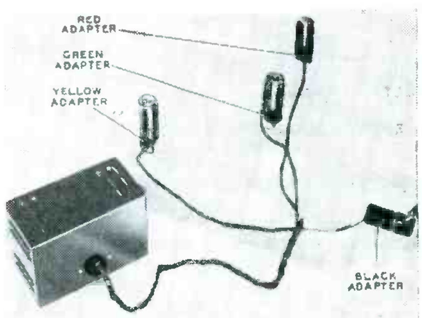
GENERAL ELECTRIC CO., Schenectady 5, N. Y., announces an electronic amplidyne which is useful for precise regulation of current,



voltage speed of motors. The unit consists of a high-gain balanced d-c electronic amplifier and a motor amplidyne. It has an output of 1½ kw, 250 volts and can be used on either a 220- or 440-volt, 3-phase, 60-cycle power supply.

Linearity Check (46)

PHILCO CORP., Philadelphia, Pa. Model 5072 Crosshatch generator enables a television service man



to check and adjust the linearity of a receiver's vertical and horizontal sweeps without depending on test charts from a television station. By means of an adapter harness the unit obtains required plate power, filament power and synchronizing voltages from the receiver itself.

Direct-Coupled Amplifier (47)

AMPLIFIER CORP. OF AMERICA, 398 Broadway, New York, 13, N. Y. Developed to accommodate the G-E

variable reluctance magnetic pickup without additional pre-amplification or equalized circuits, the model ACA-100GE direct-coupled amplifier develops 23 watts with less than one percent total distortion.

T-V Tubulars (48)

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. Type TMC-

187 capacitor developed for television service has a capacitance of 0.005 microfarads at 3,500 working volts, d-c.

Laboratory Furnace (49)

LINDBERG ENGINEERING CO., 2444 West Hubbard St., Chicago 12, Ill. has developed the model G-10 box type electronically controlled laboratory furnace with temperatures up

to 3,000 F top heat, and for continuous operation as high as 2,500 F. It is designed for operation on 230 volts, 60 cycle, single phase a-c. For further information request bulletin No. 980.

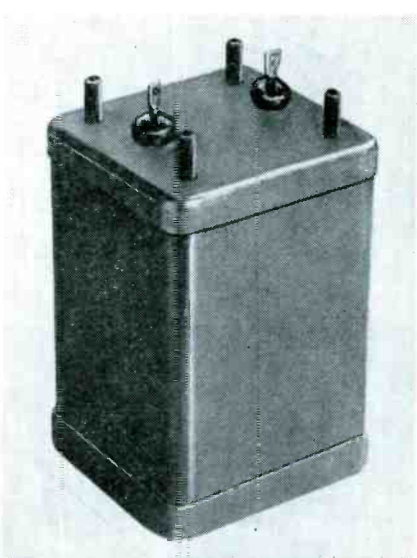
Signal Calibrator (50)

INDUSTRIAL ELECTRONICS, INC., 21 Henry St., Detroit 1, Michigan. The Electro-cal is an instrument pro-

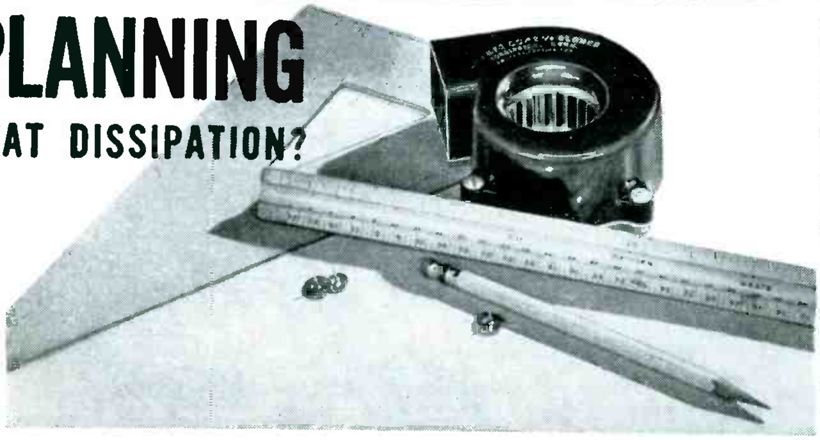
viding precision measured signal voltage for calibration purposes. Output signals in the form of 60-cycle sine waves up to 1,000 millivolts are available in eight ranges. An output signal of 0-5 volts can also be read directly on the meter.

Plastic Capacitors (51)

UNITED CONDENSER CORP., 422 E. 138th St., New York 54, N. Y. Plastic dielectric capacitors with su-



PLANNING
HEAT DISSIPATION?



MOVE AIR, 15 to 60 cubic feet a minute

There is a light, compact, highly efficient L-R Blower giving you maximum heat dispersion under all climatic or temperature conditions. Each of these blowers requires minimum space and produces maximum C.F.M. Specifications are listed below so that you may choose the size best suited to your needs.

SPECIFICATIONS

MODEL 1½, Weight (without motor)...2½ ounces
Output: 15 C.F.M. at 8000 R.P.M. Height 3"

MODEL 2, Weight (without motor)......5 ounces
Output: 25 C.F.M. at 8000 R.P.M. Height 3¾"

MODEL 2½, (Illustrated) Weight (without motor) ....5½ ounces
Output: 50 C.F.M. at 8000 R.P.M. Height 4½"

MODEL 3, Weight (without motor)...12½ ounces
Output: 260 C.F.M. at 8000 R.P.M. Height 6½"

All models have light-weight, high-impact plastic housings, turbo type wheels and are made with either clockwise or counter clockwise rotation.

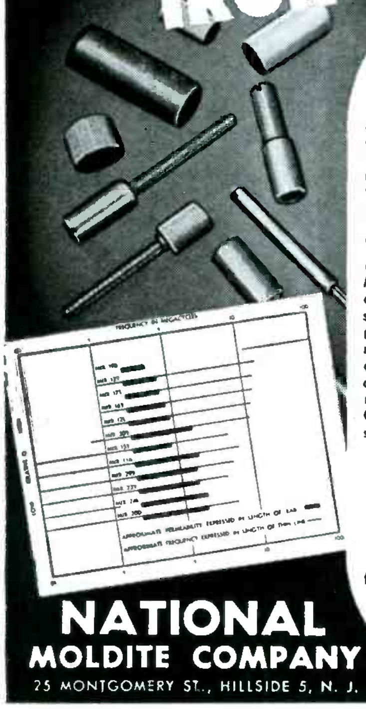
Electronic **Ripley** Controls

New York Office:
11 West 42nd Street

RIPLEY CO., INC.

Factory and Engineering Office:
Middletown, Conn.

MOLDITE IRON CORES



RADIO MANUFACTURERS ASSOCIATION
RMA

PERMEABILITY TUNING CORES
Moldite permeability tuning cores are manufactured to meet the most precise requirements. Modern mass production methods of manufacturing perm cores have resulted in increased quality and economy to our customers.

MOLDED IRON CORES
Moldite magnetic iron cores are manufactured to exact specification with an exclusive powder mix on each specific requirement at audio, broadcast, FM and Television frequencies. New formulae and methods of processing increase Q values, result in greater stability and density.

"MOLDITE SAMPLE KIT" equips engineering labs with a complete stock of sample iron cores for all applications. Cores selected and ordered by identifying number will be duplicated exactly in production. Write for latest Moldite catalog and sample kit.

M

NATIONAL MOLDITE COMPANY
25 MONTGOMERY ST., HILLSIDE 5, N. J.

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942 Maple Avenue	314 No. Michigan Ave.	Cordoba 1472
Los Angeles, Calif.	Chicago, Illinois	Buenos Aires, Argentina

BRADLEY
PHOTO ELECTRIC CELLS

Reduce Production Costs

Bradley Luxtron* photocells improve control over manufacturing operations, reducing your costs. They meet the most exacting requirements. Advanced manufacturing techniques make light-actuated Bradley cells the choice all over the world.

Luxtron photocells convert light directly into electrical energy. No external source of voltage is required. Besides the housed model shown with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pigtail contact mountings. In addition, Luxtron unmounted cells are available in many different sizes and shapes.

*T. M. REG. U. S. PAT. OFF.

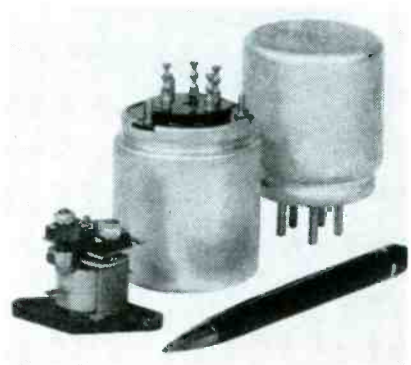
Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.
82 Meadow St. New Haven 10, Conn.

perior electrical characteristics are available in a wide range of voltage and capacitance. They can be furnished to close tolerances with housings either hermetically-sealed metal, glass or ceramic, or wax-sealed cardboard tubes.

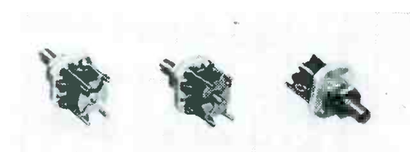
Current-Sensitive D-C Relays (52)

GENERAL ELECTRIC CO., Schenectady, N. Y. Eight types of single-pole, double-throw, current-sensitive, d-c relays are announced. Input ratings range from 10 to 180 milliwatts, 0.47 to 1,470 milliamps, and 0.07 to 67,000 ohms. Additional information is given in GEA-3819D.



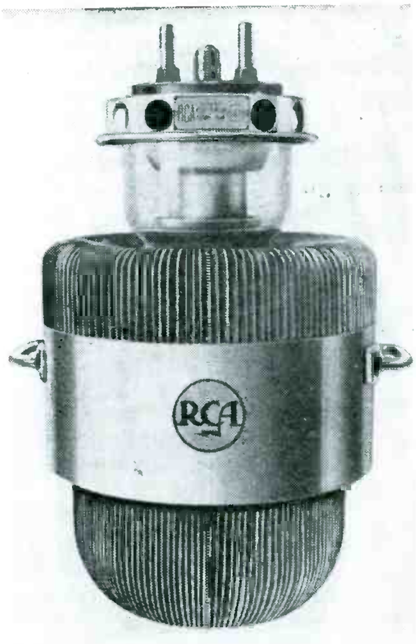
Air Variables (53)

E. F. JOHNSON CO., Waseca, Minn. A new line of air variable capacitors is available in single, differential, and butterfly types. Each of the three is available in four different capacitances. All have single-hole mounting, steatite end frames, and beryllium copper contact springs. Full details are available from the manufacturer.



Power Triode (54)

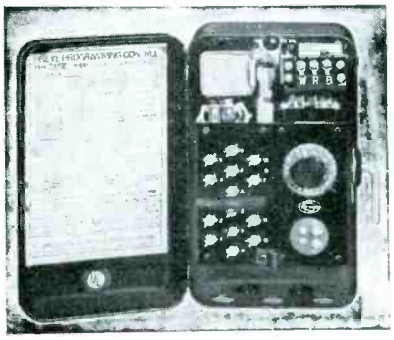
RADIO CORP. OF AMERICA, Harrison, N. J. The 5671 is a forced-air-



cooled power triode for high-power broadcast stations. It contains a thoriated-tungsten, multistrand filament.

Burner Program (55)

COMBUSTION CONTROL CORP., 77 Broadway, Cambridge 42, Mass. Fireye program control type 24PJ8



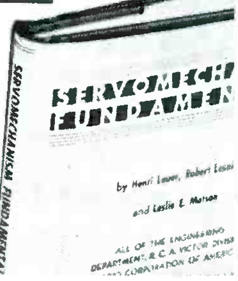
provides automatic starting and programming for commercial oil burning equipment. Full details of the equipment are given in Bulletin CD4751.

Mercury Contact Relay (56)

POTTER & BRUMFIELD MFG. CO., 549 West Washington Blvd., Chicago 6, Ill. has developed a mercury contact relay especially for current control in installations where there is danger due to ignition of fumes, dust or gas by arcs from open switches. The unit is sealed and

At last!

Practical data for designing AUTOMATIC CONTROL systems



Systematic design procedures - Test procedures - Working formulas, curves and diagrams -

Here, at last, is real, practical aid in designing servomechanisms—a presentation of theory, specific design procedures, and helpful test procedures, that will enable you to fulfill specified operating requirements, get the satisfaction you want from an automatic control system. The book analyzes various servo systems—those with viscous output damping, error-rate damping, integral control, etc. It presents scores of problems like those you actually encounter in servomechanism design, with the working formulas, curves and diagrams necessary for their solution.

SERVOMECHANISM FUNDAMENTALS

By Henri Lauer, Robert Lesnick and Leslie E. Matson

All of the Engineering Department, RCA Victor Division, Radio Corporation of America

277 pages, 6 x 9, 165 figures, $3.50

This book answers the need for a sound, practical reference on servomechanisms, and provides engineers with practical assistance in solving the problems they meet in achieving smoothly operating systems. The theory is developed by means of transient-response analysis methods. Scores of detailed schematic diagrams, drawings, graphs, charts and circuit diagrams are included. Helpful test procedures for checking the performance of a servo system have been outlined.

Ten chapters cover these topics:

1. Elementary Forms of Control Systems
2. Servo System Follow-up Links
3. Fundamentals of Mechanics and Electricity
4. Analysis of Servomechanisms with Viscous Output Damping
5. Analysis of Servomechanisms with Error-rate Damping
6. Analysis of Servomechanisms with Combined Viscous Output Damping and Error-rate Damping
7. Error-rate Stabilization Networks
8. Analysis of Servomechanisms with Integral Control
9. Transfer Function Analysis of Servomechanisms
10. Typical Design Calculations and General Considerations

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Send me Lauer, Lesnick and Matson's Servomechanism Fundamentals for 10 days' examination on approval. In 10 days I will send $3.50, plus few cents postage, or return book postpaid. (Postage paid on cash orders.)

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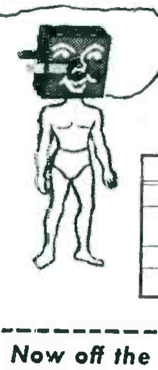
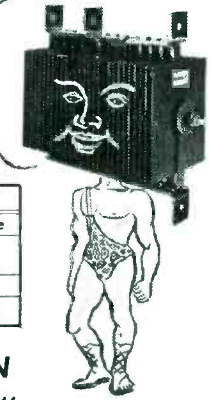
"Said the Mite to the Mighty!"



No need to quarrel, whether large or small, there's a SELETRON Selenium Rectifier for practically any application. And we can build any size to your specifications.



Yes, both the Mite and the Mighty agree . . .

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MAX RMS INPUT V	130	13.8
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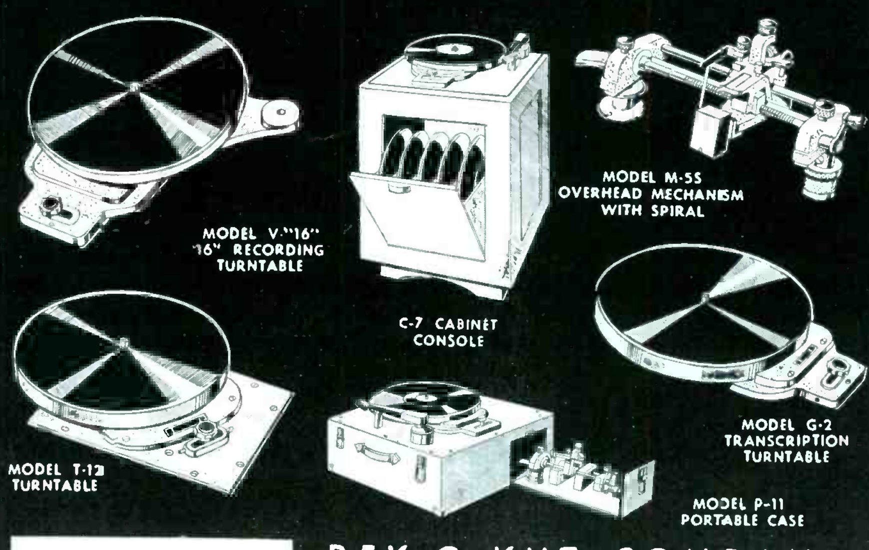

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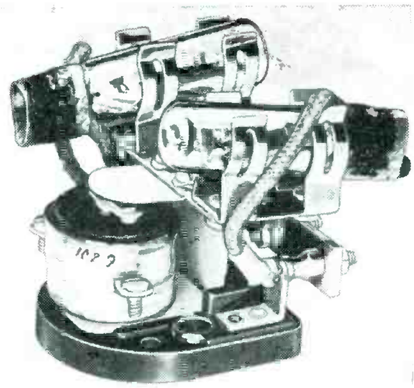
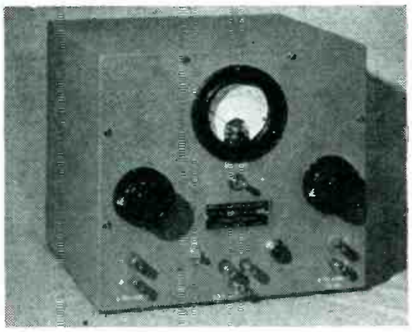
38-01 Queens Blvd. — Long Island City 1, N. Y.
Export Division – Morham Exporting Corp., 458 Broadway, New York



can be supplied for voltages up to 440 volts a-c or 230 volts d-c.

Regulated Power (57)

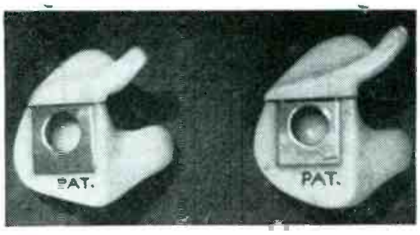
RADAR ENGINEERS, 1319 Second Ave., Seattle 1, Wash. Type RPS-3 regulated power supply furnishes



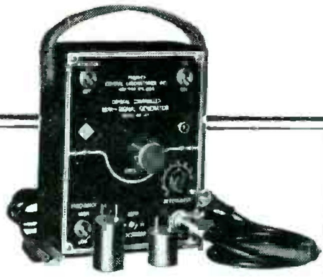
up to 300 volts at 50 milliamperes; down to minus 105 volts bias; and 6.3 volts at 2 amperes for heaters. Regulation is within 1 percent over most of the range. A voltmeter reads either positive or negative outputs.

Variable Earpiece (58)

CRYSTO-PLASTICS LAB., 110 East 42nd St., New York, N. Y. The Universal-Variable earpiece comes in only two sizes, but can be adjusted to fit any ear. Any miniature receiver unit can be attached



Get All The Facts



ON THIS NEW

PREMIER CRYSTAL—CONTROLLED MINI—SIGNAL GENERATOR

Extreme versatility is combined with laboratory precision in the new Premier Model 117 Crystal-Controlled Mini-Signal Generator.

The ultimate in accuracy is provided by the new Premier Model 117 Mini-Signal Generator. Its micrometer adjustment enables the user to zero-beat the crystal with standard frequency transmissions of WWV, and affords the utmost in precision in setting up frequency markers throughout the entire radio spectrum.

USE the Premier Mini-Signal Generator

- in **BROADCAST STATIONS**
- with **AIRCRAFT** and **AIRPORT** equipment
- in the **LABORATORY**
- in **MANUFACTURING RADIO EQUIPMENT**
- for **AMATEUR** operations
- in **SERVICE WORK**
- for general **FIELD** use . . .

The Premier Model 117 Mini-Signal Generator is *versatile*—can be used for A-M, F-M, television. Frequencies range from 100 kc. to 12 mc. — with harmonic operation above 12 mc. up into the VHF region. *Standard crystal:* 100 kc., precision finished to ±.005%. **Crystals** for other frequencies to specifications.

Packed With Facts — This four-page technical bulletin is full of detailed engineering data and specifications on the new Premier Mini-Signal Generator: circuit diagrams, construction details, operating instructions, exclusive features that make it more valuable and versatile for myriad uses. Write for Bulletin 117.

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PLN SERIES—Designed for NE-51 Neon Lamp

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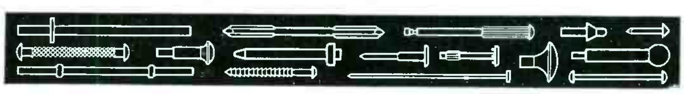
Manufacturers of Cold-Headed Specialties—Established 1850

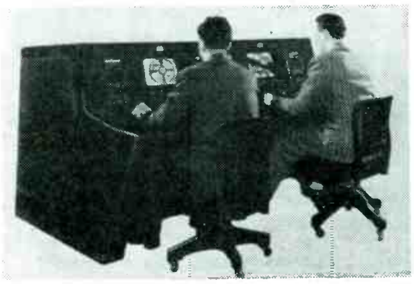


SPECIAL NAILS RIVETS SCREWS
Hassall
ESTABLISHED 1850

for use with hearing aids, pocket radios, walkie-talkies, or other communications equipment.

Television Film Pickup (59)

ALLEN B. DUMONT LABORATORIES, INC., 42 Harding Ave., Clifton, N. J. Model TA-512-A dual iconoscope



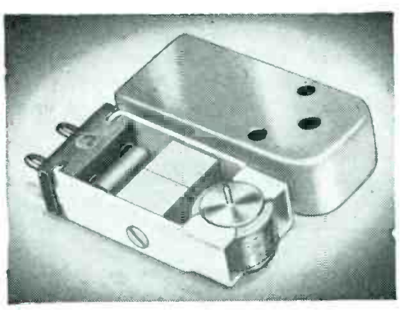
film pickup for which the control console is illustrated has been designed for the use of either positive or negative film on television programs. Electronic fading circuits are provided. The projection equipment is housed in wall cabinets.

Television Recorder (60)

EASTMAN KODAK CO., Rochester 4, N. Y. A 16-mm motion picture camera has been developed for use in television studios for recording movies directly from the face of a monitoring picture tube. Pictures are taken at the rate of 24 frames a second. The device can be used for reprogramming or for record purposes.

Variable Reluctance Pickup (61)

CLARKSTAN CORP., 11927 West Pico Blvd., Los Angeles 34, Calif. The Clarkstan RV pickup has exact velocity response to 15,000 cycles. Needle force of 20 grams is optimum for commercial pressings. As customarily furnished, the pickup has a high impedance but it can be obtained in impedances of 5, 50,



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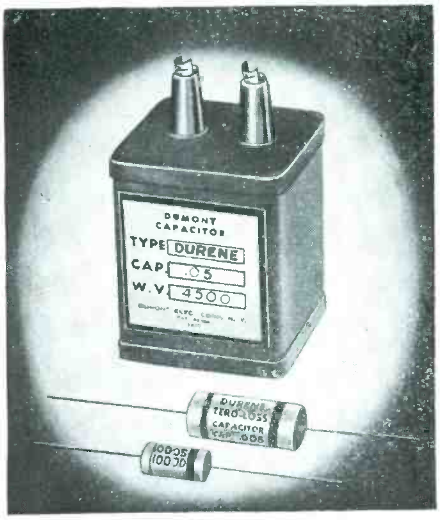
Durene

CAPACITOR

FOR

TELEVISION AND SHORT WAVE



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At last! A fixed condenser of plastic film having extreme high "Q". Ideal substitute for mica or ceramic capacitors, where sharp tuning such as short wave, television, F/M, and other critical circuits where losses must be at a minimum.

