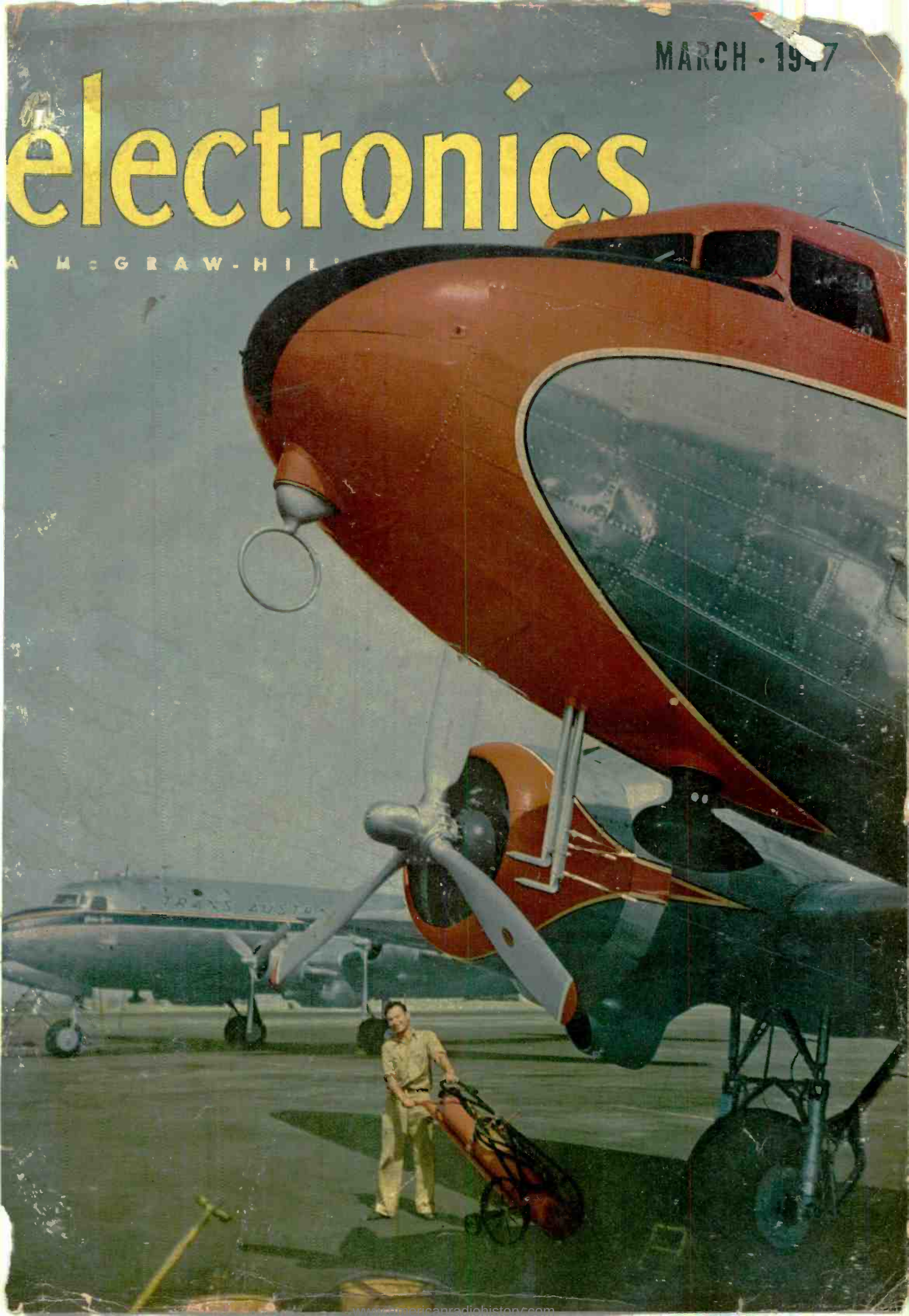
MARCH · 1947

electronics

A McGRAW-HILL



FOR SPECIAL TRANSFORMERS

It is significant that, on the whole, difficult transformer jobs find their way to UTC. A few recent illustrations of accomplishment through engineering ingenuity are shown below.

This transformer was designed for laboratory apparatus requiring a frequency range previously unheard of . . . flat within 2 DB 2 cycles to 20,000 cycles, this unit handles 25 watts output.

A manufacturer had the problem of changing his equipment from 400 cycle to 60 cycle power supply, but discovered that 60 cycle transformers are twice as large. UTC developed a unit, hermetically sealed, that fit his existing chassis, eliminating the need for a complete rebuilding of the equipment.

Narrow band filters are a common requirement for multiple channel telecontrol purposes. To effect a maximum number of channels in the audio range, filters made by UTC employ toroid high Q coils of unique structure. A typical special filter with 1500 cycle pass band is down 40DB at 1400 and 1600 cycles.

Low power 115 volt appliances such as electric razors, fluorescent desk lamps, etc. are sometimes required to operate on 220 volts. For simplicity of installation in the application of one manufacturer, a 15 watt plug-in unit was developed incorporating both plug and receptacle.