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- LEAKAGE RESISTANCE ½ MILLION MEGOHMS
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- CAP. FROM .00005 to 3 MFD.
- VOLTAGES FROM 500 to 10000 VOLTS.
- AC/DC up to 75 C
- S1 in TUBES; S2 in METAL CANS

Write for literature and prices to-day.

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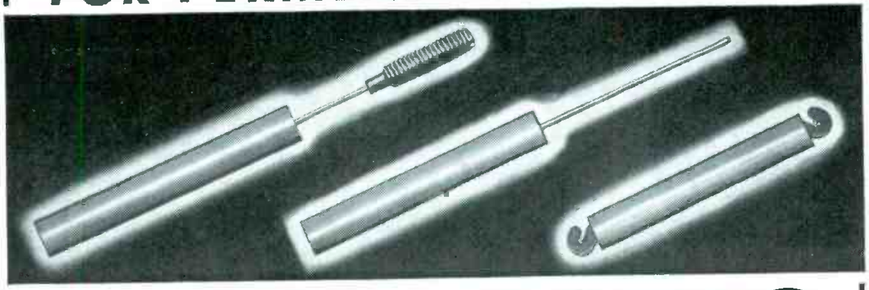

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501 West 35th Street, Chicago 16, Ill.

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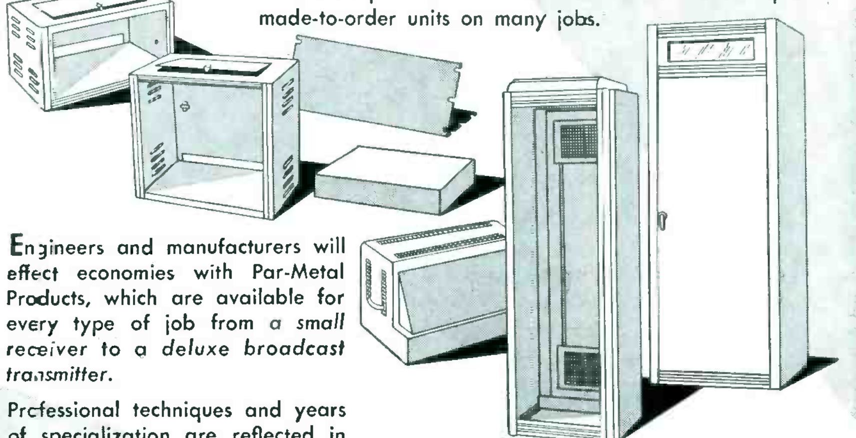
STANDARDIZED READY-TO-USE METAL EQUIPMENT

ADAPTABLE FOR EVERY REQUIREMENT

Par-Metal Equipment offers many features, including functional *streamlined* design, *rugged* construction, *beautiful* finish . . . plus *ADAPTABILITY*. Eliminate need for special made-to-order units on many jobs.



Engineers and manufacturers will effect economies with Par-Metal Products, which are available for every type of job from *a small receiver* to *a deluxe broadcast transmitter*.

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Export Dept.: Rocke International Corp.
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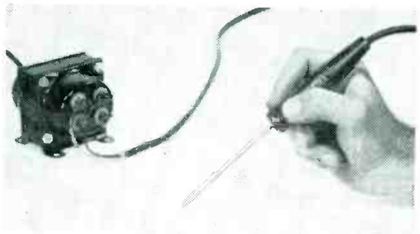
VISIT OUR EXHIBIT—BOOTH 212—I.R.E. SHOW

250, and 500 ohms. Output is 60 millivolts at 1,000 cycles with lateral displacement of 0.001 inch.

Midget Soldering Iron (62)

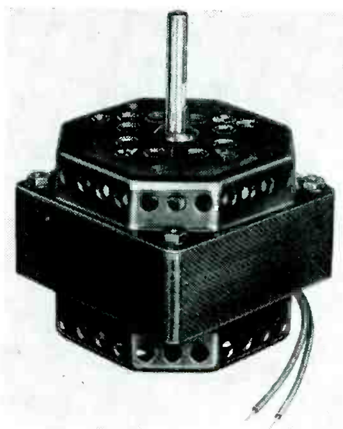
GENERAL ELECTRIC CO., Schenectady, N. Y. A new midget soldering iron is 8 inches long, has tips ¼ and



⅛ inch in diameter and weighs 1¾ ounce without the cord. It operates from 6 volts, consuming 25 watts and is illustrated with the step-down transformer used to adapt it to normal socket voltage.

Smooth Power Motor (63)

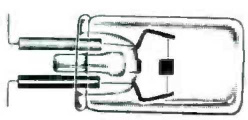
GENERAL INDUSTRIES CO., Elyria, Ohio. An improved model RM-4 small motor for use in wire and tape recorders has recently been an-

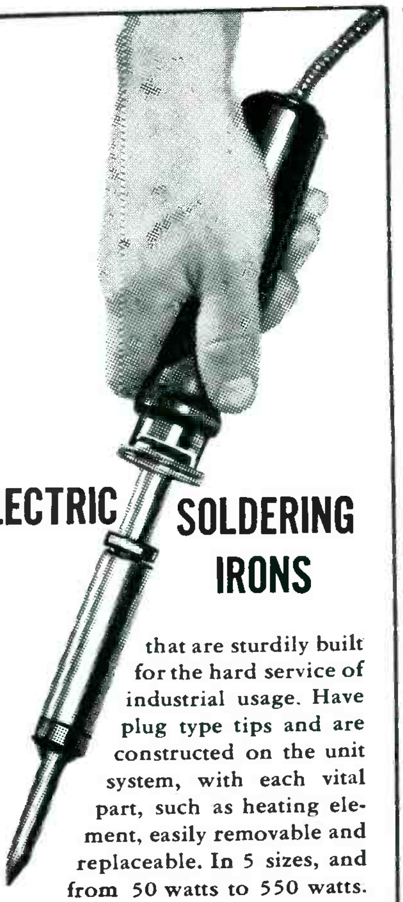


nounced. Features are freedom from vibration and magnetic field radiation, and minimum noise.

Vacuum Thermocouple (64)

FIELD ELECTRICAL INSTRUMENT CO., 109 East 184th St., New York 53,





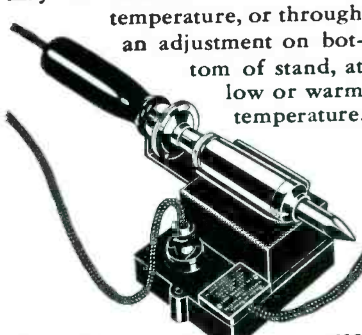
ELECTRIC SOLDERING IRONS

that are sturdily built for the hard service of industrial usage. Have plug type tips and are constructed on the unit system, with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, and from 50 watts to 550 watts.

American Beauty

TEMPERATURE REGULATING STAND

This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature, or through an adjustment on bottom of stand, at low or warm temperature.



For further information, write 115-1

AMERICAN ELECTRICAL HEATER COMPANY
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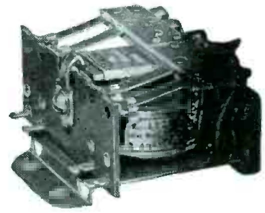
BETTER CONTROLS THROUGH BETTER RELAYS



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You will find Leach Relays rendering service around the electrical world: in Industry, Electronics, Communications, Aviation, Transportation and Power.

During the past thirty years, Leach has faithfully maintained its policy of building quality equipment; and today, you'll find Leach delivers *quality* in *quantity*. The name LEACH stands for "better relays" and assures you of "better controls."

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COSMALITE* FORMS FOR Television RECEIVERS

These spirally laminated paper base, Phenolic Tubes are delivered already punched and notched to meet the exact requirements of the customer.

Ask also about . . .

#96 COSMALITE for coil forms in all standard broadcast receiving sets.
SLF COSMALITE for Permeability Tuners.
Spirally wound kraft and fish paper Coil Forms and Condenser Tubes.

There is a definite saving to you in specifying and using Cosmalite.

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- **All-Fibre Cans • Combination Metal and Paper Cans**
- **Spirally Wound Tubes and Cores for all Purposes**
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PLASTICS DIVISIONS at Plymouth, Wisc., Ogdensburg, N. Y. • ABRASIVE DIVISION at Cleveland, Ohio
SALES OFFICES — Room 223, 1186 Broadway, N. Y. C., also 647 Main St., Hartford, Conn.
IN CANADA — The Cleveland Container Canada Ltd., Prescott, Ontario.

N. Y. The type R radiation vacuum thermocouple now available generates about 356 microvolts from the heat of a lamp consuming 546 watts at a distance of 1 meter. Details are given in Bulletin V24.

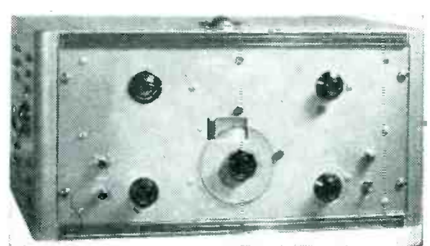
Public Address Mike (65)

AMPERITE CO., INC., 561 Broadway, New York 12, N. Y. The new velocity microphone model RBHG (high impedance) and RBLG (50 to 200 ohms) has a frequency response

from 50 to 11,000 cycles within plus or minus 2 db. Output is minus 62 db. The ribbon itself has a peak at 10 cycles.

Capacitance Meter (66)

GENERAL ELECTRIC CO., Syracuse, N. Y. Type YCL-1 r-f capacitometer measures capacitance at 75 kc directly from 0 to 1,000 micromi-



crofarads. Calibration charts allow the measurement of capacitance up to 20,000 micromicrofarads and of inductance up to 10,000 microhenrys.

Liquid Level Indicator (67)

ENGINEERING LABORATORIES, INC., 610 East Fourth St., Tulsa 3, Oklahoma. The Gagetron is a device

QUADRIGA

WASHERS AND METAL STAMPINGS

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Special alloys, carbon steel, any finish.

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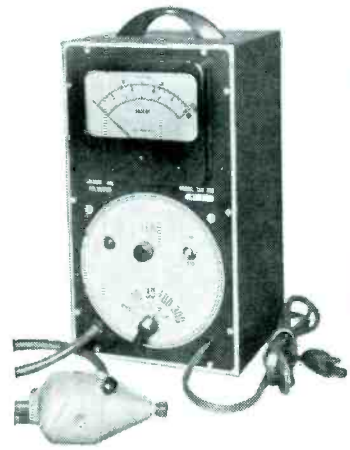
A.W. BARBER LABORATORIES

Specialists in high grade equipment, present the following instruments designed and manufactured to meet the highest quality demands.



- High Voltage D-C Probe: 30,000 volts, 30,000 megohms input impedance.
- Standard Electronic Voltmeters A-C—D-C—R-F
- Multipliers A-C—D-C all frequencies to 10,000 volts.
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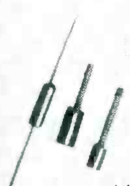

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Pioneer and largest Manufacturers of

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YOU HEAR IT

This new Signaling Timer electrically controls time intervals of industrial processes with laboratory exactness. When the interval is started, a red pilot light goes on. During the interval a pointer shows the exact time elapsed. At the end, the controlled circuit is automatically opened or closed and a buzzer sounds. Sockets allow additional lights or buzzers in remote locations.

If you need accurate timing—plus visual and audible signal attention, write us today for literature on the versatile new Series S Signaling Timer. There is a model for your particular interval, voltage and frequency requirements.

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111 EDISON PLACE • *"KNOWN THE WORLD OVER"* NEWARK, N. J.
Over 400 Types of Timers for Industry

for measuring, recording and controlling liquid levels. No connectors are necessary from the outside to the inside of the containing vessel. This effect is accomplished by the penetrating effect of gamma rays from a radium source.

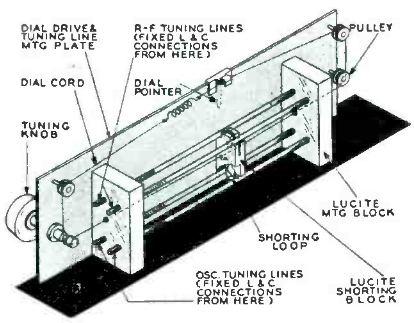
Wire Recorder (68)

NATIONAL POLYTRONICS, INC., 162 Greenwich St., New York 6, N. Y. Model 5-A wire recorder complete

with self-contained amplifier and microphone is listed at $79.50. The wire can be reused thousands of times as the machine automatically erases while re-recording.

F-M Tuner (69)

EDWARDS FM RADIO CORP., 168 Washington St., New York 6, N. Y. The Fidelotuner comprising two tunable lines and a movable short-



ing block is now available for experimenters who desire to build f-m tuners.

Decade Oscillator (70)

MUIRHEAD & CO., LTD., Elmers End, Beckenham, Kent, England. Decade

oscillator type D-105-A has a frequency range from 1 cycle to over 100 kilocycles. This resistance-capacitance type instrument is described in bulletin B-528-D. It is operated from 200 to 250 volts, 50 cycle through a magnetic-type a-c stabilizer.

Variable A-C Unit (71)

SUPERIOR ELECTRIC Co., Bristol, Conn. The new Voltbox is a portable source of a-c voltage and comprises a variable autotransformer mounted on a special aluminum base equipped with outlets and switches as well as a meter.

Literature

(72)

Capacitors. Cornell-Dubilier Electric Corp., South Plainfield, N. J. More than twenty different classes of capacitors are described in detail and illustrated in the new 24-page catalog No. 200. The handy reference book also includes list and net prices.

(73)

Technical Bulletins. Radio Corp. of America. Single page technical bulletins are available on each of four new additions to the tube line. The new tubes are the 6AV6, 12AV6, 5618, and 5652.

(74)

Magnetic Phonograph Pickups. Lear, Inc., 11916 West Pico Blvd., Los Angeles 34, Calif. The design of new magnetic recorder heads which may be used for stainless steel wire recordings is described in a 4-page reprint. Schematics and response curves are included.

(75)

Transformers. Raytheon Mfg. Co., Waltham 54, Mass. General design data is listed in a four-page brochure on transformers, reactors, and saturable magnetic components.

(76)

Wire Recording Heads. Lear, Inc., 11916 West Pico Blvd., Los Angeles 34, Cal. Two sheets give ample coverage of performance data and installation specifications for the magnetic wire recording head WH-200 and reproducing WH-201.

(77)

Commercial Crystals. Bliley Electric Co., Erie, Pa. Bulletin 36 is a well-illustrated, complete listing of all except amateur types of quartz crystals for all types of commercial applications.

(78)

Remote Shaft Rotation. Ford Instrument Co., Inc., 31-10 Thomson Ave., Long Island City 1, N. Y. Telesyn and other motors are described in 16 catalog pages. Bulk of the information concerns apparatus for remote control of shaft rotations.

(79)

Fixed Radiophone. Belmont Radio Corp., 5921 West Dickens Ave., Chicago 39, Ill. Model US 20-1 fixed station radio equipment is a compact 20-watt unit for use in conjunction with a mobile radiophone. Its specifications are listed in a four-page booklet.

(80)

Constant Voltage Transformers. Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill. Bulletin CV-102 gives construction and operating theory, as well as a wide variety of data and a complete catalog of standard constant voltage transformers.

(81)

Radioassays. Tracerlab, Inc., 55 Oliver St., Boston 10, Mass. In volume No. 7 of Tracerlog are found a complete description of radioassay procedures. Three pages are devoted to the SC-9A manual sample changer with preamplifier, designed to standardize radioactivity analyses.

F-M Servicing. General Electric Co., Syracuse, N. Y. A handy 28-page booklet (ESD-21) on f-m servicing, well-illustrated with schematics, block diagrams, sketches and curves, is available from distributors for twenty-five cents.

(continued from p 148)

may be obtained from the U. S. Naval Observatory, Washington 25, D. C.

The Canadian Dominion Observatory (Ottawa) broadcasts time signals continuously over station CHU on frequencies of 3,330, 7,335 and 14,670 kc; and at certain hours over other stations located at Ottawa, Halifax, and Churchill. Information may be obtained by writing the Dominion Observatory, Ottawa, Canada.

A comprehensive list of United States and foreign radio time signals is given in chapter 3 of "Radio Navigational Aids", Hydrographic Office publication No. 205, for sale by the Hydrographic Office, Washington 25, D. C., price $1.25.

IRE Convention Space Increased

HALF of the third floor of Grand Central Palace in New York City will be used for exhibits at the IRE 1948 Engineering Show, March 22-25, in addition to the first two floors. Radio-electronic Frontiers, the theme of the 1948 Show, will focus attention on the new progress and markets of the industry. The technical program this year consists of 130 papers in 26 sessions, plus two special symposia.

Electronic Warfare Training

FORMATION of an extensive electronics warfare program for the Reserves has been planned by the U. S. Marine Corps. The program will stress training in the fields of gca for aircraft, pilotless aircraft, radar, and television. Units will be concentrated geographically in areas where the electronic industry flourishes. Candidates will be chosen on the basis of their technical background, professional skill, and willingness to enroll in study courses in their chosen fields.

Plans are made for 560 units (each composed of an officer and nine enlisted men): 10 special tactical; 250 radar, missile, and pilotless aircraft; 200 radio and communication; 100 telephone communication.

A nationwide Marine Corps Reserve Radio Network will be set

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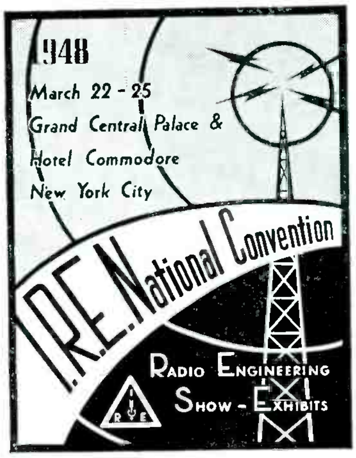


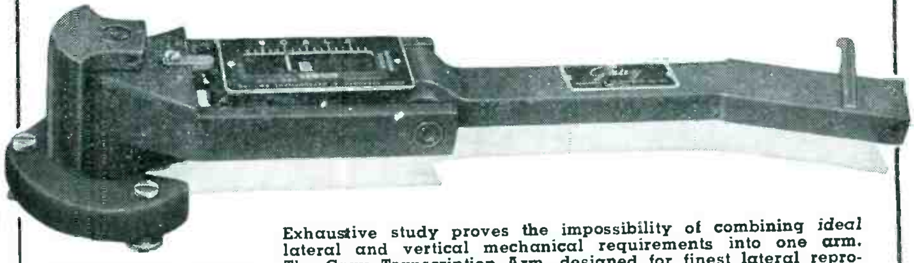
HEAR— over 100 excellent technical papers on research and engineering, covering the new "Radio-Electronic Frontiers."

SEE— 175 exhibits of radio components, parts, instruments, sound systems and transmitters.

4 Day Registration is $3.00

THE INSTITUTE OF RADIO ENGINEERS, Inc.
1 East 79th St., New York 21, N. Y.

For the finest lateral reproduction the GRAY TRANSCRIPTION ARM



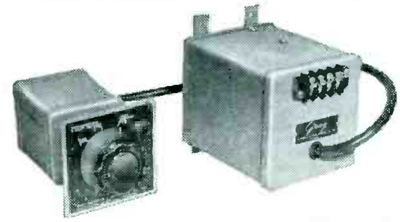
Featherweight magnesium, frictionless motion, adjustable stylus pressure, self-leveling base.

Exhaustive study proves the impossibility of combining *ideal* lateral and vertical mechanical requirements into one arm. The Gray Transcription Arm, designed for finest lateral reproduction accommodates all modern cartridges—General Electric, Pickering, etc.—has been adopted as standard equipment by national radio networks including CBS, ABC and numerous independent radio stations. Arm less cartridge $35.00.

DIAMOND G.E. CARTRIDGES!

At last a permanent solution to the quality pick-up problem. We can now supply a Selected G.E. Cartridge with finest quality Diamond Stylus for mounting in the Gray Transcription Arm. The practically unlimited life of the Diamond Stylus makes it an exceptionally economical investment at $29.63 net to radio stations.

Gray Equalizer For G.E. Cartridge



FOR RADIO STATION USE. No. 601, 4-position Equalizer (Flat, N.A.B., etc., etc.) expertly engineered for use with the G.E. Variable Reluctance Cartridge. Matches pick-up to microphone channel. Adopted by radio networks. Complete $42.50.

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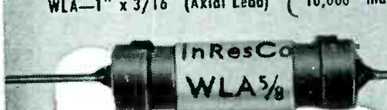
WIRE WOUND
RESISTORS

WL 5/8—5/8" x 3/16" (Radial Lead) .01 Ohms min. 3,000 Ohms max.
WLA 5/8—5/8" x 3/16" (Axial Lead) .01 Ohms min. 3,000 Ohms max.

WL—1" x 3/16" (Radial Lead) .01 Ohms min.
WLA—1" x 3/16" (Axial Lead) 10,000 max.



New Economy Line!

Here's a new line of resistors priced for real economy. Wire wound to a tolerance of 1% — higher accuracy on special order at slightly higher cost. Write today.

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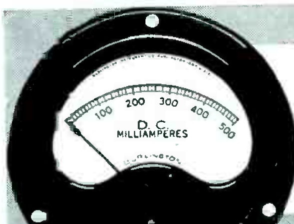
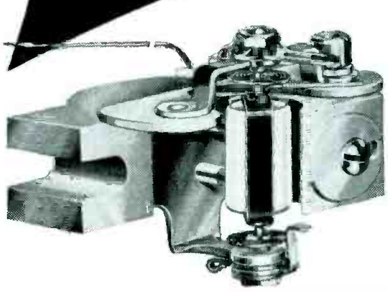
APPLICATION-DESIGNED RESISTORS!

ONE OF A SERIES



ALNICO MAGNETS

WHY BURLINGTON PANEL INSTRUMENTS PROVIDE UTMOST RELIABILITY . . .



MAGNETS OF ALNICO are standard for all DC instruments because it is the most stable magnetic material available, having greatest resistance to effects of stray magnetic fields, vibration, shock and heat. All ranges AC and DC available in $2\frac{1}{2}''$, $3\frac{1}{2}''$, $4\frac{1}{2}''$, rectangular or round case styles and are fully guaranteed for one year against defects in workmanship or material. Refer inquiries to Dept. F-38.

Burlington INSTRUMENT COMPANY
BURLINGTON, IOWA

up to function in conjunction with the Naval Reserve Communication net.

Reservists will receive instruction in all phases of electronics through correspondence courses, lectures, training films and recordings. Units will be provided with the latest equipment necessary for thoroughly training personnel in operation, maintenance, and tactical application. Training will also include field trips to both civilian and military electronic laboratories, manufacturing plants, radio communication facilities, and telephone companies.

Individuals interested in participation in this program may obtain complete information from the nearest Marine Corps Reserve activity, or by writing to the Electronic Warfare Section, Division of Reserve, Headquarters, U. S. Marine Corps, Washington 25, D. C.

Research Corporation Awards

AS THE RESULT of a National Research Council survey of the undergraduate origins of those receiving a Ph.D. in physics over a 10-year period, two men were given special awards by Research Corp. (holder of Cottrell electrical precipitation patents and other donated patents). A. A. Knowlton, professor of physics at Reed College, Portland, Oregon, received a special award for his record of stimulation and inspiration of undergraduates for three decades. Clifford N. Wall, who left North Central College at Naperville, Illinois in 1944 for a permanent physics staff appointment at the University of Minnesota, was likewise specially awarded with a plaque and honorarium of $1,000.

Lee DuBridge, now president of the California Institute of Technology, was voted an annual award in recognition of his scientific contributions in the field of radar and his outstanding administration of the wartime microwave laboratory. The other annual award was presented to Merle A. Tuve of the Carnegie Institution of Washington, for scientific contributions in

making possible the proximity fuze and outstanding administration of the groups which equipped the armed forces with this device.

Navy Aids to Research

UNDER its electronics program during the fiscal year 1947 the Office of Naval Research helped the following laboratories to convert to peacetime basic research: Cruft Laboratory at Harvard, using the Radio Research Laboratory; Reseach Laboratory of Electronics at MIT, using facilities of the Radiation Laboratory; Insulation Research Laboratory at MIT, to initiate research on insulation material with special emphasis on dielectrics.

Research under ONR contracts has been started on direction finding, nonlinear devices with special attention to magnetic amplifiers, and observation of electromagnetic radiation in the radio frequency spectrum from the Milky Way, the sun, and other celestial bodies.

New research tools have come into use for studying superconductivity and ferromagnetism at microwave frequencies. Ultrasonic power can now be generated at frequencies as high as 1,000 mc, with possible applications to moving target indicator problems and storage requirements in digital computers. Microwave techniques have proven useful in the construction of linear accelerators for nuclear research.

The Naval Research Laboratory reported production of a c-r tube for storing signals indefinitely, a simulator tube, a new type of microwave oscillator, and a sealed model of a high-power magnetron. It also engaged in much research in communications in general, radio techniques, search radar countermeasures, and systems utilization.

The NRL Radio Division originated, and demonstrated for the first time during the past year, two basically new radar tracking systems. Also developed were two subminiature ten-channel pulse-time airborne telemetering systems, and multichannel communication equipment for the 225-400 mc range.

In the field of sound, investiga-

tion led to the development of new types of crystals and a special technique for growing quartz crystals.

SAE Report on Automotive Radio Installations

THE SOCIETY OF AUTOMOTIVE ENGINEERS has published a 45-page report dealing with applications of two-way radio communication to the operation of automotive fleets. A subcommittee of the society, composed of truck fleet operators and 23 engineers from the communications and automotive industries and headed by W. C. Baylis, communications engineer of the New York Power and Light Corp., collaborated in the preparation of the report.

Subjects studied and reported on include selection of automotive generators and batteries to accommodate the increased load due to the radio equipment; physical description of radio equipment and the space requirements for its installation; antenna space and mounting requirements; selective calling systems; safety features to be included in the design and installation of equipment; licensing of operating personnel. Charts and sample calculations to aid in determining generator and battery requirements are incorporated in the report along with tables of weights and dimensions of typical two-way radio equipments.

Range of Reliable Communication

General conclusions were reached by the subcommittee as to the range of reliable communication that can be had in the three frequency bands available for mobile communication. In the 30–44-mc band, with 250 watts of transmitter power at the fixed station, ranges of 10 to 15 miles can be obtained. In open country, with favorable conditions, this range will increase to 40 to 50 miles. The 152-162 mc band will provide ranges of 8 to 10 miles in cities and 25 to 35 miles in open country. This high-frequency band appears to be less influenced by obstructions in urban areas than does the 30–44-mc band. The more recently available frequency band of 72–76-mc was given only limited tests, but appears to have a range comparable to that of the 30-44-mc band and noise level typical of the 152–162-mc band.

Cost of the 30–44-mc equipment was about $500 at the time the report was prepared, while that of the 152–162-mc gear was $600. The cost of 72–76-mc equipment is between these two figures. These estimates do not include the cost of selective calling equipment, installation expenses, nor the cost of changes to existing automotive electrical equipment that may be necessary in making a radio installation.

Copies of the report may be had from the Society of Automotive Engineers, Inc., 29 West 39th St., New York, N. Y. Price is $2.00 to nonmembers of the SAE and $1.00 to members.

BUSINESS NEWS

TELEX, INC., Minneapolis, Minn., has added to its hearing aid laboratory an annex 10,000 sq ft in area and two stories high, to house the tool and die and precision plastic divisions.

New annex of Telex, Inc.

MICROWAVE EQUIPMENT CO. recently opened a new showroom and general offices at 397 Bloomfield Ave., Verona, N. J. Manufacturing facilities are being expanded to include test components for the microwave frequencies.

THE NATIONAL ASSOCIATION OF RELAY MANUFACTURERS held its first annual meeting on January 16 and 17, in Chicago. A complete report of its progress in standardization of specifications and nomenclature for electrical relays was given.

WIRE RECORDING CORP. OF AMERICA has taken over the assets and manufacturing facilities of St. George Recording Equipment Co. of New York City. The new plant is at 1331 Halsey St., Brooklyn, N. Y.

MANUFACTURERS of precision instruments converted to the new absolute ohm, as adopted by the International Committee of Weights and Measures, in January 1948. The new unit is about 0.05 percent smaller than the International Ohm formerly used; resistors having 0.1 percent accuracy or better will therefore be made to the new standard, identified by abs stamped on the label.

SYLVANIA ELECTRIC PRODUCTS, INC., has begun construction of Sylvania Center, a campus-type electronic research development at Bayside, N. Y. The research project, under the direction of Bennett S. Ellefson, is designed for the long-term peacetime development of electronic and lighting equipment, television, f-m, and radar.

UNITED ELECTRIC CONTROLS CO., Boston, Mass., manufacturers of electric temperature, pressure, and vacuum controls, moved to larger quarters in Watertown, Mass.

RADIO CORP. OF AMERICA has announced a million-dollar expansion program providing an additional 40,000 sq ft of floor space for television tube production at its Lancaster, Pa., plant.

ACHESON COLLOIDS CORP., Port Huron, Michigan, now occupies its new plant with increased manufacturing and laboratory facilities, supplemented by those of its newly purchased London subsidiary, E. G. Acheson, Ltd.

New Acheson Colloids plant

OHMEGA LABORATORIES, INC., Pine Brook, N. J., recently formed outgrowth of Kay Electric Co., will carry out special development work for the parent company and manufacture instruments for electronic measurements.

PERSONNEL

WAYNE COY, radio director of the Washington Post, was appointed chairman of the FCC by President Truman, with confirmation of his nomination by the U. S. Senate to fill out the term of former chair-

New SUPERHET TUNER

by "Adaptol" has

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"Adaptol" Superhet Tuner is *compact.* Highly suitable for use in conjunction with Wire and Tape Recorders. Has many *Experimental* uses . . . *Tuner* for Custom-Built Radios . . . Has many *"conversion"* uses.

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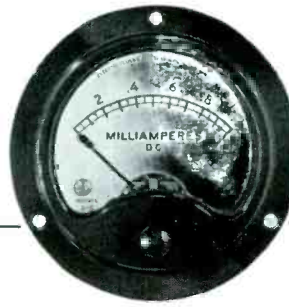

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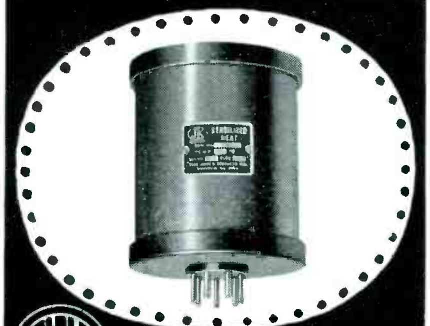

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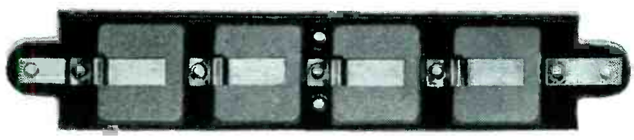
—A *New* ARCTURUS *Development!*



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man Charles R. Denny. He previously served as director of NAB and of FM Broadcasters, Inc., predecessor of the present FM Association.

W. Coy

G. E. Sterling

GEORGE E. STERLING, formerly chief engineer of the FCC, was named by President Truman to succeed E. K. Jett (resigned) as a member of the FCC. He has been associated with radio since 1913 when he took out the first amateur license in the state of Maine. His recent appointment became effective with Senate approval.

R. L. SMITH-ROSE, new IRE vice-president, was promoted to director of radio research in the Department of Scientific and Industrial Research, London. He had been superintendent of the radio division of the National Physical Laboratory since 1939 and was responsible for extensive investigations in radio direction finding and propagation of radio waves over the ground and through the lower atmosphere.

JOHN A. WILLOUGHBY has been designated acting chief engineer of the Federal Communications Commission.

CARLTON WASMANSDORFF, for six years superintendent of communications for the Glendale, Calif. police department, is now in charge of development engineering for Hoffman Radio Corp., Los Angeles. He was at one time chief engineer for Maguire Industries in New York, and served two years in San Francisco as chief engineer for Globe Wireless.

NEAL MCNAUGHTEN, former chief of the allocation section of the FCC engineering department's broadcast division, recently became assistant director of the engineering depart-

ment of the National Association of Broadcasters.

FRANK G. BACK received the Television Broadcasters Association award for the development of the Zoomar Lens, which makes possible instantaneous following of action by the camera.

JAMES A. MCGREGOR, formerly an engineer with the American District Telegraph Co. and associated with MIT Radiation Laboratory from 1940 to 1945, is now president of Microwave Equipment Co., Verona, N. J.

NEWELL A. ATWOOD, Commander, USN, engaged in electronics duty with the Navy since 1941, is now Electronics Officer at the New York Naval Shipyard, Brooklyn, N. Y.

VIRGIL M. GRAHAM, director of technical relations for Sylvania Electric Products, Inc., Flushing, N. Y., has been elected chairman of the Joint Electron Tube Engineering Council sponsored by RMA and NEMA.

V. M. Graham

E. D. A. Geoghegan

EAMONN D. A. GEOGHEGAN has been appointed factory manager of the Chicago plant of Solar Mfg. Corp. He was formerly chief engineer at Tobe Deutschmann Corp. in Canton, Mass.

WILLIAM C. EDDY, director of television at WBKB in Chicago, was presented with an award by the Television Broadcasters Association for application of existing microwave equipment to a relay between South Bend, Ind., and Chicago.

EDWIN T. KAISER, previously associated with Western Electric Co. as design engineer and with Essex Electronics Co. as plant manager, has been appointed production manager of U. S. Fiber & Plastics Corp., Stirling, N. J.

NEW BOOKS

Very High-Frequency Techniques

BY THE STAFF OF THE RADIO RESEARCH LABORATORY, *Harvard University. McGraw-Hill Book Company, Inc., New York, N. Y.*, 1947, 1,057 *pages*, $14.00 *per set of two volumes.*

THESE VOLUMES are concerned primarily with the problems incident on the design of transmitters, receivers, transmission lines, and antennas of considerable bandwidth in the frequency region from 100 to approximately 10,000 mc. The greater proportion of the discussion is confined to the region from perhaps 300 mc, where conventional lumped-constant circuits become impractical, to about 6,000 mc, which marks roughly the upper limit of the more successful designs. Of course, the discussion of designs at higher frequencies may have been limited by security considerations. In addition to the unusual bandwidth requirements, the discussion differs from other presentations of wartime radar research in the emphasis on c-w rather than pulse techniques.

There is a great deal of interesting material contained in these volumes. The presentation suffers somewhat from the difficulties which inevitably accompany multiple authorship; the differences in terminology and points of view of approximately 50 authors have not been completely eliminated. Thus, in one chapter on antennas, gain otherwise unspecified means gain relative to an omnidirectional radiator, while in another the same term denotes gain relative to a dipole.

A fairly successful attempt to eliminate repetition in various chapters where fields of interest overlap has been made by extensive cross-referencing. However, this has the rather unfortunate result that many of the figures illustrating one chapter are likely to be found in another and, indeed, frequently in the other volume.

Many of the results cited are of considerable interest and seem quite striking to one unacquainted with broadband techniques. Thus the use of a single antenna and transmission line system over a

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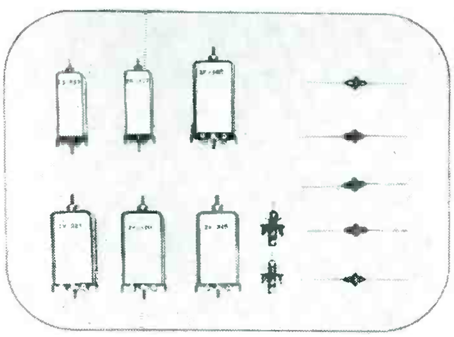

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frequency range from 100 mc to 1,400 mc seems a rather remarkable accomplishment. The discussion of high-frequency oscillators, both power oscillators and local oscillators for receivers, seems quite complete. An interesting discussion of the resnatron is a valuable feature of the book.

An adequate index is included, together with a bibliography; the latter is probably most valuable for its inclusion of a list of recently declassified internal reports available through the Department of Commerce.—B. J. MILLER, *Chief, Guided Missile Electronics Section, Ordnance Development Division, National Bureau of Standards.*

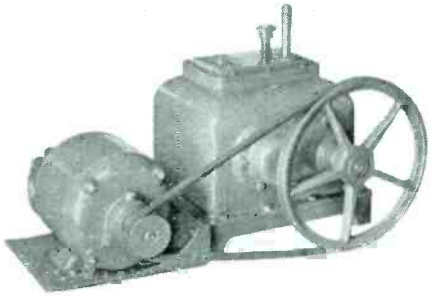
Frequenz Modulation

BY PAUL GUTTINGER. Verlag AG *Gebr. Leemann & Co., Zurich* 39, *Switzerland*, 1947, 183 *pages*, *Fr.* 25.

THIS compact, authoritative, essentially mathematical volume on phase and frequency modulation furnishes an excellent theoretical foundation to teachers, students at graduate level, and research and design engineers who are interested in f-m and can read technical German.

Three relatively independent chapters cover General Theory of Frequency and Phase Modulation, Distortion, and the Influence of Interference in F-M. In the chapter on distortion, criteria for distortionless transmission are established and formulas developed which permit calculation of distortion in single-and double-tuned circuits. Formulas are also developed for distortion due to multipath transmission which lead the author to the conclusion that transoceanic f-m transmissions are not feasible. The discussion on interference includes an analysis of imperfect limiting which is particularly timely in view of the appearance on the market of a number of so-called f-m receivers that could profit immeasurably by the application of the principles covered in this section.

The chapter on f-m transmitters discusses prewar crystal-controlled (phase shift) and reactance tube modulated f-m transmitters in general terms. Some illustrative examples, with formulas for reactance



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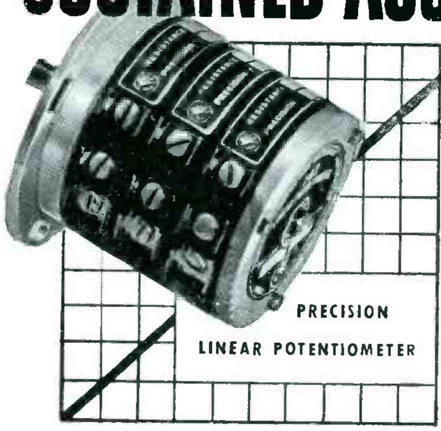

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The final chapter on f-m receivers contains material of interest to the designer. In the discussion of the r-f stage, formulas are developed for input resistance and capacitance which include the influence of grid-plate capacitance, plate circuit tuning, transit time, and cathode inductance. For the i-f amplifier a criterion is given to limit circuit distortion to 1 percent. Formulas for gain per stage and amplitude characteristic in db for single-and double-tuned stages are also given. The discussion on the limiter is excellent but is concerned with principles rather than actual circuits. The chapter closes with a discussion of discriminators and a mathematical analysis of the commonly used phase discriminator.

This volume also contains a mathematical appendix on Bessel functions and complex integration and an extensive chronologically arranged f-m bibliography of nearly 300 items running from 1922 to 1947.

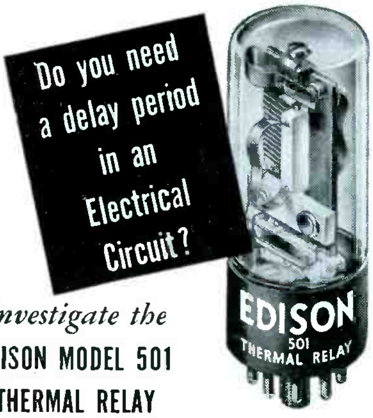
To anyone interested in f-m and having a reasonable working knowledge of German, this book will prove a useful tool.—JOHN H. BOSE, *Columbia University, New York, N. Y.*

Automatic Record Changer Service Manual

PUBLISHED BY HOWARD W. SAMS & Co., *Indianapolis, Indiana, October* 1947, *approx.* 400 *pages*, $4.95.

THIS book provides complete and standardized service data on 41 different postwar automatic record changers and recorders, including the Brush Soundmirror magnetized paper tape recorder, Brush Mail-a-Voice magnetized paper disc recorder, Silvertone model 771 wire recorder, St. George series 1100 wire recorder, and Webster models 79 and 80 wire recorders. Each of the 41 sections contains entirely original data based on first-hand examination, test, and analysis of the actual instrument, just as is done for radio receiver models during preparation of Photofact Folders published by the same company.

Two opening chapters, devoted



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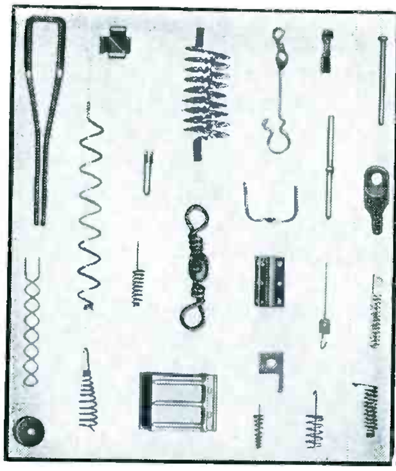

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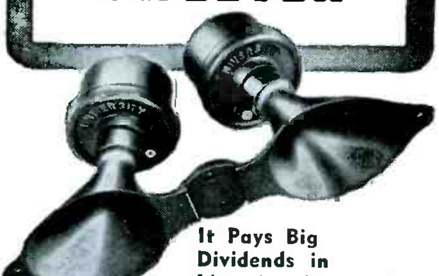

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to general types of automatic record changers and types of motor drive systems associated with them, are gems of technical organization and writing on a complicated subject. The various methods used for record support, record selection, pickup arm handling, determining set-down point, and tripping are described clearly, concisely, and logically so that one gets a satisfying complete picture of how these mechanisms are supposed to work.

Going far beyond the usual manufacturer's service manual, this book with its clear-cut instructions and illustrations truly offers an education in the latest styles of mechanical gadgetry for converting recordings to sound automatically.—J.M.

Mathematics for Radio Engineers

By LEONARD MAUTNER, *Research Engineer, Allen B. DuMont Labs. Pitman Publishing Corp., New York,* 1947, 327 *pages*, $5.00.

WRITTEN for engineers who have lost facility in handling mathematics and those who, although proficient in radio techniques, have never acquired a command of mathematics, this book briefly reviews the elements of enumeration, then describes trigonometric relations, complex algebra, differential and integral calculus, solution of differential equations, and Fourier series. In scope the book penetrates further into the subject than books intended for technicians, but is less extensive than engineering texts used in colleges. As such it bridges a gap in math-book literature.

Although this is a mathematics book, material is presented in its relation to typical basic problems of radio rather than as abstract mathematical methods. The presentation thus makes the subject more tangible than usual works of this calibre. Because of the choice of only those phases of mathematics frequently encountered in solving radio circuit problems, and the close correlation of the mathematics with radio, engineers will find this book a ready key to mathematics in their work. Answers are included for the problems at the ends of the chapters so that the book is useful

for home study. The work is also suited for trade schools which believe that radio technicians, to advance in their work, should be well grounded in mathematics.—F. R.

• • •

Books Received for Review

ELECTRETS. By Thomas A. Dickinson. Plastics Research Co., Alhambra, Calif., 1948, 32 pages, $2.50. Pocket-size monograph dealing with properties, applications, and manufacturing techniques of electrets, defined as dielectric bodies that retain an electric field after the applied voltage is removed. Purpose of book is to show that expensive permanent magnets for electronic equipment can be replaced with polarized dielectrics such as plastic or ceramic units.

UNDERSTANDING VECTORS AND PHASE. By John F. Rider and Seymour D. Uslan. John F. Rider Publisher, Inc., New York, N. Y., 1947, 153 pages, 99 cents. Pocket-size paper-cover book for men lacking an engineering background, to help them understand radio-electronic articles and books written at the engineering level. Eight chapters explain vectors and give examples of their use in radio circuits.

SPI HANDBOOK. Society of the Plastics Industry, 295 Madison, New York, N. Y., 1947, 451 pages, $7.50. Though prepared by a committee of some 300 authorities in the field as a handbook for molders and fabricators of plastics parts, much of the contents is of importance also to the ultimate user. Chapter coverage includes design of molded articles, use of inserts, cementing and assembly of plastics, machining and finishing and recommended practices for fabricating laminated plastics.

INDUSTRIAL APPLICATIONS OF INFRARED. By James D. Hall, Advisory Engineer, Lamp Division, Westinghouse Electric Corp. McGraw-Hill Book Co., New York, 1947, 201 pages, $3.50. What would have been one chapter of a book on heating several years ago has now justified expansion by inclusion of numerous specific examples of use. Chapters discuss infrared heat, equipment, installation, and applications of infrared lamps for a variety of processes requiring surface application of low-level heat.

PERPETUAL TROUBLE SHOOTER'S MANUAL, VOL. XV. John F. Rider, Publ., Inc., New York, N. Y., 1947, over 1,200 pages, plus 181-page HOW IT WORKS supplement, $18.00. This series constitutes a tool for radio servicemen and a guide to current radio practice for set designers. Where original manufacturers' diagrams are not clear, supplementary diagrams have been added. The paper-bound supplement covers new electrical and mechanical features of receivers and has an index to the manual. Among subjects included are the double superhet, superhet oscillators, r-f coupling, feedback, phase inversion, gimmicks, and f-m circuits.

THE ABC OF ELECTRONICS. By E. B. Watton. Percival Marshall & Co. Ltd., 23, Great Queen St., London, W. C. 2, 1947, 133 pages, 7/6. Bird's-eye view of modern industrial electronics, with one chapter on communications, combining technical explanations of operating principles with popular descriptions of such applications as the Radarange, snooperscope, speaking clock, and tube train counter. Well illustrated.

TABLE OF THE BESSEL FUNCTIONS $J_0(z)$ AND $J_1(z)$ FOR COMPLEX ARGUMENTS, 2nd ed. Mathematical Tables Project, National Bureau of Standards, Columbia University Press, New York, 1947, 403 pages, $7.50. A clarification in labeling graphs has been made in this edition. No errors in the tables having been reported, they have been reproduced from the original plates.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Reference Sheet Data

DEAR SIRS:

METICULOUS readers who wish to use the graph in the Reference Sheet, Efficiency of Inductive Coupling, page 138, December ELECTRONICS, may make the following additions.

In the formula, subscripts can be added to Q in both places where it appears. In the lefthand graph, all values of Q_s are identical with the values given in the righthand graph. The primary resistor in the diagram can be indicated as R_p. The ordinates of both parts of the graph are, of course, k_2Q_p.

A. C. HUDSON
National Research Laboratories
Ottawa, Ontario

Hartley Law

DEAR SIRS:

ELECTRONICS is to be complimented upon the fast and clear reporting of the IRE symposium regarding the revision of Hartley's Law which was held in New York on November 12, 1947.

Since so little has appeared on this subject treating it in a general way, I feel that one correction is necessary for the historians. The first statement of the new law to appear in print was, to my knowledge, in the Quarterly Progress Report of the Research Laboratory for Electronics of the Massachusetts Institute of Technology, dated 15 April 1947, which receives an extensive circulation among the military services. ELECTRONICS can probably lay claim to first publica-

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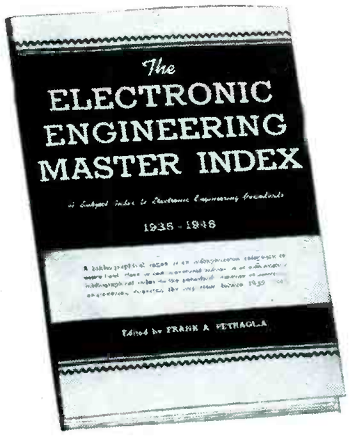

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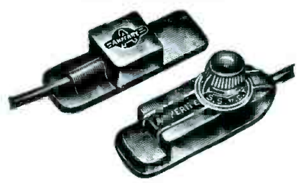

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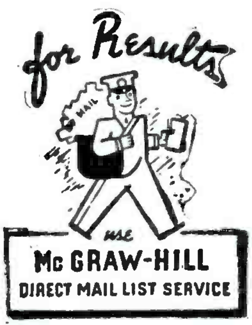

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tion in a magazine of general interest and circulation.

Another historical step in this field should be credited to Dr. D. Gabor of the British Thomson-Houston Company Research Laboratory in his article entitled "Theory of Communication" in the *Journal of the Institution of (British) Electrical Engineers* in November 1946.

Mr. Wheeler made a very important point in his discussion which appears to have been lost or overshadowed by the proceedings of the evening. He pointed out that uncertainty of signal location due to noise should not be dismissed in that simple statement wherein one considers only the rms power in the noise or signal plus noise. It is becoming increasingly important that the engineer have available in engineering form (as opposed to the mathematical), means of dealing with these uncertainty relationships.

In many systems it may be possible to take a calculated risk in operating at low signal-noise ratios where this uncertainty sphere is more diffuse. In such systems, the engineer must have available the probabilities that noise may be mistaken for signals or that signals be missed completely. Mr. Wheeler also pointed out that in many simple receiving systems the noise power N was related to the bandwidth of the system W by well-known relations.

Dr. Shannon also discussed briefly the significance of distortion as a warping of the space which might in theory be rewarped by another operation to achieve its original form. This is also a significant point as it relates Hartley's discussion of intersymbol interference caused by circuit decay or distortion to Dr. Shannon's remarks.

HERBERT SHERMAN
Watson Laboratories
Air Materiel Command, U. S. A. F.
Eatontown, N. J.

Parts and Patents

DEAR SIRS:

MR. MAISEL of Portland, Ore. (Backtalk, Jan. 1948) says "One problem . . . here in the remote

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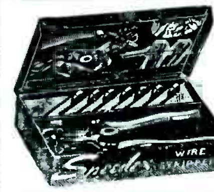

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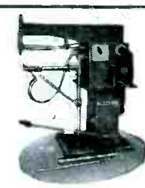

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west is the lack of the latest available components . . . a challenge to us local fellows . . . ".

The implication is that anyone who lives east of Chicago has only to walk to the corner radio store to find shelves crammed with electronic rarities — subminiature tubes, varistors, butterfly circuits, and of course button capacitors.

I have been doing circuit development in a large Government laboratory in Washington, D. C. for several years, and some time before that lived in Los Angeles. Radio parts are definitely less available here than they were in Los Angeles. Washington has several good parts jobbers, but their size and stocks are modest and their locations inconvenient. For that matter, I have seen plenty of similar places in New York and Chicago that weren't so hot either.

Personally, I buy parts by mail order. The Laboratory gets components from sources all over the country. Unusual items are often ordered directly from the manufacturer.

Any material that is not regularly bought by lots of radio servicemen and amateurs is likely to be pretty scarce at parts dealers in any city, no matter where it is. A year ago the mail order houses seemed to be habitually out of stock on half or more of the things I ordered (even as were the local dealers), but recently I have had much better luck. The greater distances in the west make for higher parcel post charges, of course; but gasoline, bus fare, and shoe leather don't come for free either.

On another subject, Mr. Meredith's letter (Backtalk, Jan. 1948) shows that he is a most unusual patent attorney. In my four years as a patent examiner I encountered few attorneys who didn't use "electron discharge device" when they meant *tube*. One reason for patent lingo being what it is, is the necessity for broad language to avoid its being interpreted later in a restrictive sense. The other reason is that it is harder to write up a case thoughtfully than it is to just let the words roll out.

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*USE with capacitor to obtain any voltage up to twice rated output.

XTALS

We can supply power xtals of any frequency ground to .02 tolerance in any type of holder for any surplus or standard transmitters or test equipment as well as any receiver IF frequency. Prices on request—write to our engineering department.

METERS

- MM 4-0-100MA Model 301 Weston 3½" $3.95
- MM 10-0-1 amp DC-Model 301 Weston 3½" .. 3.95
- MM 14-0-150 MA NX 35 Westinghouse 3½" .. 3.95
- MM 19-0-800MA Weston Model 301MA 3.35
- MM 33-0-1MA-MD-300 1 K-McClintock 3½" .. 3.95
- MR 13-0-8 R.F. amp—425AM-Weston 3½" .. 4.95
- MV 8-0-4 K.V. DC—Roller Smith 3½" 2.95

G. E. INTERLOCK SWITCH

Hi-voltage is lethal—protect yourself and family—this switch automatically shuts off HI-volt. circuits while adjustments are being made—low pressure—hi current capacity positive action. Silver plated contacts. Pr.... **$1.00**

5TP4 PROJECTION TUBE

Perfectly operating condition but with very slight imperfection. Ideal for engineers, experimenters, inventors, or school instructors. Regular price of these tubes is $65.00—
Special Bargain **$20.00**

INDUSTRIALS—LABS—SCHOOLS PURCHASING AGENTS

Be sure that you are on our mailing list for money saving bulletins that will save you many dollars on supplies & equipment.—Write TODAY.

All Prices f.o.b. N. Y. C.

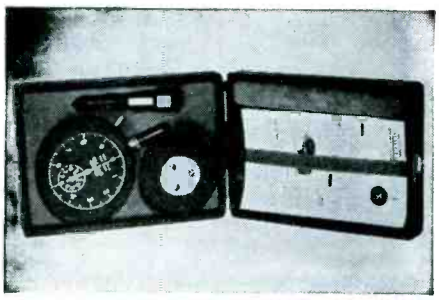
NIAGARA RADIO SUPPLY CORP.

160 GREENWICH STREET, NEW YORK 6, N. Y.

CREDIT EXTENDED TO RATED ACCT'S.

PORTABLE CHRONOMETRIC TACHOMETER

$24.50



JAEGER WATCH CO. MODEL #43-A-6

CAN BE USED FOR SPEEDS UP TO 20,000 R.P.M.

CAN BE USED FOR LINEAL SPEED MEASUREMENTS TO 10,000 F.P.M.

IDEALLY SUITED FOR TESTING THE SPEEDS OF MOTORS, PARTICULARLY OR FRACTIONAL HORSE POWER, GENERATORS, TURBINES, CENTRIFUGALS, FANS, ETC.

VERY SMALL TORQUE—Requires Practically no Power to Drive.

UNEQUALLED READABILITY 2" OPEN FACE DIAL—EACH DIVISION ON LARGE DIAL EQUALS 10 R.P.M.; EACH DIVISION ON SMALL DIAL EQUALS 1,000 R.P.M.

GREATEST ACCURACY — Meets Navy Specifications — Guaranteed to be within ½ of 1%.

RESULTS OF TEST READING REMAIN ON DIAL UNTIL NEXT TEST IS TAKEN.

PUSH BUTTON FOR AUTOMATIC RESETTING.

COMPLETE WITH THE FOLLOWING ACCESSORIES:

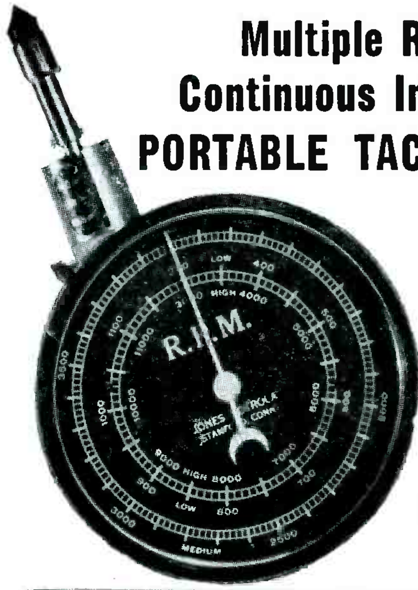
1—LARGE POINTED RUBBER TIP
1—LARGE HOLLOW RUBBER TIP
1—6" CIRCUMFERENCE WHEEL TIP
1—OPERATING INSTRUCTIONS
1—TEMPERATURE CORRECTION CHART.

The combination of the above features will give accurately, within a few seconds, by direct reading, the R.P.M. of shafts or the lineal speeds of surfaces without any accessories or timing of any kind. Each unit comes complete in a red velvet lined carrying case 5" x 3½" x 1½". NET LIST PRICE $75.00—SURPLUS—NEW—GUARANTEED.

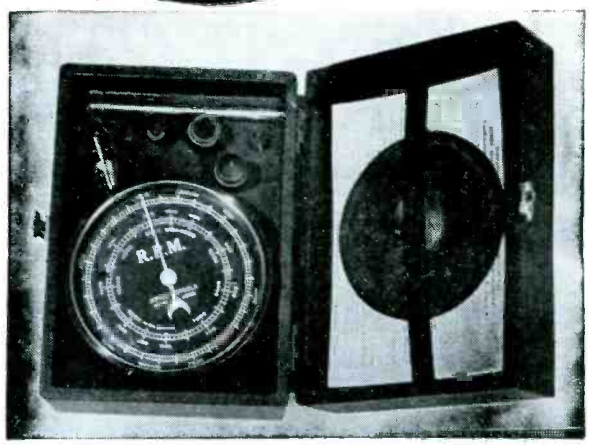
YOUR COST $24.50 FOB, NEW YORK

Multiple Range Continuous Indicating PORTABLE TACHOMETER

$24.50



2/3 Actual Size



This unit is of the centrifugal mechanical type and is designed to show instantaneously and continuously the speed or change in speed of any revolving shaft or surface. No stop watch or other mechanism required.

Three Ranges in R.P.M. and Three Ranges in F.P.M.

LOW RANGE 300- 1,200
(Each Division Equals 10 R.P.M.)
MEDIUM RANGE 1,000- 4,000
(Each Division Equals 20 R.P.M.)
HIGH RANGE 3,000-12,000
(Each Division Equals 100 R.P.M.)

LARGE OPEN DIAL 4" DIAMETER.

RUGGEDLY CONSTRUCTED For Heavy Duty Service.

BALL BEARING AND OILLESS BEARINGS — Require No Lubrication Whatsoever.

READILY PORTABLE — Fits Neatly Into Palm of Hand.

GEAR SHIFT FOR SELECTING LOW, Medium and High Ranges.

GREATEST ACCURACY — Meets Navy Specifications 18-T-22, Type B, Class A.

COMPLETE WITH THE FOLLOWING ACCESSORIES:

1—STEEL TIP
1—CONICAL RUBBER TIP Metal Mounted
1—RUBBER LINED Metal Cone Tip
1—PERIPHERAL RUBBER WHEEL 1 Ft. in Circumference
1—EXTENSION ROD
1—SMALL SIZE CONVEX RUBBER TIP, Metal Mounted
1—OPERATING INSTRUCTIONS.

MADE BY JONES MOTROLA, STAMFORD, CONNECTICUT. Comes Complete in Blue Velvet Lined Carrying Case: 7½" L x 4" H x 5" W. LIST PRICE $75.00—SURPLUS—NEW—GUARANTEED.

YOUR COST $24.50 FOB, NEW YORK

All items are Surplus-New-Guaranteed. C.O.D.'s not sent unless accompanied by 25% Deposit. Orders accepted from rated concerns, public institutions, etc., on open account. We carry a complete line of surplus new meters suitable for every requirement, such as portable, panel, switchboard, recording instruments, laboratory standards, etc. Over 50,000 Meters in Stock. We also stock various surplus components, tubes, parts, and accessories and can supply large quantities for manufacturers, exporters, etc. Send for free circular Manufacturers, Exporters, Dealers—We invite your inquiries.

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PORTABLE CURRENT TRANSFORMER

Weston Model 461 Type 4 (see illustration). This unit can be used with any precision 5 Amperes A.C. Meter to extend the ranges of the meter to 50, 100, 200, 250, 500 or 1000 Amperes A.C. Accuracy within ¼ of 1%; Normal Secondary Capacity = 15 Va; Binding Posts for 50 Ampere tap: Inserted primary for 100, 200, 250, 500 and 1000 Amperes; Insulated for use up to 2500 volts. List Price $98.00........................**NET fob, NY $35.00**

MULTI-RANGE PORTABLE A C VOLTMETER

Weston Model 433, 150/300/600 volts AC. Accuracy within ¾ of 1% from 25 to 125 cycles. Hand calibrated Mirror scale 4.04" long with 150 scale divisions: Knife edge pointer. Moving iron Band type. Magnetically shielded. Dimensions 5"x6"x3½" ....**Net $47.50**

PORTABLE A. C. AMMETER 0-200 AMPERES SELF CONTAINED

Weston Model 155, accuracy within ½ of 1%; Hand calibrated mirror scale 5.18" long. Knife edge pointer unshielded movement, 25-500 cycles. Hardwood case. Dimensions 7" x 7⅛" x 3¼" @ $32.00

SPECIAL METERS

Frequency Meter — Dual Range — covers frequency ranges from 48 to 52 cycles and 58—62 cycles J.B.T. 30-F—Dual element, Vibrating Reed type—115 V—3½", rd fl metal case........$5.95

Voltage Polarity Phase Rotation Tester—Triplett 337 AVP—Checks 115, 220 and 440 line voltage—locates open circuits, blown fuses, damaged wiring, etc. Indicates whether A.C. or D.C. and polarity of D.C.—Checks phase rotation to determine direction of rotation of motors, operation of controls, etc—Consists of a 3" square meter and a small polarized vane movement in a small handy sized case—Complete with 36" leads with test prods $8.50

D. C. MICROAMMETERS

100-0-100 microampere—zero center—approximately 950 ohms resistance—W.E.—3½", rd fl bake case —concentric style $6.50

A. C. VOLTMETERS

15 V. (100 MA)—W.H., NA-35—3½", rd fl bake case $3.95

150 V (10 MA)—W.H., NA-35—3½", rd fl bake case $5.50

150 V—Triplett 331-J.P.—with external resist for series connection to increase range to 300 V. (multiply reading by 2) to make a dual range 150-300 Voltmeter—3½", rd fl bake case...$5.50

D. C. MILLIAMMETERS

20 MA—GE DO-53—3" sq fl bake case........$3.25
80 MA—GE DO-41 3½" rd fl bake case.......$3.25
1 MA—Triplett 0321—3½", rd fl bake case—with circuit diagram $3.95

PORTABLE D.C. AMMETER MULTI-RANGE 0-3, 0-30, 0-300 AMPERES

General Electric DP-9 (50 MV movement) Accuracy within ¾ of 1%; Hand calibrated mirror scale; Knife edge pointer, magnetically shielded. Complete with leads and external shunts for 3, 30 and 300 Amps. Plastic case with hinged cover. Dimensions 2 7/16" x 6 9/16" x 4 13/16". @ $37.50

PORTABLE D. C. AMMETER MULTI-RANGE 0-3, 0-30, 0-300 AMPERES

Roller Smith Type NPD (50 MV movement) Accuracy within ½ of 1%; Hand calibrated mirror scale 5.25" long; magnetically shielded. Complete with leads and external shunt for 3, 30, and 300 Amps. Hardwood carrying case 8"x8"x5½" with hinged cover. @ $45.00

PORTABLE D. C. VOLTMETER DUAL RANGE 0-3, 0-150 VOLTS

Westinghouse Type PX-4, accuracy within ¾ of 1%; 3½" long mirror scale; Knife edge pointer, 200 ohms per volt movement. Dimensions 4½" x 4½" x 2". @ $17.50

PORTABLE D. C. VOLTMETER 0-10 VOLTS

Weston Model 280, accuracy within 1%; Hand calibrated mirror scale 2.76" long. Knife edge pointer, magnetically shielded, 100 ohms per volt movement. @ $7.50

PORTABLE A. C. AMMETER WESTON MODEL 528

DUAL RANGE 0-3 Amp. and 0-15 Amp. full scale for use on any frequency from 25 to 500 cycles. The ideal instrument for all commercial, industrial, experimental, home, radio, motor and general repair shop testing. Comes complete with a genuine leather, plushlined carrying case and a pair of test leads. A very convenient pocket sized test meter priced at less than 50% of manufacturers list. Your cost ....**ONLY $12.50**

PORTABLE A. C. VOLTMETER WESTON MODEL 528

DUAL RANGE 0-15 and 0-150 Volts for use on any frequency from 25 to 125 cycles. Complete with plushlined leather carrying case and a pair of test leads. This Voltmeter, with the matching model Ammeter above, makes an ideal pair of test meters for any mechanic to carry around in his tool box. **ONLY $9.50**

COMBINATION OFFER: 528 Voltmeter—528 Ammeter—**BOTH FOR $21.00**

RADIO FREQUENCY AMMETERS

1 A R.F.—Weston 425—3½", rd fl bake case @ $7.50
2.5 A—Weston 507—2½", rd fl bake case @ $3.95
2.5 A—Simpson 36—3½", rd fl bake case @ $4.95
2.5 A—W.H. NT-35—3½", rd fl bake case @ $5.50
2.5 A—McClintock—3½", rd fl bake case @ $4.50
3A—W.H. NT-35—3½", rd fl bake case @ $5.50

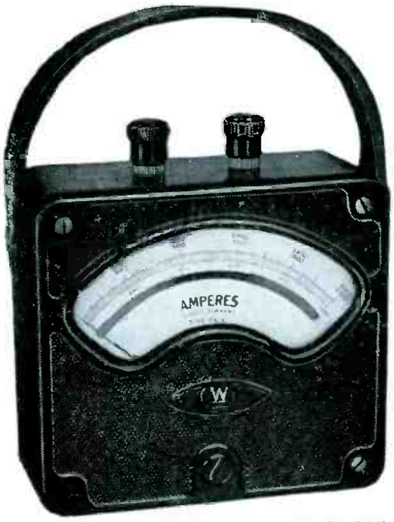
D. C. VOLTMETERS

15 Volt—G.E., DW-41—black sc, no Caption—sc cal 0-15—2½", rd fl bake case @ $2.50

30 Volt—G.E., DW-41—2½", rd fl bake case @ $2.95

1.5 KV—W.H. NX-35—with 1000 ohms per volt—external prec wire wound resistor & mtg clips —3½", rd fl bake case @ $7.25

PORTABLE D. C. AMMETER 0-1 AMPERES D. C.



Westinghouse Type PX-4, accuracy within ¾ of 1%. 3½" long mirror scale with 100 scale divisions; Knife edge pointer; Moving coil D'Arsonval movement. Dimensions 4½" x 4½" x 2" @......$17.50

PORTABLE D. C. AMMETER 0-25 AMPERES—SELF CONTAINED

General Electric DP-9, accuracy within ¾ of 1%; Hand calibrated Mirror scale; Knife edge pointer, magnetically shielded. In plastic case with hinged cover. Dimensions 2 7/16" x 6 9/16" x 14 13/16". @ $19.00

PORTABLE D. C. AMMETER 0-50 MILLIVOLT MOVEMENT

Weston Model 45 for use with external shunts. Accuracy within ½ of 1%; Hand calibrated mirror scale 5.18" long with 100 scale divisions (Scale calibrated 0-25 Amps.) Knife edge pointer; magnetically shielded; Complete with external 25 Amp 50 MV shunt and leads. (We also have other external shunts for use with this meter). In Hardwood carrying case 8" x 8" x 4¾" with hinged cover. Complete @ $32.50

1000 Amp 50 MV shunt @ $12.00
2000 Amp 50 MV shunt @ $20.00
4000 Amp 50 MV shunt @ $40.00

CODE TRAINING SET AN/GSC-T1

Made by T. R. McElroy, Boston.

Operates off 6, 12, 24 or 110 V D.C. or 110 V or 230 Volt, 60 cycle.

An excellent unit for schools or clubs for code training. This unit is designed for group training of telegraph code to students whereby each student sends a message from any prepared text to the instructor. It provides a visual signal through a blinker or an audible signal through a monitoring speaker. Has volume control, variable frequency oscillator, a phone jack for a monitoring headset, pitch and tone control, rotary switch for selecting the operating voltage and power supply.

Complete with spare fuses, power cord and battery adapter; 10 Telegraph Keys with 10' line each, 1 #6 x 5 tube and 2 #6AG6 tubes.

Complete in chest 10½" x 17" L x 13½" H—Net wt. 49 lbs.

Can be used anywhere — batteries A.C. or D.C.

Durable—Good for a lifetime of Service! NET fob, NY $24.50

All items are Surplus-New-Guaranteed. C. O. D.'s not sent unless accompanied by 25% Deposit. Orders accepted from rated concerns, public institutions, etc., on open account. We carry a complete line of surplus new meters suitable for every requirement, such as portable, panel, switchboard, recording instruments, laboratory standards, etc. Over 50,000 Meters in Stock. We also stock various surplus components, tubes, parts, and accessories and can supply large quantities for manufacturers, exporters, etc. Send for free circular—Manufacturers, Exporters, Dealers—we invite your inquiries.

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FULL WAVE BRIDGE TYPE

Input	Output	Current	Price
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0-36VAC	0-28VDC	6Amp	5.95
0-50VAC	0-21VDC	2Amp*	2.95
0-54VAC	0-45VDC	220MA	1.29
0-56VAC	0-32VDC	2Amp*	3.95
0-75VAC	0-43VDC	2Amp*	4.95
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0-108VAC	0-90VDC	1.2Amp	1.95
0-108VAC	0-90VDC	1.6Amp	2.49
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FULL WAVE C.T.

0-18VAC	0-12VDC	600MA	.98
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PRECISION RESISTORS for METERS BRIDGES, AMPLIFIERS ALL STANDARD MAKES

*½%	**5%	†10%	(Rest 1%)
2000**	4300**	5100**	12000**
30000**	84000**	150000**	220000**
245000**	250000	950000	1155

ABOVE SIZES 20c. EA ASSTD....10 FOR $.98

.116	89.8	580	2580	8500
.42	100	600	2600	9000
.5	105	612	2635	9445
.7	101	640	2700	9710
1.3	107	700	2860	10,000
1.75	113.1	733	2900	10,500
2	120	750	3000	12,000
3	121.2	800	3100	14,460*
4	125	900	3290	14,600
4.35	150	910	3384	15,000
5	160	1000	3500	15,000
5.025	165	1030	3730	17,000
6	170	1110	4000	17,000
7	182.4	1150	4300	18,000
7.5	200	1155	4440	19,000
7.8	209.4	1175	4444	20,000
7.9	230	1225	4500	20,520*
8	235	1250	4720	21,500
10	240	1260	4850	22,000
12	245.4	1322	4885	23,000
14.5	250	1350	4900	24,000
20	260	1500	5000	25,000
25	280	1510	5000	29,900
26	286	1600	5100	30,000
30	299	1640	5270	33,000
37	300	1650	5500	37,000
40	320	1800	5730	40,000
45	340	1830	6000	50,000
45.1	400	1865	6200	54,400*
49	418.8	1900	6300	60,000
50	426.9	2000	6500	65,000
55	440	2080	7000	68,000
56.7	452	2142	7500	75,000
60	480	2300	7700	80,000
71.4	487	2400	7950	84,000
75	500	2485	7950	90,000
80	520	2490	8000	91,000
81.4	540	2500	8250	95,000

ABOVE SIZES EACH 45c......TEN FOR $3.00

0.1 MEG	.16675	.25 MEG	.4 MEG	.6 MEG
.1	.175	.254	.402	.62
.12	.185	.265	.422	.654
.13	.201	.268	.458	.7
.135	.22	.294	.478	.75
.14	.229	.314	.5	.7613
.14	.24	.33	.57	.8
.147	.245	.3335	.575	.9
.15	.25	.3535		.95

ABOVE SIZES EACH 60c......TEN FOR $5.00

1 MEG	2	4	5	11.5
1.2	2.855	4.23	9.05	12.83
1.579	3	4.5	10	20
1.8	3.673			

ABOVE SIZES EACH 90c......TEN FOR $6.95

VICTOREEN VACUUM PRECISION RESISTORS

.83MEG, 1MEG, 1.5MEG, 2MEG, 3MEG, 3.75MEG, ½ OF 1% ACCY HIVOLTS AT $1.00, TEN FOR $7.50
IRC NAVY PRECISION 1MEG, ½ OF 1%. 1.69
IRC NAVY WW 2MEG, 1/5 OF 1% HV.. 4.95

STROBOFLASH AN SET #1503/2LAMPS INPT 12V COMPLETE POWER SUPPLY, CABLES & BATTERIES & 2KRYPTON HI INTENSITY LAMPS........ $95.00
STROBOFLASH KRYPTON LAMPS & IGNTN TRANSF; 12,000,000LUMENS/15 to 30000FLASHES ....2 FOR 21.00
STROBOFLASH #1503 CONVERTED TO 115VAC & 3 KRYPTON LAMPS & CHECK BULBS 198.50
STROBOCONDSRS
3MFD/660VAC/2000WVDC/32MFD FOR. 11.50
EE5/TELEPHONE INTERCOM USED.PAIR 9.95
CRYS'DIODES IN21A,22,23A,25,26,27.3FOR 2.00
CRYS'DIODES IN21A,22,23A,25,26,27 EA $1 ....12 FOR 10.00
SYLVANIA IN34 XTAL DIODE @ $1.49; 2FOR$2.50 ....10 FOR 11.50
TS268 XTAL DIODE TEST SET NEW..... 19.95
IF'DBL SLUG TUNED 10TO13MC'S HIQ 2 FOR .98
SEND FOR TRANSFORMER&CONDSR LIST

ANT TUNING UNIT 1001A/1500TO7000KC/1KWRF/PI NETWORK ADUSTABLE IN&OUTPT CASED COMPLETE METER, COILS, CONDENSER VAR, INSULATORS, DATA........ 12.95
AMPLIFIER 25WATT&TWO TRUMPETS... $95.00
W. E. 125TO250WATT/MULTICELL TRUMPET & NINE DRIVERS COMPLETE...... 125.00
TRUMPET & WE DRIVER 35TO55W...... 29.95
WE PM DRIVER 25TO55WATT WATERPROOF, BLASTPROOF NEW $12.95..2FOR 21.95
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BALLOON 4FT & HYDROGEN GAS GNRTR. 4.50
BOX KITE NYLON........ 2.49
GIBSON GIRL SCR578 COMPLETE...... 19.95
SELENIUM BRIDGE RECT 300V/40MA... .69
BC1073 WVEMTR 150-210MC'S LN*.... 10.95
BC230 XMTTR 2.5TO7.7MC'S LN*...... 5.95
RADIO COMPASS RCVR BC433/MN26 LN* 21.95
APS13/RCVR&XMTTER410MC'S/LESS-TBS 6.95
RT-APN-1 ALTIMETER LESS TUBES LN*. 12.95
BC457-458-459-696 LN* EA........ 5.95
BC456 MODULATOR LESS TUBES LN*... 1.69
BC212 TANK INTERPHONE&TUBES DYN. 3.95
BC191/BC375 ONE TU & TUBES LN*... 9.95
OSCILLOSCOPE 3" KIT TUBES&PWRSUP. 15.95
FM TUNER & TUBES HIGAIN&PWR...... 69.95
COLLINS ART13 SPEECH AMPLIFIER & PARTS TO CONVERT TO PEAK CLIPPER & LOW PASS FILTER INCLUDES DATA, TUBES, PARTS 8.25
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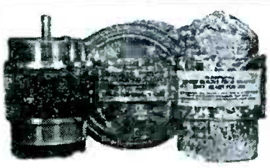

AUTOSYNS TYPE-5 115V/60 CY In Like New* Gtd Condition

REMOVED FROM M-1 GUN DIRECTOR OIL CHAMBER ELEC&MECH OK&GTD*
TYPE5/C78248 SYNCHRO TRANSMITTER 5.95
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2750V/ONE AMP @ $54........2 FOR 99.00
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1320V/375VCT/110MA.5V/3A, 2.5V/3.25A& 6.3V/2.75A CASED HV IN.. 8.95
1350VCT/150MA, 6.3V/5A,5V/2A UTC... 6.95
640VCT&1250V/250MA$4.95 @ ...2 FOR 8.95
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1100VCT/212MA$5.95: 10V/8A/12KV.... 6.95
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100VCT/45MA; 795VCT/80MA; 3x5V/3A& 6.3VCT/1A,6.3VCT/.3A HV/HMTCLLYCSD 4.95
7.5VCT/6.5A, 6.3VCT/3A 3.75
700VCT/150MA; 10V/3.25A,2.5V/10A & 6.3VCT/2A,5V/3A; HV INSLTD CASED... 5.50
115 OR 230V/10AMP/2KW TRANSFORMER 19.95
93, 103, 112, 117 OR 230V/1.6KW..... 14.95
115 OR 230V/8AMP/1.8K1 AUTOTRANSF 14.95
115 OR 230V/50-60CY/3.4AMP 4.95
110 OR 220 OR 220 OR 440V/190W..... 4.50
2.5V/1.75A, 4V/6A/20KV CASED...... 5.50
DYN 28VIN/OUT540V/250MA USED LN*. 2.50
DYNMTR 6VIN/OUT240V/100MA or 12&24V IN/500V/50MA; PM NEW NAVY. 3.49
DYN 12&24VIN/275V/110MA/PM 1.95
DYNMTR 28VIN/OUT250V/60MA ..2 FOR 1.98
"TAB" MONEY BACK GUARANTEE. $5 MIN. ORDER F.O.B. N.Y.C. ADD SHIPPING CHARGES & 25% DEPOSIT.

XTAL POWER OSCS "AT" TESTED BLANKS

6000	7050	7400	7650	8100	8322
6522	7100	7410	8000	8104	8325
6547	7110	7420	8010	8124	8374
6925	7150	7430	8014	8300	8438
7000	7210	7450	8025	8304	8477
7010	7300	7540	8030	8318	8488
8524					

Each 35c; Four $1; Ten for...$2.00
2000R5000KC STANDARD MTD EA..... 3.95
181.95, 93.12, 3675, 3750KC/VACUM XTAL @ .... .98
7010.000KC/DC30 W.E. MTD XTAL..... .49
3735,4190,4780,5030,5235,5485,5880& 6335KC, MTD/FT243/AT XTALS @ 39¢ 10 FOR 3.50
6.3TO6.8/8.3TO9.3 & 7TO7.2MCS/FT243 @ .... .39
AIRCRAFT XMTTR RCA AVT112A USED NO XTAL 14.95
AMATEUR RADIO HANDBOOK 1948..... 2.00

"TAB" FOR TUBES

1B3/8016..	$2.00	12SR7....	$.81	9006......	$.49
1E7G	.98	25Z5	.70	902A ..	2.85
1L4	.98	28D7.....	.89	2AP1.....	1.95
1P5G.....	.79	30........	.74	2AP1A ..	4.95
2A5 ...	.75	35Z5	.61	3AP1.....	3.25
2C40	.73	35L6 ...	.74	3BP1.....	2.75
2D21.....	.98	5CL6 ...	.72	3DP1.....	2.75
2X2......	.49	80........	.52	3FP7.....	2.75
2V3G.....	.98	83V ...	1.25	3GP1.....	3.95
3A4 ...	.75	OC3/VR105	.74	3JP12 .	3.95
3B7/1291..	.95	OC3/VR150	.74	5AP1.....	2.75
3D6/1299.	.95	211.......	.79	5BP1.....	3.75
3S4	.90	250TH....	18.00	5BP4.....	3.75
5R4G	1.00	304TL.....	6.95	5CP1.....	3.75
5T4......	1.53	307A ..	3.25	5FP7.....	3.95
5U4G	.69	446A ..	1.98	5HP1.....	3.95
5W4......	.98	450TH....	25.00	7BP7/1813	3.95
5Y3G	.53	450TL....	29.95	9JP1 ...	3.95
5V4G.....	1.00	WL531. ..	18.00	12DP7....	5.95
5Z3	.80	703A......	4.95	1B24 .	2.95
5Z4	1.00	717A ..	.89	1B27 ..	2.95
6AB7.....	.98	723.......	2.95	1P24 ...	2.95
6AC7.....	.72	723AB....	4.95	2E22 ..	1.50
6AG5.....	.97	725	4.95	10Y......	.35
6AG7.....	.98	803.......	9.00	15E ..	1.49
6AJ5.....	.98	804.......	8.95	2C26 .	.39
6AK5	81	805.......	4.95	2C34/RK34	.49
6AL5.....	.95	807.......	1.49	2C48/446A	.88
6AR6.....	1.28	808	1.95	3B24 .	.74
6B4G.....	1.29	811.......	2.49	3C23 .	4.95
6B8G.....	.98	813.......	8.90	4E24/257.	10.00
6C4 ...	.39	815.......	3.95	2J21	12.75
6C5 ..	.75	814.......	5.95	2J32	16.95
6C6 ...	.73	816.......	1.15	2J55	18.00
6C8G.....	.98	826.......	1.45	2K29....	4.95
6D4......	.98	829B/3E29	3.90	VT127....	2.95
6D6......	.74	836.......	1.10	631P1/SN4	3.75
6E5	.98	837.......	2.25	CK1005 ..	.30
6F6/1613..	.69	845.......	4.95	C6J ..	4.95
6F7	1.20	860.......	2.49	F127A....	12.00
6F8	1.20	861.......	9.00	T200.....	12.00
6G5/6H5	.98	864.......	1.00	4J47	35.00
6G6......	1.08	865.......	1.00	2RA15....	5.95
6H6G ...	.48	868.......	1.00	CE215....	5.95
6H6M.....	.68	872A......	2.20	2RA6.....	3.95
6J4......	1.98	884.......	1.10	CE206....	3.95
6J5......	.72	922.......	1.49	FG104 ...	14.95
6J6......	.81	923.......	1.39	FG105 ...	16.95
6J7......	.88	931A ...	2.49	5D21.....	19.00
6K6GT...	.74	954.......	.49	TUNGAR*	
6K7......	.78	955.......	.49	199698*...	2.95
6K8......	1.20	956.......	.49	20X672*.	2.95
6L6G.....	1.24	957.......	.49	289881*...	2.50
6L7 ...	1.16	958A......	.49	MAZDA PL**	
6N7......	1.23	1613......	.69		
6S7	1.20	1616......	2.75	44** Box .	$.40
6SA7G ...	.98	1619......	.39	47** Box .	.50
6SC7.....	.84	1622/6L6M	1.49	49** Box .	.60
6SN7.....	.91	1624......	.79	S6** Box	1.40
6SG7.....	.95	1625......	.39	SOCKETS	
6SJ7	.79	1626......	.45	Acorn.6 for	1.00
6SL7 ..	1.00	1629......	1.39	866......	.24
6V6GT....	.98	1635......	1.90	872/211...	.49
6X5......	.87	1641......	.84	803/304...	.90
6Y6G	.88	2050......	1.18	813......	.44
7C5 ...	1.00	2051......	.88	829/832...	.25
12A6 ..	.29	7193......	.49	807......	.24
12AH7 ...	1.00	8005......	4.25	705/715...	.69
12K8.....	1.08	8012......	3.95	Maginal	.49
12SA7....	.79	8013......	3.95	Diheptal ..	.69
12SG7....	.88	8016/1B3..	2.00	2X2HV...	.30
12SH7....	.88	8020......	4.95		
12SK7....	.88	9001......	.49	TUBES GTD	
12SL7	1.08	9002......	.59	except open Fil.	
12SN7....	.85	9003......	.49	& Breakage	
12SQ7 ...	.75	9004......	.49		

KIT SILVER & MICA CONDSRS.....50 for $2.00
KIT SILVER MICA CONDSRS.......30 for 1.50
KIT CONTROLS/50-2megs/AB/POTS.10 for 2.00
KIT RSTRS ½&1Watt/50to2meg....100 for 2.50
KIT VITREOUS WW RESISTORS....20 for 1.00
KIT SOCKETS 25 asstd (8-7-5-4P)........ 2.49
KIT POWER RHEOS, 25&50Watt......6 for 3.49
KIT ROTARY SWITCHES ASSTD.......6 for 1.75
KIT G&P Tube caps ¼, ⅜, 9/16"..50 for 1.49
KIT COIL FORMS Thd'd small HF...50 for 1.00
KIT IRON CORE SLUGS & SCREW...50 for 1.00
KIT KNOBS ASSTD With Insert......25 for 1.25
KIT MOTOR BRUSHES ASSTD.......100 for 1.00
KIT FUSES ASSTD BUSS & L. F....300 for 1.95
KIT GROMMET Rubber Radio asst...100 for 1.00
KIT SPAGHETTI SLEEVING ASSTD..75 for 1.00
KIT CERAMICON CONDSRS ASSTD..15 for 1.00

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AS 125/APR Cone type receiving antenna, 1000 to 3200 megacycles. (as shown) New $4.50

SO-13 ANTENNA. 24" dish with feedback dipole. 360 deg. rotation, complete with drive motor and selsyn.
New 75.00
Used 45.00

APS-4 3 cm. antenna. Complete. 14½" dish. Cutler feed dipole, directional coupler, all standard 1" x ½" waveguide. Drive motor and gear mechanism for horizontal and vertical scan. New 65.00

AN/TPS-3. Parabolic dish reflector approx. 10' diam. Extremely lightweight construction. New, in 3 carrying cases 49.00

Relay system parabolic reflector; approx. range: 2000 to 6000 mc. Dimensions: 4½' x 3'. New 85.00

TDY "Jam" radar rotating antenna, 10 cm. 30 deg. beam, 115 v.a.c. drive. New 100.00

140-600 mc. cone type antenna, complete with 25' sectional steel mast, guys, cables, carrying case, etc. New 49.50

RADAR SETS

S09-10CM. SURFACE SEARCH 4, 20 and 80 mile ranges; Raytheon, 250 KW peak power input to 2J27 magnetron. Complete set including: spare parts, tubes, wave guides and fittings. Send for information.

S013—IDENTICAL TO S09. Complete set, used. Consists of transmitter and receiver, PPI scope modulator, motor alternator, rectifier, power unit and new rotating antenna $375.00

SN RADAR-GE, low power, 5 and 25 mile ranges. Uses GL464 as pulsed oscillator, 5" "A" scope, "S" band. Extremely compact; ideal for demonstration and laboratory work. 115V 60C operation. Used, excel. Cond. $600.00

MICROWAVE TUBES
(Magnetrons)

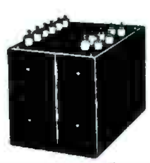
Tube	Freq. Range	Pk. Pwr. Out.	Price
2J31	2820–2860 mc.	285 Kw.	$10 00
2J21A(725-A)	9345–9405 mc.	50 Kw.	25 00
2J22	3267–3333 mc.	265 Kw.	15 00
2J26	2992–3019 mc.	275 Kw.	15 00
2J27	2965–2992 mc.	275 Kw.	15 00
2J32	2780–2820 mc.	285 Kw.	15 00
2J38	Pkg. 3249–3263 mc.	5 Kw.	25 00
2J55	Pkg. 9345–9405 mc.	50 Kw.	25 00
3J31	24,000 mc.	35 Kw.	17 50
W.E. 700A	680–710 mc.	100 Kw.	35 00
W.E 720BY	2800 mc.	1000 Kw.	25 00

KLYSTRON SOCKETS FOR 723, A, B, and similar types .... 2 for 1.00

MAGNETS

For 2J21 (725-A), 2J22, 2J26, 2J27, 2J31, 2J32, and 3J31 .... Each, $8.00
4800 Gauss, ⅝" bet. pole faces, ¾" pole diam. 8.00
1500 Gauss, 1-½" bet. pole faces, 1-⅝" pole diam. 8.00
1000 Gauss, electromagnet, adjustable 2-⅜" to 3" bet. pole faces. 2½" pole diam. 12.00
2100 Gauss, 1-⅛" bet. pole faces, ¾" pole face diam. 4.00

12 and 24 Volt Filament Transformers



(All primaries 110 v. 60 cycles). No. 517: Output: 12 v @ 10 amps or 24 volts @ 5 amps $2.75
No. 2Z17: Output: 24 volts @ 3 amp. size: 3" x 3½" x 3" (as shown) $1.50

INVERTERS

PE 206-A. Input: 28 VDC @ 38 amp. Output: 80 volts @ 500 volt-amps. 800 cycles. Leland. New, complete with enclosed relay, filter, instruction book $12.50
PE 218: Input: 25-28 VDC @ 92 amps. Output: 115 volts @ 1500 volt-amps, 380-500 cycles $15.00

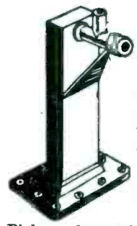
30 MEGACYCLE RECEIVER STRIP

2 Mc. I.F. Bandwidth, 20 db Gain per Stage, 120 db. Overall Gain .. $25.00

"Communications"

THE BEST BUYS IN SURPLUS

MICROWAVE PLUMBING
10 Centimeter



Sand Load (Dummy Antenna) wave guide section with cooling fins, app. 23" high $28.00
10 cm. dipole and reflector, with type "N" fitting 2.75
10 cm. McNally cavity type SG .... Ea. 3.00
Crystal mixer, "S" band. Complete with type "N" fitting and 1N22 crystal 3.85
10 cm. waveguide. 5'9" choke to cover. Per section 12.00
Per set of 4 sections 45.00
Pick-up loop with adjustable tuning section, used in duplexer cavity 1.50
Waveguide to flexible coax coupler (RG 18/U), with flange Gold plated. App. 10" high (as shown) 17.50
10 cm. Horn, rectangular-to-square-to-circular RF assembly ending in horn, radiating circularly polarized beam. Waveguide input. Complete with flange 35.00
Rigid coax directional coupler CU90/UP, 20 db. drop. Has short right angle, about 8" 5.50
Flexible coax connector, ⅞" rigid coax to ⅝" rigid coax. Rigid coax slotted section. CU-60/AP 5.00
Stub-supported rigid coax, gold plated. 5' lengths. Per length 5.00
⅞" coax, rotary joint 8.00
Magnetron coupling to ⅞" rigid coax 4.00
⅞" coax, rt. angle bend, 15" L. OA 2.00

3 CENTIMETER

Thermistor mount in waveguide with tunable terminations $8.00
Tuner/attenuator, W.E. guide, gold plated 3.75
TR-/ATR section with wavemeter iris flange .. 4.00
CG/APS-3, straight waveguide section, 10" choke to cover 1.75
Right angle elbow, 5½" choke to cover, 2½" radius, E plane 4.50
H plane 5.50
Twist, 90 deg., 6" choke to cover 5.00
Waveguide sections 2½' long, silver plated, with choke flange 4.50
Waveguide, 90 deg. bend, E plane, 18" long ... 4.00
Waveguide, 90 deg. bend, E plane with 20 db. directional coupler 4.75
Rotary joint, choke to choke 6.00
Rotary joint, choke to choke, with deck mounting 6.00
S-curve waveguide, 8" long cover to choke 2.50
Duplexer section using 1B24 .... 10.00
3 cm. wavemeter; transmission type with square flanges. (Also available in absorbtion type with square and circular flanges) 15.00
3 cm. stabilizer cavity, tunable transmission type. Model 1551 (TFX 11GA) 20.00
3 cm. waveguide, 1-⅛" x ½" ID, 1/16" wall Per ft. 1.25
Choke flanges, circular, solid brass .... .55
"T" section (TR-ATR) 7-⅛" choke to choke, square flanges 3.50
Bend, 180 deg., 2½" radius ea curve, 12" cover to cover, with pressurizing nipple 3.00
Directional coupler CG 124 APS-15A on 16" section cover to cover, 15 deg., bend 5.00
Feedback dipole with 90 deg. twist, 7½" long OA 3.50
TR cavity for 721-A tube 2.50

1.25 CENTIMETER

"K" band mixer seciton $10.00
Waveguide directional coupler 25.00
Wave Guide Section 1" cover to cover 2.00
T Section choke to cover 4.50
Mitred Elbow cover to cover 3.00
Mitred Elbow and "S" sections choke to cover. 3.50
Flexible Section 1" long choke to choke 3.00

CONNECTORS

UG 21/U. Type "N". Male .... $ .75
UG 86/U. Gold Plated .... .95

SPECIALS

10 CM. RF Package. Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input, 707-B receiver-mixer $150.00
Modulator-motor-alternator unit for above 75.00
Receiver rectifier power unit for above 25.00
Rotating antenna using dipole feed and parabolic reflector. New less hood 75.00
USED 45.00
RT39APG15 Transmitter-receiver. Lighthouse tube oscillator. .5 KW. App. 2700 Mc. operation. With lighthouse and TR tubes 100.00

All merchandise guaranteed. Mail orders promptly filled, prices F.O.B. N. Y. C. Send Money Order or Check. Rated Concerns send P.O. Shipping charges only send C.O.D. Send for Flyers.

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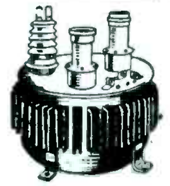
PULSE EQUIPMENT



All Standard name items

APQ-13 Pulse modulator. Contains multivibrator, amplifier, rectifier, air and oil sections. Designed for 400 cycle operation. W.E. # D 151756. Contains following tubes: 1—3E29, 1—6AG7, 1—8016, 1—705-A $49.95
G.E. PULSE NETWORK. #25E5-1-350-50P2T, 25 KV, 5 sections, "E" circuit, 1 microsecond pulse length, 350 PPS, 50 ohms impedance $45.00
G.E. PULSE NETWORK. # 6E3-.5-2000-50P2T. 6 KVA, "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance $6.50
705-A Rectifier Tube, with Ceramic Socket ... $1.25

PULSE TRANSFORMERS

HI-Volt input transformer, W.E. # D166173. Impedance ratio 50 ohms to 900 ohms. Freq. range: 10 kc to 2mc. 2 sections parallel connected, potted in oil $12.00
W.E. KS 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1.1:1, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core $2.00
GE # K 2731
Repetition Rate: 635 PPS. Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms. Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. PWR. Out: 800 KW. Bifilar: 2.75 Amp $19.50
Type G.E. K2450A Will receive 13KV, 4 micro-second pulse on pri., secondary delivers 14KV Peak power out 100KW GE $15.00
HI Volt input pulse Transformer W.E. # D169271 .... $9.95
Pulse Input, line to magnetron, G.E. K2748A .. $12.00
Utah Pulse or Blocking Oscillator Transformer Freq limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1⅛ x 19/32 .... $1.50

MICROWAVE TEST EQUIPMENT

"S" band lab. bench set-up. Consists of one direct-reading wavemeter, app 2600-3400 mc. (cavity type); one dummy load with crystal probe, one line stretcher full wave; two waveguide to RG 18/U coax couplers, two 1" sections w/flanges. All standard 3" x 1½" waveguide $250.00
10 CM ECHO BOX, complete with micrometer adjust cavity & resonance indicator. Type TS 238/GP. With calibration chart $105.00
10 CM WAVEMETER. Model "SL". Micrometer adjust cavity with microammeter resonance indicator. Includes 115 VAC operation converter section. In grey metal carrying case, complete with cables & spares. Made by Western Electric. $135.00
W.E. I 138-A Signal generator, 2700-2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram $50.00

DYNAMOTORS

PE 73CM. Power supply for BC 375. Input: 28 VDC. Output: 1000 VDC @ 350 Ma. Starting relay, filter, etc. $1.95
BD 77KM Power supply for BC 191. Input: 14 VDC. Output: 1000 VDC @ 350 Ma. with spare fuse links, etc. $5.95
PE 101C, Input: 13/26 VDC @ 12.6/6.3A. Output: 400 VDC @ 135 Ma., 800 VDC @ 20 Ma. 9 VAC @ 1.21 A $3.49
Input: 28 VDC. Output: 250 VD @ C @ 60 Ma. Westinghouse $1.95
PC77. Input: 12 VDC. Output 275 VDC 110 Ma. 500 VDC @ 50 Ma $3.25
DAG 33A: Input: 18 VDC @ 3.2 A. Output: 450 VDC @ 60 Ma $2.45
DM 33 A, Input: 28 VDC @ 7 A. Output: 540 VDC @ 250 Ma. Power supply for modulator for SCR 274 N $3.95
Dyn. Model 23350. Input: 27 VDC @ 1.75 A. Output: 245 VDC @ 75 Ma $1.75
DM-21: In 14 VDC 3.3 A Out 235 VDC 90 Ma. with filter $2.59
PE 55. Input: 12 VDC @ 25 amp. Output: 500 VDC @ 400 ma. (slightly used, but in excellent condition) $4.95
MP 10-G. Power supply using 2 dynamotors. Input: 24-28 VDC. Output: 1000 VDC @ 40 ma. 320 volts dc @ 100 ma. New, complete with enclosed relays, filters, etc. $40.00
MK II dynamotor power supply. Input: 12 VDC @ 9.4 amp. Output: 275 VDC @ 110 ma. 500 VDC @ 50 ma. New, with connecting cable and plugs $4.75

Varistors $.95 Ea.
(Western Electric)
D-167176
D-170225
D-162356

Thermistors $.95 Each
(Western Electric)
D-167332 Bead
D-170396 Bead
D-163392 Button

SPECIALIZED ELECTRONIC MATERIAL

HIGH QUALITY · LOW PRICE · IMMEDIATE SHIPMENT

TRANSTAT VOLTAGE REGULATORS

Manufactured by Amertran, three Models are available

Model #TH 2½B
Fixed Winding 230/130
Commutator range 0-260 Volts, .65 KVA.
Max. amp. 2½
Price $19.95

Model #29144
Fixed Winding 115 Volts—60 cycles
Commutators range 103-126 Volts
Maximum output .25 KVA
Housed in shielded case 5" x 6" x 6"
Price $8.95

Type RH
Fixed Winding 115 Volts—400 cycles
Commutator range 75-120 Volts
Load — .72 KVA
Housed in Shielded case 5½" x 6" x 6½"
Price $3.95

PIONEER GEN-E-MOTOR

Dynamotor #SS2669 input volts 18 output volts 450
Overall dimmensions 6" x 3½" x 4"
$1.75

TRANSFORMERS

Plate
Primary 115 volts 60 cycles
Secondary 1350 volts C.T. at 450 ma.
Housed in shielded case 5" x 5½" x 5⅛"
Price $3.95

Filament
Primary 115 volts 50-60 cycles
Secondary 6.3 volts at 6.6 amps.
Shielded case 2⅞" x 3½" x 4½"
Price $1.25

Filament
Primary 115 volts 60 cycles
Secondary 2.6 volts 10 amps.
6.4 volts 5.5 amps. C.T.
6.4 volts 1 amp. C.T.
Price $1.95

Driver Transformer
Thordarson #T-67D78
Suitable for use in driving Class AB or Class B audio modulator.
Stepdown ratio primary to ½ secondary 2.1/1
Primary resistance 500 ohms
Secondary resistance 250 ohms C.T.
Housed in fully shielded case 3⅛" x 3¼" x 2¾"
Price $1.25

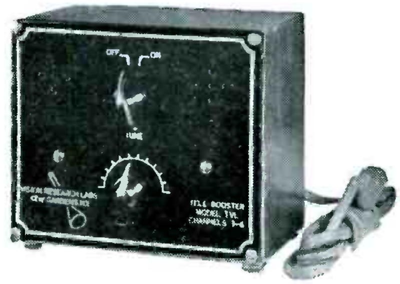
Push-Pull Output Transformer #T17S13
(Similar to Thordarson)
Match Class AB 6L6 Tubes (6600 olms) to 500 olm line
Fully shielded in case 4" x 3½" x 4¼"
Price $1.25

TUBES

(New surplus priced for quick sale)

Type	Price
1B24	$2.95
2C46	4.95
2J34	9.75
2J55	9.75
3B24	.55
3C23	2.45
4B27	2.95
5D21	9.95
4C33	2.95
5U44	.45
6E5	.60
6F8	.95
6H6	.45
6SJ7	.45
6Y6	.65
23D4	.35
45	.55
RK60	2.95
VR78	.45
HY114B	.45
350B	4.95
388A	4.95
394A	2.95
705A	1.95
801A	.45
954	.45
957	.45
1629	.20
9002	.35
9003	.18
9006	.35
50	1.25
VR90	.75
VR105	.75
VR65	.45
1626	.65
1629	.25
1R4	.65
1631	.65
1632	.25
1633	.65
1644	1.25
7193	.45
RCA 836	.75
866 A	.95
Sylvania 3 D6/1299	.75
28D7	.45
724B	1.95
3FP7	.95
5FP7	.95
GE VU111/10E146	.45
Raytheon CK1005	.85
Raytheon 2J37 Magnetrons	6.50
RK72	.75
RK73	.45
Electrons, Inc. ELC5B	

Characteristics
Grid controlled rectifier, Rates continuous current 5.0 amps. Peak forward volts 1250 — 1.95



TELEVISION BOOSTER!
(Model TVL)

Increases signal strength to the television receiver 16-18Db. Rejects unwanted off-channel interference. Simply installed by connecting in series with antenna terminals of receiver, self contained power supply.

Three models available
Model TVL—Channels 1 thru 6
Model TVH—Channels 7 thru 13
Model FM—88-108 Mc (FM Band)
Available in Walnut or Mahogany finish
Size 3" x 5" x 6"
Price $26.95

FREQUENCY SWEEP GENERATOR

Vision Model TSW-50 for visual alignment of FM and television receivers

Features
Tubes: 6C4—Osc #1, 6C4—Osc #2, 6AG5—Mixer, 6AG5—Cathode Follower, 5Y3—Rectifier
Mean Frequency Range, 4 bands: A—5 to 30 mc B—20 to 50 mc C—50 to 100 mc D—170 to 216 mc. (covers television and FM IF and Broadcast Frequencies)
Sweep Width: Variable from 500 kc to 10 mc.
Maximum Output: 1 Volt
Output Impedance: 100, 10 ohms
RF Probe for Point to Point check
Electro-mechanical sweep mechanism.
Terminated coaxial output cable Furnished complete with tubes, probe and output cable and instruction booklet.
Price $68.50

4000-6000 VOLT LOW CURRENT DC SUPPLY

These units have been designed for use with television, cathode ray, electron multiplier and other types of equipment requiring high voltage with currents up to 1 milliampere. Brand new completely wired and tested. Ready to operate from 115 volt power line. D.C. output is filtered.
Price Complete $12.50

2000-3000 Volt D.C. Supply, similar to above, but with lower output voltage. Ready to operate from 115 Volt power line.
Price Complete $7.95

Write for Descriptive Catalogs Listing a Large Variety of Electronic Components

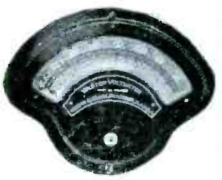
EDLIE ELECTRONICS, INC.

135 LIBERTY STREET — *Telephone: Barclay 7-4763* — NEW YORK 6, N. Y.

SURPLUS BARGAINS!

WESTON MODEL 271

Large Fan Shaped Microammeter



Another of the famous Weston fan shaped line. Very large scale 5.8" long. These meters were made by Weston to General Radio specifications, with special mirrored scale and knife edge pointer. Accuracy 1%.
0—600 Microamps
170 M.V.
Coil Res: 250 Ohms

Your Price................$12.50
10 for $100.00

PORTABLE A.C. AMMETER

WESTON #528

Double range ammeter. 0—3 Amps and 0—15 Amps. Two of the very useful ranges for your Lab. or shop. Complete in genuine leather case with test leads.

Your Price $12.25

TRANSTATS—3 K. V. A.

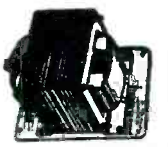
Type RH Input: 115 V 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-30 Volts at 30 Amps. No Knob.

A Real Buy at........$18.00

(same type, but .25 KVA. Input: 103-126 V. Output: 115 V.-2.17 A.)

Price $6.50

STEPDOWN TRANSFORMER



Made by General Electric. Heavy duty stepdown transformer, with considerable overdesign. Ideal for rectifier applications, low voltage heating, general laboratory use, etc. Open frame type.

Input: 115 Volts—60 Cycles
Output: 15 Volts (at full load)
Capacity: 180 V.A.
Size: 3½" x 3½" x 4".

Your Cost $3.75

Quantity prices available

HEAVY DUTY STEPDOWN TRANSFORMERS

Input: 115 V. (with 8 taps in primary).
Output: from 16 to 10.5 V. (in 8 steps).
Capacity: 1.25 KVA—Sec. Amps: 100.
Size: 13"x10"x5". Approx. Weight: 30 Lbs.
Open Frame Construction.

Your Cost $12.50
10 for...............$100.00

H. V. Plate & Fil. TRANSFORMER

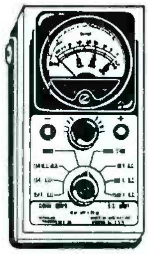
Westghse Encased Oil Filled

Plate: Pri-108-122V, 60 Cy. Sec—15 KV @ .020 A. 18 KV @ .015 A. Fil: Pri—105/115/125 Sec—2.5 V @ 5 A Overall Dimen: 13½"W x 14½"L x 7" D. Weight: Approx 50 lbs.

Price $22.50

All meters are white scale flush bakelite case unless otherwise specified.

VOLT—OHM—MILLIAMMETER



Made by Triumph Mfg. Co. to Signal Corps Specs—Test Set 1-77-H.
Ranges:
Volts DC—0-30/300/1500
Volts AC—0-15/150
Ohms—0-1000
0-300,000
M.A., DC—0-150
Equipped with snap-on carrying handle—size 5¼"x 3½"x2⅜". Your Price $8.50

D. C. MICROAMPS

0-100 Microamps, res. 100 Ohms 3" Rd. Westinghouse NX/35

$7.95

0-150 Microamps — 2" rd. G.E. — DW51 or Whse NX33. Res: 500 Ohms.
Your Cost $3.75

D.C. AMPS & MILLS

0-1 Ma 2" G.E. DW41.................$2.95
(special scale)
0-1 Ma 2" Weston 506................. 3.75
0-2 Ma 2" Sun 1AP525-5................. 2.25
0-2 Ma 3" Weston 301................. 4.95
0-3 Ma 2" Weston 506 with metal case... 1.85
0-5 Ma 2" Dejur S-210................. 1.95
0-25 Ma 2" G.E. DW41................. 2.95
0-30 Ma 2" G.E. DW41................. 2.95
0-100 Ma 2" sq. Simpson 127............ 2.95
0-100 Ma 3" Weston 301................. 4.95
0-500 Ma 2" G.E. DB41................. 3.25
0-1 Ma 3" sq. Westhe RX-35
(Scale: 1.5 KV)................. 4.25
0-1 Ma G.E. DO-41-Black Scale 3" (Scale: 3 KV)............. 3.85
0-15 Ma 3" Westhse NX-35
(scale: 15/150/300)............. 2.95
0-30 Ma 3" Weston 301 (Metal)......... 3.75
0-1 A. 3" sq. Weston 301................. 5.50
0-10 A. 3" sq. Triplett................. 2.50
0-10 A. 3" Simpson #25................. 4.50
30-0-30 A. 3" Simpson 25................. 4.50
0-30/120/600 Ma Weston Portable-Model 280—Precision Type 5.95
0-300 A. 3" Roller-Smith................. 4.95
(fl. bake. Type TD-50 MV)
(with ext. shunt)
0-300 A same as above................. 2.25
(without shunt)
0-300 A. 4" Weston #643................. 8.50
(fl. metal—black scale—ext. Shunt)
0-300 A. 4" same as above................. 5.50
(without shunut)

D. C. VOLTS

0-15 V. 2" Westhse BX-33................. 2.75
(Black scale)
0-15 V. 2" Simpson #125................. 2.95
0-20 V. 2" Weston 506................. 2.95
(1000 Ohms per Volt)
0-15 V. 3" Westhse. CX-35................. 3.95
0-40 V. 2" Weston 506................. 2.95
0-150 V. Weston 301................. 4.50
(Black scale-metal case)
0-150 V. 3" G.E. DO-41................. 4.75
0-150 V. 4" Weston 643................. 6.75
(Black scale—flush—metal)

A. C. VOLTS

0-10 V. 2" G.E. AW-42.................$2.95
0-10 V. 3" G.E. AO-41................. 3.75
0-150 V. 2" Simpson 155................. 2.95
(metal case)
0-150 3" G.E. AO-41................. 4.50
0-150 V. 3" Simpson 55................. 5.95
0-75 V. 4" Weston 642................. 6.75
(Surface Metal Case)
0-300 V. 4" sq. Triplett................. 3.25
(431A 300/600 V. scale)

A. C. AMPS

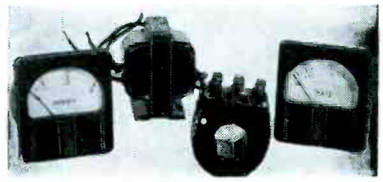
0-1.5 A. 2" Weston 507 (RF)...........$3.50
0-2 A. 3" Westhse RT-35 (RF)........... 3.95
0-3 A 3" Westhse NA-35................. 3.95
(scale: 120 A.)
0-30 A. 3" Triplett (metal)............ 2.95
0-5 A. 4" Weston 642 (surf.)............ 7.95
(surface-metal)
0-5 A. 4" sq. Triplett 431A............ 2.95
(scale: 150/300)

WESTON MODEL 269 FAN SHAPED METER

One of the Weston popular fan shaped line. Exceptionally long scale for size of instrument. Accuracy — with 1%. Scale length—4". Spade pointer. Here is a good movement for special purpose instruments. Comes with blank scale with arc drawn in. Ready for plotting calibration points. Can be used to make up any range of volts, amps, MA., etc.
Full scale deflection—5 M.A.—40 M.V.

List $29.83
Your Cost $8.95 10 for $75.00

A.C. VOLT-AMMETER SET



Westinghouse RA-37—4" Sq. 0-300 Volts AC
Scale: 300/600 Volts A.C.
With Potential Transformer for 600 Volt Range $10.00
Westinghouse RA-37—4" Sq. 0-5 Amps AC.
Scale: 75/150 Amps A.C.
With Donut Current Transformer for Double Range 75/150 to 5............$10.00
Price: **for ALL 4 PIECES**...........$17.50

HEAVY DUTY RHEOSTAT

WARD LEONARD

10 ohms — 9.2 Amps —9.2 Amps (Not tapered). 14" Dia. Complete with handle and legs for rear of panel mounting.

Your Cost $5.95

RECTIFIER TUBES

6 Amp. (Tungar type) for battery chargers, rectifiers, etc.

Your Cost $1.50
(minimum order of 10 tubes)

SELENIUM RECTIFIERS

Full Wave Bridge

Approximate Rating

Federal Type #	Input Max.	Output Max.	Amps.	Price
10B1CV1	18 V.	14 V.	.5	$ .98
10B2CV1	36 V.	28 V.	.5	1.50
4B3CV2	48 V.	36 V.	.5	2.75
5B2AV1	36 V.	28 V.	1.6	4.25
5B2AV5	36 V.	28 V.	8	11.75
11BA6AM1	120 V.	100 V.	1.6	11.95
9DO612R	150 V.	115 V.	1.6	14.50

G. E. PYRANOL CAPACITORS

Cap. Mfd.	Volts D.C.	Height Weight Length	Price
10	1000	5-7/8 x 1-3/4 x 3-7/8"	$1.85
4	1000	5-7/8 x 2-3/4 x 1-1/4"	.85
1	1000	3-5/7 x 2 x 1-1/16"	.50
1	500	2" x 1-1/4" x 1-1/16"	.25
.25	1000	1-1/2 x 1" x 3/4"	.25

G. E. H. V. PYRANOL CAPACITORS

.001 Mfd.—50 K.V. DC.—5⅛"x7¾"x4" $12.50
Insulators 4" Dia. x 7" High.
.1 Mfd—25 K.V. DC.—13"x7"x4"........$9.85

POWER TRANSFORMER

Pri—440/220 V 60 Cy Sec—125/115/105 V Rating .8 KVA RCA Open construction, Bracket mounted, pri & sec terminal boards. Overall dimensions: 5¾"H x 7½"W x 8"D. Mounting dimensions: 6⅞"x5⅞". Price

$12.50

ALL PRICES INDICATED ARE FOB, OUR WAREHOUSE, NEW YORK, N. Y.

POWERTRON Electrical Equipment Co.

119 LAFAYETTE STREET *Phone:* **WOrth 4-8610** **NEW YORK 13, N. Y.**

NEW GUARANTEED SURPLUS!!

SYNCHROS

1G, 1F, 1CT
5G, 5F, 5CT,
5DG, 5HCT, 5SG,
5HSF, 6G, 6DG, 7G,
7DG, etc.
Pioneer Autosyns — AY-1, AY-14, AY-20, AY-30, AY-54, etc.
Army Ordnance—X, XXI, IV, V, etc.
Elinco M1-1, M1-2. **Kollsman** 775-01.
G. E. 2J5HA1, 2J5FB1, 2J6F3, 2JD5HB1, etc.

60 CYCLE AC MOTORS

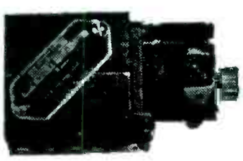
G.E. Reversible. 1/150 H.P. Shunt wound. 40 volts 5000 rpm. Split field. Stock #SA-18 **Price $4.75 ea. net.**
Stock #SA-19. Similar to above but not split field. **Price $2.75 ea. net.**
Barber-Colman. 0.001 H.P. wound shaded pole type. Reversible by relay or s.p.d.t. switch. Stock #SA-27 **Price $3.75 ea. net.**

Pioneer Magnetic Amplifier Assembly. Saturable core type output transformer. 400 cycle. Operates from plates of 6SN7 to supply 1 phase of servo motor. Stock #SA-44. **Price $8.75 ea. net.**
Sinsusoidal Potentiometer—Navy Type CFW-631539. 32000 ohms. 2 output voltages. Sine and Cosine function of shaft position. D.C. input. Stock #SA-124. **Price $7.50 ea. net.**
Constant Speed D.C. Motor — G.E. 5BA25MJ24. 24 V. D.C. 7100 rpm. RC noise filter. Stock #SA-100. **Price $8.50 ea. net.**
Timing Motor—Haydon 1 rpm. 115 V. A.C. Stock #SA-133. **Price $2.85 ea. net.**
DC Selsyn System—24 V. DC transmitter and indicator. Indicator calibrated for flap position. 360° dial easily added. Stock #SA-129 **Price $9.50 per system.**

PIONEER SERVO AMPLIFIERS
12073 and 12077

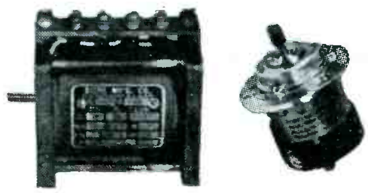
Delco 5069466 DC Motor.

27 V. 10,000 rpm. 1" x 1" x 2" Stock #SA-65.



Price $1.95 ea.

SERVO MOTORS



Pioneer CK-2, CK-5, 10047-2-A and **Kollsman** 776-01 for 400 cycles.
Diehl FP-25-3, FPE-25-11 (CDA-211052) and ZP-106-8 (CDA-211377) for 60 cycles.

Tachometer Generators

E.A.D. J-36.
2 V D.C. per 100 rpm.
Suitable to 5000 rpm.
Stock #SA-130. **Price $8.75 ea. net.**
Elinco PM-2. Similar to S-130. Use to 2000 rpm. Stock #SA-53. **Price $6.25 ea. net.**
Elinco FB-55. 4.7 V. per 100 rpm. Use to 10,000 rpm. Stock #SA-3. **Price $12.50 ea. net.**

400 Cycle Motors

E.A.D. J-33. 115 V. 3 phase. Synchronous. 8000 rpm, 2" x 3". Stock #SA-59. **Price $6.75 ea. net.**
E.A.D. J-72B. 115 V. 2 phase induction motor. 4700 rpm. Stock #SA-140. **Price $9.75 ea. net.**
Westinghouse Blower. Type FL. 6700 rpm. Capacitor type motor. 2 inch Sirrocco blower. Outlet ¾" x 1⅛". Includes capacitor. Stock #SA-144. **Price $6.75 ea. net.** Quantity prices on request.

PIONEER TORQUE UNITS
KOLLSMAN COMPASS SYSTEMS

Minneapolis - Honeywell Stabilized Aerial Camera Mount. Complete with amplifier, inverter, and carrying case. Stock #SA-9. **Price $125.00 ea. net.**

Micro Wave Antenna

12 Cm. dipole and 13 in. parabola housed in weather proof Radome. 24 V. DC spinner motor for conic scan. Shipping weight 70 lbs. Stock #SA-95.
Price $9.50 ea. net.

INVERTERS

Pioneer
12116, 12117,
12121, 12123, etc.
Holtzer Cabot MG-149F, MG-149H, MG-153, MG-153F, etc.
General Electric 5D21NJ3A, etc.

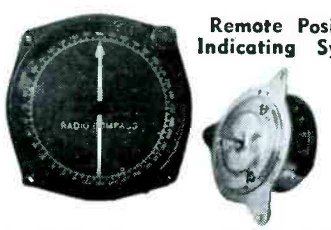
DC MOTORS

Diehl FDE-14-2. 27.5 V. Shuntwound. Reversible. 1½" diam. x 2½" lg. Stock #SA-10. **Price $4.75 ea. net.**
Delco 5066665. 27.5 V. 4000 rpm reversible. 1 oz/in torque. 2½" lg. x 1¾" diam. Stock #SA-14. **Price $4.75 ea. net.**
Diehl 5068571. 27.5 V. Alnico field. 10,000 rpm. Similar to S-65 but has straight shaft extension. Stock #SA-151. **Price $2.75 ea. net.**
John Oster. Series wound. 27 V. 7000 rpm. 1/100 H.P. Stock #SA-30. **Price $2.75 ea. net.**

Radio Compass Loop LP-21-LM. Stock #SA-99 Price $9.50 ea. net.
Phase Shift Capacitor—4 stator single rotor. 0-360° phase shift. Stock #SA-114. Price $4.75 ea. net.
Magnesyn—Pioneer CL-3. 6 power. Transmitter or receiver. Stock #SA-6. Price $3.75 ea. net.
Null Type Synchro Indicator. Consists of Bendix size 5 synchro, magic-eye tube, illuminated 360° dial, rectifier tube, transformer, etc. Use with S-43. Stock #SA-119. **Price $6.95 ea. net.**

SINE COSINE GENERATORS
Diehl Types FJE-43-9 and FPE-43-1

Remote Position Indicating System



6-12 V. 60 cycles. 5 inch indicator with 0-360° dial. Heavy duty transmitter. Stock #SA-115. **Price $9.95 per system.**

All Items New & Guaranteed

SERVO-TEK PRODUCTS CO.
INCORPORATED
Surplus Division

Open account shipments to rated concerns, others may order C.O.D.

247 CROOKS AVE. ARmory 4-2677 CLIFTON, N. J.

BUY From a Needle to a Locomotive SELL

Versatile MOTOR of 1000 uses. Actual size 1" x 1" x 2¼". ALNICO Field. Operates 6 to 30 volts DC. Speeds up to 10,000 RPM. REVERSIBLE. Tiny removable gear on shaft. Ideal for models, etc. .... $2.50 Check or M.O.

MOTORS

Delco #5069600 Alnico Field, 250 RPM. 27 V DC ¼" spline shaft ½" long, 1⅜" x 3¾" overall size. .... $ 3.95

Delco Mini Motor, Alnico Field, 10,000 RPM operates 6, 12 or 24 V DC 1" x 1" x 2" overall. 2.50

Redmond 24 V DC, 6,000 RPM .96 amp 3" dia x 4" long ¼" x 1" shaft. 2.00

Redmond 6 V DC 2,000 RPM reversible shunt wound 5/16" x 1" long spline shaft. 3" x 5½" overall size 5.00

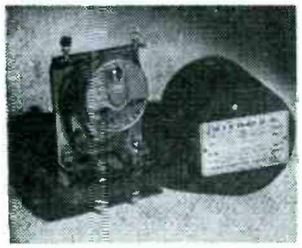
Bodine 6 V DC 17 RPM geared slo speed powerful. ½" x 1½" long right angle shaft. 4" x 8" overall size. 15.00

F. A. Smith 27 V 10,000 RPM 3/16" x 1" long shaft with worm gear on front end. ½" x ¾" long knurled shaft on back end. 2.50

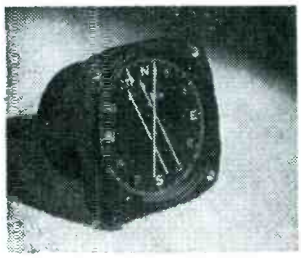
G.E. 24 V shunt 145 RPM geared 14" oz torque 1½" x 4" overall size. 2.50

MINI BULBS

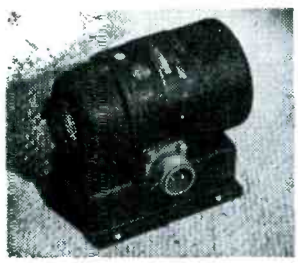
Miniature Bulbs #318 or #323 (3 volt) .19 amp for instruments, hobbyists etc.
Per. Dozen 1.50



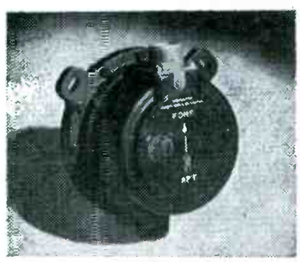
D—2 MIN. ADJUSTABLE TIMER



A— COMPASS INDICATOR



B— INVERTER



C— COMPASS TRANSMITTER

PUMPS

A—Pesco pump, vacuum or pressure. Vane type. ⅝" spline shaft. ½" threaded prts. 4" dia. x 5" long overall size. 7.00

B—Delco 24 V DC ¼ H.P. Vacuum or Pressure. Diaphragm type. 6" x 12" overall size 15.00

Micro switches normally open or normally closed. 3 for 1.00

A— KOLLSMAN B— COMPASS C— TRANSMITTER

and remote indicator with power supply for operation on 24 V DC Government cost $250.00. Special Price 25.00

R.W. CRAMER D— TIMER

Adjustable time delay. 0 to 120 seconds. 110 V AC. Capacity 10 amps. 4.50

INVERTERS

400 cycle Inverters PU/16 AP 24 V DC—60 Amp. Output 6.5 Amps 115 V... 15.00
PE 218 24 V DC—80 Amp. Output 15 KVA 13 Amps., 115 V. 25.00

TANKS

A—Tanks 400 lbs. pressure. 5½" dia x 14" long. ⅛" pipe fitting one end. 2.00

B—Oxygen hi pressure 1800 lbs. with valve, shatterproof. 5¼" dia x 21" long, weight 14 lbs. 6.00

BATTERY

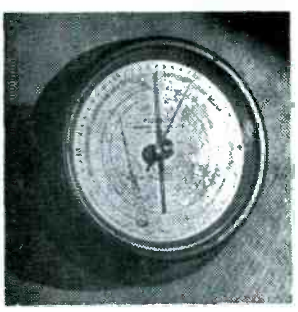
6 Volt Willard battery 15 amp capacity 5" x 5" x 6" over-all size 3.50

AXIAL BLOWER

100 C.F.M. 24 V AC or DC 4½" diameter 5" long 4.50

SIREN

Powerful 12 V DC—6" high 6" long. 5.00



BENDIX BAROMETER

Bendix Friez precision aneroid type, wall mounting 6" dia x 3" wide. 15.00

STANDARD 110 V. AC MOTORS

A—Redmond 1/30 H.P.—Cont. duty, 4" dia.—6" long. 1550 RPM 10.00

B—Jack & Heintz ¼ H.P. Resilient mounted ⅝" dia. shaft. Capacitor type. 1725 RPM 22.50

C—Jack & Heintz ⅓ H.P. Capacitor type 1725 RPM, ⅝" dia. shaft. Resilient mount. 25.00

LANTERNS

A—Powerful Signal or Spotlite, 6" dia. sealed beam in plastic case. Complete with colored filters and carrying case. 6, 12, or 24 volt. Price $5.50

B—Spotlite 12 V with trigger switch and 10 ft. wire.......... 2.50

C—Spotlite or Lamp 6 or 12 Volt has combination trigger and on, off switch. Pistol grip handle, all metal and protecting grill for bulb. 6.50

AMERICAN SURPLUS TRADING CO.

332 CANAL STREET, N. Y. 13, N. Y. Canal 6-7055

Finest of surplus at a fraction of cost

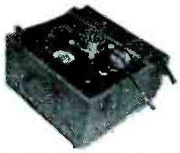
PEAK ELECTRONICS CO.

Industrials Schools - Labs

DAVEN AUDIO FREQUENCY METER Model 837E

Direct reading from 0-30 KC in 4 separate ranges on 6" Weston Model 271 Fan Meter. Built-in voltage regulated power supply operates from 115 volts 60 cycles, has high input impedance. With pick-up can be used to determine frequency in vibration tester. With suitable mixer can check deviation of R.F. carrier from standard. Mounts on 8¾"x19" rack panel. Complete with tubes. Slightly used but perfect. Only..........$59.50

S.C. TEST SET—1-114



In portable wood case 6" x 6" x 10" (including cover not shown). Has Weston 0-150 volt A.C. meter 60 cycle, 2 switching circuits. Complete with line and test cables. A bargain at only $3.95.

CHOKE BARGAINS

WE 4.3 hy 620 ma. 42 ohms..................$4.95
N.Y.T. 8 henry 160 ma. 140 ohms D.C........ 1.39
C.T.C. 1.5 henry 250 ma. 72 ohms............ .69
R.C.A. 50 henry 680 amps. high voltage.....19.50
Fed. Tel 6 henry 1.8 amps. high volt........29.50

R.C.A. POWER TRANSFORMER

770 V.C.T. 100 ma., 6.3 volts—2.5 amp. 5 volts—2 amps.—3½" x 4" x 4½"........$2.75

AMERTRAN STEPDOWN TRANSFORMER

220-110 100 watts, shielded..................$2.49

MIDGET VARIABLE BARGAINS

Hammarlund MC 250S 250 mmf............$ .89
Hammarlund MC 320S 320 mmf........... .79
Hammarlund APC 100 100 mmf........... .39
Hammarlund APC 50 50 mmf............ .29
Hammarlund HFD 30X Dual 30 mmf. D.S... 1.19
Bud MC 913 Dual 35 mmf. D.S............ 1.25

LINK BC 438 FREQUENCY METER

195-215 mcs. Built in 110 volt 60 cycle power supply. Complete with tubes and crystal. Slightly used. Limited quantity...........$9.95

TRANSMITTING VARIABLES

Cardwell XD160 XD. Split stator. 160 mmf./section .125 spacing......................$7.95
Hammarlund MTC 150—150 mmf. .07 spacing (easy to split)......................... 1.49

HANDY LAB KITS

25 Popular silver micas.....................$1.95
50 Popular pigtail micas.................... 2.39
25 Popular ceramicons...................... 1.50
25 Wirewound resistors 5 to 30 watt......... 2.50
15 Bathtub condensers....................... 1.95

HIGH VOLTAGE MICAS

C.D. .002 2500 W.V. 5000 V.T. type 9......$ .19
C.D. .002 3500 W.V. 7500 V.T. type 9........ .69
Micamold .005 2500 W.V. type 4............ .69
Solar .005 10 KV. D.C. 11 amp. 3000 K.C.... 7.95
C.D. .004 3KV. D.C. 20 amp. 18000 K.C.... 2.50
R.C.A. .02 2000V. D.C. 10 amp. 300 K.C.... 1.75
Sangamo (F2L) .015 2000V. D.C........... 1.50
C.D. (6H) .0013 5000V. D.C............... 1.00
C.D. (6H) .005 5000V. D.C. 11 amp. 1000 K.C. 2.50
R.C.A. .0002 2500 W.V. 5000 V.T........... .39
Sangamo (G3) .0005 20KV................ 12.95
Sangamo (G4) .001 30 KV................. 27.75

FEDERAL TELEGRAPH TRANSMITTER

B.C. 325-B—Phone-CW. 110V 60V cycle input—400 watts output CW. Crystal and Variable Frequency Control — Has Blower Motor, Crystal Oven, Transtat, Modulation Oscilloscope, 11 Panel Meters, etc. Perfect condition....$575.00

500 foot Drums RG8/U Coaxial Cable $24.50 per Drum

U.H.F. COAX. CONNECTORS

UG12U—831R—831J—UG21U—831AP—831SP .39 ea.
Large stocks of Coax. and A/N connecters.

AMERTRAN TRANSTAT or Stepdown Transformer

110/220 volts 60 cycle input. Output variable plus or minus 10% of 115 volts at 8.5 amps. Also can be connected to give different voltage combinations. Brand new ......only $17.50

AMERTRAN VOLTAGE REGULATOR

130/230 volts 50/60 cycles input. Output variable from 0—260 volts. 1.3 KVA, single phase. Like new $29.50

SPERTI RF VACUUM SWITCH

9200 volts peak, 8 amps. Used as antenna switch in Collins ART 13. BRAND new $1.75

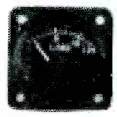
VOLTAGE REGULATED Power Supply

Input 110 volts 60 cy. output 150 volts regulated. Used VR 150/30 and 6 x 5. Well filtered (3 chokes) and has extra 6.3 volt winding. 16" x 3½" x 5". Complete with tubes. Used, but good. $6.95

OIL CONDENSERS CD, GE, Aerovox, etc.

2mfd 600 vdc....	$ .39	3 mfd 3000 vdc..	$3.95
4mfd 600 vdc....	.59	1 mfd 4000 vdc..	3.75
3/3 mfd 600 vdc..	.79	1 mfd 5000 vdc..	4.50
4/4/4 mfd 600 vdc	.95	.1 mfd 7500 vdc..	1.95
14 mfd 600 vdc..	1.35	.1/.1 mfd 7500 vdc	2.45
2 mfd 1000 vdc..	.79	.01/.01 12 KV dc	5.75
4 mfd 1000 vdc..	.95	.005/.01 12 KV dc	5.50
2 mfd 1500 vdc..	1.25	.65 mfd 12500 vdc	12.95
1 mfd 2000 vdc..	1.15	.75/.35 mfd (dual) 8/16 KV dc......	14.95

WHERE SPACE IS LIMITED



This tiny GE motor only 1½ inches square. Basic movement 0—1 ma. Ideal as "S" meter for BC348, etc. Only.......$3.95 ea.

METERS (brand new)

2" GE 0—5 ma (amp scale).......$1.95
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2" GE 0—1 amp R.F. (internal thermo) 3.49
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2" McClintoch 0-50 microamps. (square)...................... 7.50
2" Weston type 507 0-120 Ma RF.. 4.95
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3" W. E. 500-0-500 microamps. (Blank scale)....................... 3.95
3" Westinghouse 0-50 amps. A.C... 4.95
3" Westinghouse 0-2 ma D.C....... 3.95
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3" G.E. 0-15 ma D.C. (square)..... 3.95
3" Westinghouse 0-150 volts A.C.... 3.95
3" G.E. 0-200 microamps (volt-scale) 6.95
3" G.E. Running Time Meter........ 7.95
4" G.E. 1-0-1 ma D.C. (Blank scale) 3.95

FEDERAL SELENIUM RECTIFIER

Full wave. 36 volts input. 28 volts output at 6.1 amps. Brand new $7.95

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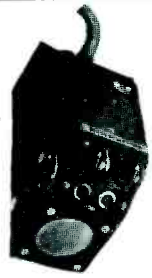
(Cornell Dubilier, Aerovox, W. E. only)

25 mfd 25 w.v. tubular C.D..................$ .25
50 mfd 50 w.v. tubular Aerovox............. .29
4 mfd 150 w.v. tubular C.D.................. .18
8 mfd 450 w.v. tubular C.D.................. .37
12 mfd 450 w.v. tubular C.D................. .44
500 mfd 15 w.v. tubular C.D................. .49
10 mfd 450 w.v. can C.D..................... .49
16 mfd 450 w.v. can C.D..................... .69
20x20 mfd 450 w.v. can Aerovox............. 1.05
80 mfd 200 w.v. can W.E..................... .69
200 mfd 200 w.v. can W.E.................... .98
1000 mfd 25 w.v. can Aerovox................ .95

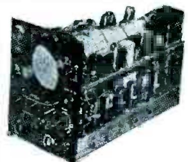
Tremendous stocks on hand. Please send requests for quotes. Special quantity discounts. Prices f.o.b. N. Y. 20% with order unless rated, balance COD. Minimum order $3.00.

G.E. 2" SCOPE



This compact unit only 4½" x4"x6¾". Ideal for modulation indicator, etc. Has focus, intensity and reticle brilliance controls. Uses 2API C.R.T. and 9006 rectifier. We supply instructions with each scope. Rectifier built in. Need only 500-600 volts A.C. plus 6.3 volts. Changes very simple with cable and 9006 but less 2API $4.95
2API C.R.T. 2.50

APN 4, 5" SCOPE INDICATOR (25 tubes)



Makes an ideal basis for 5" scope. Also can be converted into Panadaptor with marker pips at 100 KC - 20KC - 2 KC., for measuring drift and width of F.M. Has electronic switch for observing 2 frequencies simultaneously. Unit contains an accurate 100KC crystal. Tube complement: (1) 5CPI (3) 6SL7 (14) 6SN7 (6) 6H6 (1) 6SJ7. Complete with tubes and 100KC crystal. Marvelous buy at $24.95

POWER PLANT (PE 197)

4 cylinder Hercules Gas driven engine. Output 110 volts 60 cycles, voltage regulated, 5KW-6.3KVA at 80% Pwr. Ftr. Single phase, complete with running spare parts, meter panel, battery, tools, remote cable, etc.
Weight 1200 lbs. Export Packed. Excellent for emergency power. Brand new.............$575.00

MISCELLANEOUS SPECIALS

2-11 mmf. Butterfly with ball bearings.....$ .59
G.E. S.P.D.T. Relay 10000 ohm coil......... .59
Heineman Circuit Breaker 5 amp. 110V. A.C. .89
G.E. Solenoid W/Microswitches 24 V. D.C... .69
Ohmite 25 ohm 25 watt Rheostat........... .39
Microswitch 10 amp. (interlock)........... .59
C.H. Bat Handle Switch—D.P.S.T. ½ H.P. .95
Veeder Root Counter...................... .95
Single Plate to P.P. input 3:1 ratio trans... .49

MEGOHM METER

Industrial Instruments Model L2AU 110/220 volts 60 cycle input. Direct reading from 0-100000 megohms on 4" meter. Can be extended to 500000 megohms with external supply. Sloping hardwood cabinet 15"x8"x10". Brand new with tubes plus running spare parts including extra tubes. Great value only $69.95

WIRE WOUND RESISTORS

Standard Make

5 watt type AA. 20-25-50-200-470-2500-4000 ohms .... .09 ea.
10 watt type AB. 25-40-84-400-470-1325-1900-2000-4000 ohms .... .15 ea.
20 watt type DG, 50-70-100-150-300-750-1000-1500-2500-2700-5000-7500 10000-16000-20000-30000 ohms .... .20 ea.
30 watt type DI, 100-150-2500-3000-4500-5300-7500-18000-40000 ohms .... .24 ea.

1% PRECISION RESISTORS—

Standard Make

2000-2500-5000-8500-10000 ohms .... .39 ea.
50000-95000 ohms .... .49 ea.
100000-750000-1 meg .... .89 ea.

SELSYN AND SILVERSTAT KIT

Kit contains one synchro differential gen. type 6DG —90/90 volt 60 cycle A.C. One 220 V. A.C. 5MFD Motor Cap. Two silverstats—ideal for use as voltage regulator. This regulator is the leaf type (similar in function to a carbon pile). It provides a continuously variable resistance from 10 to 1200 ohms. When used in bridge circuit, ideal to control servo motor. All brand new in original boxes—ship wt. 40 lbs.......................$4.95

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HEADQUARTERS FOR TRANSMITTERS, FOR MARINE, AVIATION AND COMMERCIAL APPLICATIONS

TELEMARINE

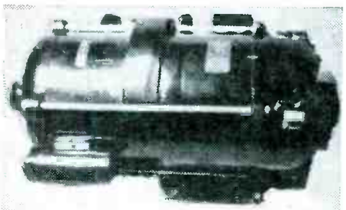
CAREFULLY SELECTED SURPLUS ELECTRONIC EQPT., FOR VALUE, CONDITION & USEFULNESS

110 DC to 110 AC Converter

Mfd. By ESCO, Type R182, for marine use. Converts 115 V. DC to 115V. AC, very conservatively rated at 135 watts. Tests show that it is satisfactory for service up to 200 watts. Self-ventilated, semi-enclosed, wool-oiled bearing construction. Includes filter condensers and choke coils in base, as well as small condensers across each brushholder, for filtering purposes. Provided with rubber connecting cords, and standard outlet receptacle.

NEW. PRICE EACH...... $29.00

AMPLIDYNE MG SET MOTOR 110/220, 60 C.A.C.



For Automatic or Remote Control of heavy equipment. Mfd. by General Electric. Generator is Type V-5875677, motor 73AB58; Navy type CG-21ABU. Generator delivers 250 volts DC, 375 watts. Motor,—115 or 230 volts, 1-phase, 60 cycles AC, rated at ¾ HP RPM-1725. Includes capacitor for starting, and instructions for 115 or 230 volt connections. Generator section can be removed, and entire assembly shortened to make valuable ¾ H.P. AC motor. Quantity sufficient to warrant this conversion.

PRICE, EACH........... $60.00

FM-AM SIGNAL GENERATOR

For Servicing FM and Television

Known as Test Oscillator TS-32/TRC-1, and mfd. by LINK, this item is a bargain for servicemen, laboratories, and production testing dep'ts. Frequency range 70 to over 100 mc. Small, well-built, uses only 3 tubes (6SH7, 6SL7GT, and 6SN7GT) as a crystal osc.-buffer amplifier, phase modulator—frequency multiplier, and audio frequency stages respectively. Modulation frequency (FM) is 1,000 cps, and a toggle switch in front permits "On or Off" modulation. A 2 ft. rubber cable with octal male plug permits ready connection to chassis (television or radio) for power. With circuit diagram, instructions, tubes, but less crystal.

PRICED, LOW!!! EACH....$5.95

SHIP RADIO EQUIPMENT

Most complete line of standard ship radio equipment, including installation materials! Ship Auto Alarms, Direction Finders, Radio Receivers, Radio Telephones, Main and Emergency Transmitters (Intermediate and High-Frequency types), Antenna insulators, shackles, wire, stand-off insulators, motor generators, etc. Write for our listings, or send us a list of your requirements. We have a large stock, at unusually low prices.

RADIO TRANSMITTERS

Immediate Delivery from Stock

10 KW Low and Intermediate Frequency Bunnel Transmitter, 150 to 550 KC. A1 emission. Consists of BC-365F Exciter-Driver (300 watts), PA-1A Power Amplifier, RA-1A Rectifier, AT-1A Antenna Tuning Unit with pre-fab (knock-down) tuning "house", with all spares such as tubes, meters, capacitors, resistors, transformers, etc. All NEW Equipment, in original factory packing. Operates from 220 volts, 3-phase, 50-60 cycles AC. Four (4) complete units available—$8,000.00 each.

2-KW Hi-Frequency Transmitter: 4-Bands, 2 to 18 mc. Model H-2000, mfd by Radio Laboratories, Inc. Consists of P.A. unit using 2—833A tubes, in cabinet 36x36x74¼" high, and Power Supply using 4—872A and 2—866 tubes, in cabinet 24"x36"x74¼" high. Operates from 110 or 220 volts, 50-60 cycles, 1-phase AC. Driving power required, 70-125 watts. New condition; with tubes. **PRICE, EACH** $2,000.00

Exciter-Driver, for Above. Either Model 300-B, 4-Channel Radio Laboratories unit designed to operate with above; or BC-447, 300 watts, 2-channel transmitter (described below). Complete with tubes. Each $450.00

1-KW or more, BC-339 Complete CW Transmitter. All self-contained in one cabinet, complete RF circuits, power supply rectifiers and control equipment. X'tal control, 4-26.5 mc. Operates from 220/3/60 AC. New and complete with all tubes and spares. **PRICE, EACH** $2,100.00

TEMCO, Model 1000AG, 1 KW CW Transmitter. Crystal-control, 2-16 mc. Operates from 110/1/60 AC. 6 preset channels of operation. Excellent condition. With tubes. **PRICE, EACH...$1100.00**

BC-325 Transmitter, 400W.-A1, 100 W.-A2 & A3. 1.5 to 18.0 mc. M.O. or X'tal control on 6 frequencies.. **Operates from 110/220/1/60c. AC.. With** tubes, in excellent condition. Price........$650.00

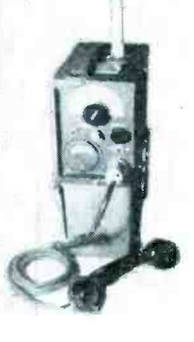
BC-447, 300 W. A1, 2-Channel Transmitter. Complete and self-contained in one cabinet, 36x29x72" H., includes RF sections, power supplies, and control equipment. Freq. range 4.0 to 13.4 mc. Operates from 110/220V/1/50-60 c. AC. With tubes. Excellent condition. **PRICE, EACH** $450.00

Model 600-B, 600 Watt Radiotelephone transmitter, mfd by Temco for the Navy (shore station). 600 watts on phone, 1 KW on CW; frequency range 1.5 to 20.0 mc. Provision for multi-channel operation. Includes separate Remote Control and Speech Amplifier unit. Operates from 220 volts, 1-phase, 50-60 cycles AC. With tubes—no spares. Only one unit available. Price $2,000.00.

350 Watt Airport Tower Control Radiotelephone transmitter, mfd by Aircraft Accessories Co. Model RC-52. Two channels, separate transmitter for each (common power supply). A1, A2 and A3 emission. Range 1.5 to 7.0 mc. Almost new condition. Includes separate Remote Control Panel unit, tubes, but no spares. Only one available. Price $1,000.00.

Collins 75 Watt Autotune Transmitter. Model TCB, 10-channels instantly available by dial-telephone selection at transmitter or remote position. A1, A2, or A3 emission. Frq. range 1.5 to 12.0 mc. Operates from 110 volts, 1-phase, 50-60 cycles AC. Complete with all spares (tubes, transformers, autotune motors, capacitors, etc.), remote operating unit, handsets, etc. Excellent condition. Only two available. Priced way below cost at $750.00 each.

5-Meter Walkie-Talkie



Model BC-322 Transceiver: simple, popular communications unit. Freq. range 52-65 mc. Uses only two tubes, types 33 and 30. Includes a 5 KC crystal in a crystal calibrator circuit. Range 5 to 150 miles, depending upon location and altitude. Operates from single battery block (not supplied) available from mfr., or other sources. Supplied with telescoping antenna and handset, almost new condition.

PRICE, EACH $24.95

12-Volt MOBILE P. A.

Brand new, RCA, complete, 25 watts peak, 12 - 15 watts average, Amplifier and close - talking Pressure type (moving coil) Microphone. Operates from 12-14 volts DC. Self-contained vibrator power supply. Tubes supplied: 6J7, 6SN7, and 2-6L6. Flat response to 5,000 cps. Output impedance to 15 ohms (2-8 ohm voice coils). Shock mounting employed throughout. Designed for Airplane installation, to withstand shock and vibration. Ideal for sound trucks, boats, portable P.A., etc. Conversion to 110V. AC operation easily accomplished. Drain 2 amps standby, 6 amps. operate.

PRICE, EACH........... $69.25

6 V. D.C. DUAL VI-PACKS

Designed for 25 watt mobile transmitters, by Galvin-Motorola. 2-packs-in-1, with two transformers, two vibrators, and two 0Z4-A gaseous rectifier tubes. Output 540 volts DC, at 160 mils. Simple conversion to 300 volts at 300 ma. Instant output, no heating time required.

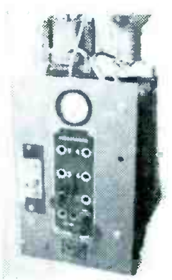
PRICE, EACH............ $9.00

3-Band Portable D.F. Receiver

Just the thing for yachts, fishing craft, tracking down interference, etc. Made for the Navy, beautifully designed and constructed. Freq. range: 1.5 to over 18.0 mc. 8 miniature tubes in superselective superhet circuit. Telescoping sense Antenna and loop fit in cover of rugged metal case when carrying. Built - in loudspeaker, as well as phone jack. Uses standard batteries. Includes spare tubes, magnetic compass, fuses, etc. NEW. Less batteries.

PRICE EACH...........$110.00

230 V. Tungar Bulb 1-6 Battery Charger



Charge from 1 to 6 batteries, from 210 to 250 volts, 1-phase, 50-60 cycles AC., 6-amp. charging rate. Rugged transformer, with tapped pri. 210/230/250 volts. With built-in charging meter, Tungar 6-8 amp bulb, fuses, etc. New

PRICE, EA $19.95

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Laboratory Equipment

Signal Generator, for portions of S band, pulse modulation, variable duration and delay, calibrated output, power meter for internal and external metering.

Signal Generator, X band, pulse modulation, variable duration and delay, calibrated output.

Signal Generators for the range of 1000-2000 megacycles, 1000-3000 megacycles and 2000-3700 megacycles, calibrated output, pulse modulation, variable, duration and delay.

Signal Generator, Ferris 18B microvolter, 20-150 megacycles, metered output, 400 cycle modulation.

R.F. Attenuator, DC to 1000 megacycles 20 DB., type N connectors. Can be connected in series to give multiples of 20 DB attenuation.

Wavemeter TS 33/AP, 8600-9500 megacycles, calibrated.

X Band Power Meter, TS 36/AP, complete with accessories, new.

Wavemeter TS 69/AP, 350-1000 megacycles, calibrated.

X Band Power Load, TS 108/AP complete with case and accessories **$10.00.**

Radar Transmitter-Receiver, 2400-2700 megacycles, very compact, 110 volts 60 cps, new **$175.00.**

General Radio Precision Wavemeter, type 724A, range 16 kc to 50 megacycles, 0.25% accuracy, V.T.V.M. resonance indicator, complete with accessories and carrying case, new **$200.00.**

Audio Signal Generator, 20-20,000 cps, R C tuned, Hickok model 198, good working order, **$45.00.**

RCA 5" Cathode Ray Scope, model 160 B, new **$135.00**

Clough Brengle, Resistance, Capacity and Turns Ratio Bridge, model 230, new **$55.00**

U. H. F. Mutual Inductance Attenuator, calibrated 30-100 db, **$15.00**

Calibrated S Band fixed Attenuator, 19.8—20.2 db, type N fittings **$10.00**

Lossy Line, 10 db attenuation, type N fittings, **$3.00**

Pulse Transformers:

Utah 9280 **$1.00**
Westinghouse EWP-145 **$3.00**
W.E. D161310 **$3.00**

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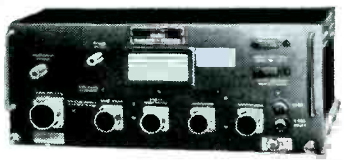
FM TRANSMITTER

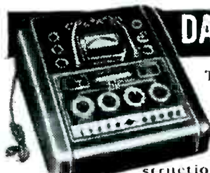


Used as indicator for altitudes up to 4000 ft.—but readily adapted for signalling, control circuits, etc. Contains dynamotor for operation from 27.5 volts. Complete with all 14 tubes: 2-12H6, 2-955, 2-9004, 4-12SJ7, 3-12SH7, and VR-150-30. Two antennas, altitude indicator, limit switch, connectors, instruction manual. MA-2198 .... **$37.95**

Secondary Frequency Standard

Used to identify band edges and frequencies of unknown signals. Unique assembly uses 2-12SL7GT and 1-12SA7. Frequency divider and multiplier circuits provide 1000-cycle modulated outputs on 50KC and 200KC with harmonics up to 18MC. Complete with tubes, schematic diagram, less 200KC crystal. MA-OSC-3T.......... **$2.95**

DACO Tube Tester



Tests performance, leakage and shorts in ALL receiving tubes, even sub-miniature and acorn, PLUS provision for tubes that may be invented. Durable construction is fully shielded; dust-proof case, high-visibility meter, illuminated chart; no books or charts to be misplaced. Simple, fast operation with positive contact slide-switches; tests EVERY tube element. 110 volt AC. 16½" x 14½". MA-2193 .... **$29.50**

PORTABLE DACO TUBE TESTER

Same construction and operating features as counter model. Enclosed in sturdy case with durable black leatherette covering. 12¾" x 12⅓". MA-2194.......... **$32.50**

FM and HAM ANTENNA

AN-104-B. ¼-wave at 100-156 MC; formerly used with SCR-522, 274-N, ARC-5. A pair make an excellent broad-band dipole for FM reception. Coaxial connector in base. Very sturdy; use anywhere. MA-2153.......... **39c**

Special Filament Transformer

115-volt, 60 cycle primary; 3 secondaries: 2.5V-10 amp, 6.3 VCT-5.5 amp, and 6.3VCT-1 amp. Hermetically sealed for long life; insulation tested at 5000 volts. Porcelain insulated connector lugs. MA-2066.......... **$2.95**

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DYNAMOTORS
400 CYCLE INVERTERS
AMPLIDYNES
SYNCHROS

MOTOR GENERATORS

Brand New War Surplus Machines built by Allis Chalmers Co. to U. S. Navy Specifications.

Input: 115 V. D.C. at 14 amps., 3600 rpm. Output: 120 V. A.C., 60 CY, 1 ph. at 10.4 amps., 1000 Watts continuous duty. Ball bearings. Splashproof. Fully enclosed. Centrifugal starter. Frequency adjustable to load. **Price $87.50**

Same machine but for 230 V. D.C. input, **Price $125.00**

Spare parts kit with extra brushes, brush-holders, field coils, bearings, etc., for either machine, **Price $29.50**

DYNAMOTORS—500 Watts Type CAJO-211444

Input: 105-130 Volts D.C., 6 amps. Output: 13 or 26 Volts D.C. (26 V. at 20 amps. in series or 13 V. at 40 amps. in parallel) Designed for radio use, fully R.F. filtered, complete with separate line switch, etc. *Brand new in original crates,* **Price $59.50**

INVERTERS—400 Cycle Pioneer Type 12123-1A Pioneer Type 12121

Pioneer Type 12123-1-A.
Input: 24 volts D.C., 12 Amps.
Output: 115 volts, 0.5 Amps., 400 cycle, 3ph. **Price $49.50**
Pioneer Type 12121. **Price $59.50**

G. E. AMPLIDYNES

Input: 110 volts, 60 cycles, Single Phase.
Output: 250 volts, 0.6 amps. **Price $89.50**

SYNCHROS (Selsyns, Antosyns, etc.)

G.E. types 2J5FB1, 2J5S1. Ford Inst. types 5SDG Bendix types 1-1, 11-2, X, CAL 18300 Electrolux type XXI Diehl type 1V, 78414. Navy ordnance types 5F, 5G, 5CT, 5DG, 1F, 1CT, and many other types in stock.

Prices f.o.b. Tuckahoe, New York
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Immediate Delivery

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SURPLUS TEST EQUIPMENT

General Radio: 670F, 732B, 805A, 619E, ten 583A, as is, $40 each.
Ferris: 18B, 18C, 18D, 33A
Measurements: 62, 71, 75, 84
BoontoN: 150A; one 160A, one 170A, used, at list price.
RCA: 709A, MI-18720 Microwave Sig Gen (800-1200mc.)
Weston: 772 Analyzers, new; D. C. Relays
One complete television synchronizing generator, monoscope camera, distribution amplifiers, and auxiliary signal source equipment for RF carrier picture alignment.

VILLAGE RADIO EQUIPMENT CO.
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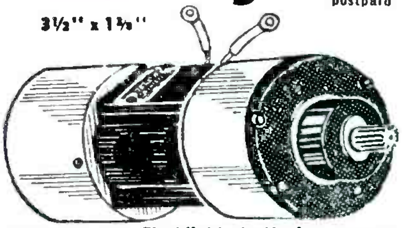
At last: a synchronous Alnico Field reversible D.C. motor which will run over ONE WEEK on a 6 volt flashlight battery. Geared down to ½ rev. per minute. Mounted with two G.E. Switchettes and a relay. Fuse holder and extra fuse, two Bristol wrenches to change timing cams, two 220 ohm resistors furnished to run on 12 or 24 volts. Only 500 available.

$5.50 postpaid

3½" x 1⅞"



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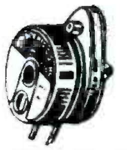

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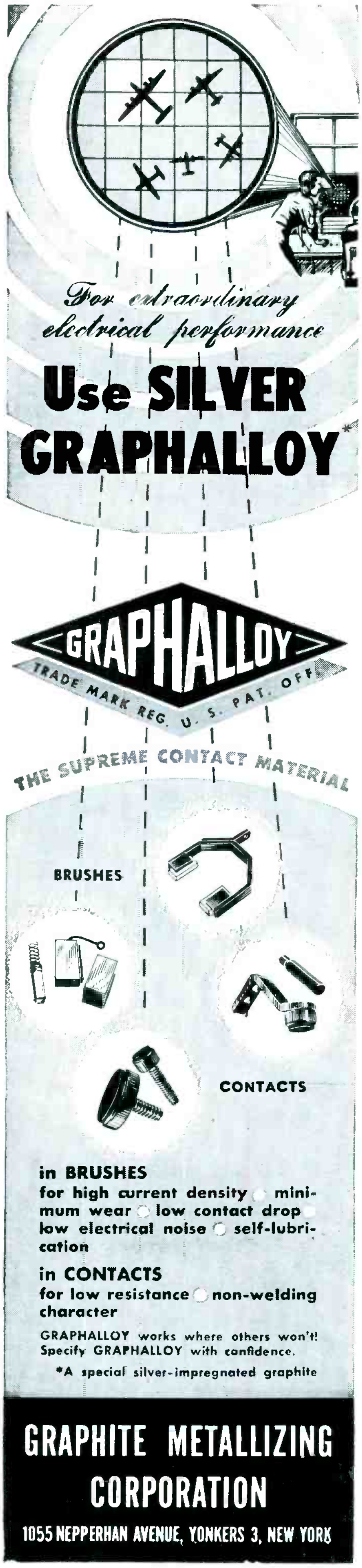

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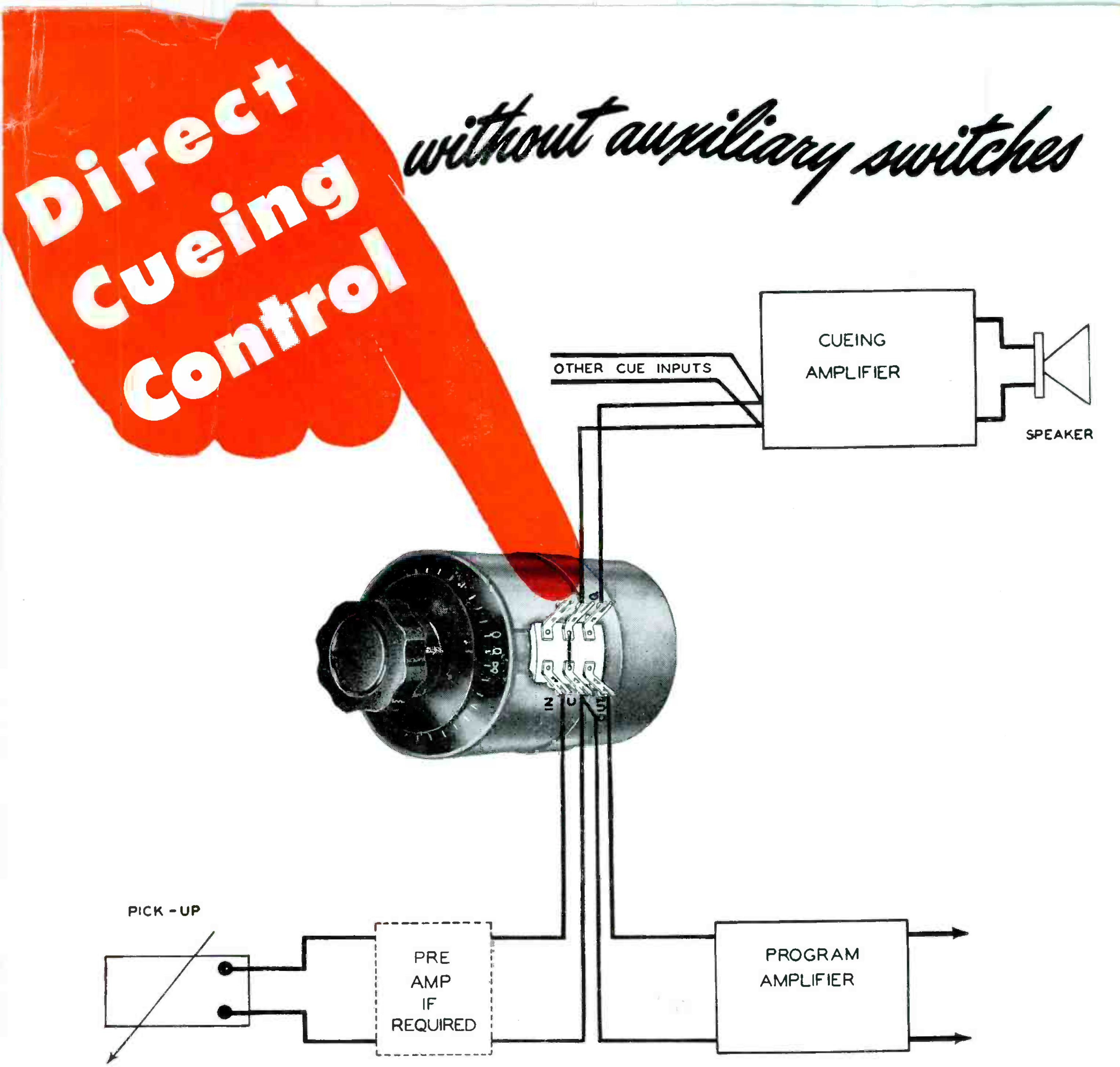

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Minimum life—10,000 hours!

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As contrasted with their receiving-tube counterparts, RCA Special Red Tubes feature vastly improved life, stability, uniformity, and resistance to vibration and impact. Their unique structural design makes them capable of withstanding shocks of 100 g for extended periods. Rigid processing and inspection controls provide these tubes with a minimum life of 10,000 hours when they are operated within their specified ratings. Extreme care in manufacturing combined with precision designs account for their unusually close electrical tolerances.

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