The UTC engineering department is available for consultation on your design problem

United Transformer Corp.

150 VARICK STREET • NEW YORK 13, N. Y

EXPORT DIVISION: 13 EAST 40th STREET. NEW YORK 16, N. Y., CABLES: "ARLAB"

electronics

McGRAW-HILL PUBLICATION

MARCH • 1947

FLYING SKYWIRES .....
Douglas DC3 aircraft for executives, showing just a few of its many antennas for communicati

FCC VIEWS TELEVISION ADVANCES .....
Color vs black-and-white contest sharpens as industry demonstrates competing equipment

HEATING WITH MICROWAVES, by J. Marcum and T. P. Kinn .....
Methods of utilizing waveguides for applying energy to moving or stationary materials

UHF TELEVISION RELAY SYSTEM, by Wilson Boothroyd .....
F-M equipment operating on 1,350 mc is useful for inter city multiple relay work or studio-transmit

PRODUCTION TESTING OF TACHOMETERS, by Herbert F. Storm .....
Power for the calibration of instruments at 21 test speeds is generated electronically

RADIO DISPATCHING FOR TAXICABS .....
Rates are reduced, income is increased and equipment costs are amortized rapidly

TELEMETERING FROM V-2 ROCKETS, by V. L. Heeren, C. H. Hoeppner, J. R. Kauke, S. Lichtman, P. R. Sh
Time-modulated pulse system in nose of rocket telemeters 23 readings to ground over 1,000-mc radio link

SUBMINIATURE ELECTROMETER TUBE, by C. D. Gould .....
Tetrode having very high input resistance is used in portable x-ray radiometer

TIMER FOR DIECASTING MACHINE, by Gerald DeLong 110
Cooling of metal in 25 molding machines is controlled by simple electronic circuit

EXPERIMENTAL C-R TUBES FOR TELEVISION 112
Greater screen brightness, all-electronic color tube, and optical relaying developments

ULTRASONIC GARAGE-DOOR OPENER, by Boley A. Andrews 116
Inaudible vacuum-type whistle on car actuates crystal microphone feeding amplifier and relay in motor circuit

F-M CYCLOTRON 119
World's largest cyclotron accelerates electrons to nearly the speed of light

PREDETERMINED COUNTERS, by John J. Wild 120
Switches insert predetermined starting count as required for industrial counting, batching, timing, and totalizing

PULSE-MODULATED OSCILLATOR, by Allan Easton 124
Circuit for generating sweep-calibrating and marking signals of uniform amplitude

STABLE VOLTMETER, by R. W. Gilbert 130
By means of a compound feedback circuit, stability is obtained in a conductively coupled instrument

WAVELENGTHS OF SOUND (Reference Sheet), by Bertha M. Henvis 134
Tables and simple nomograph give wavelength in common mediums at any sonic or ultrasonic frequency

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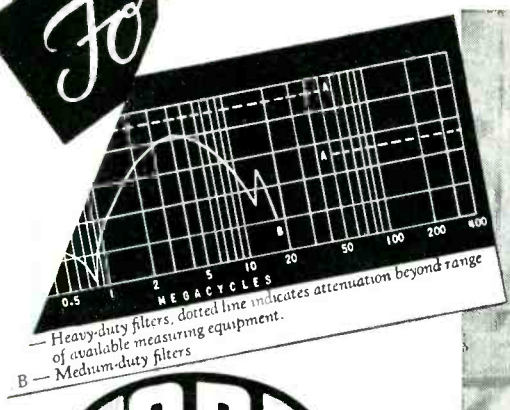
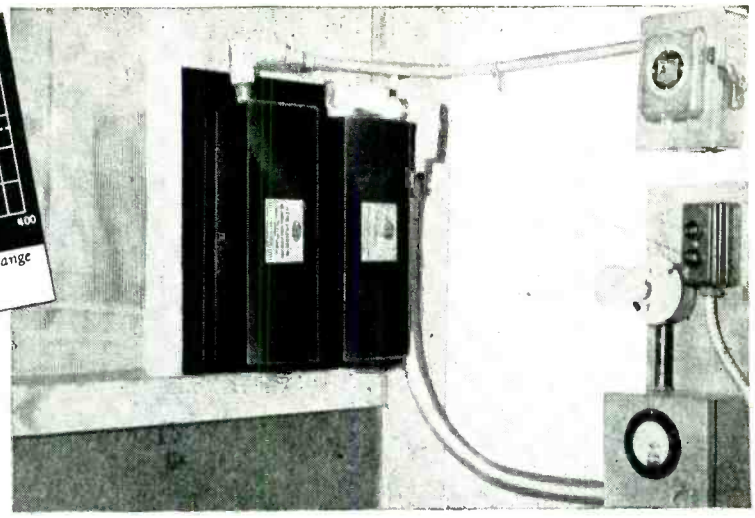
For RADIO-SILENT *Test Rooms*



A — Heavy-duty filters, dotted line indicates attenuation beyond range of available measuring equipment.
B — Medium-duty filters

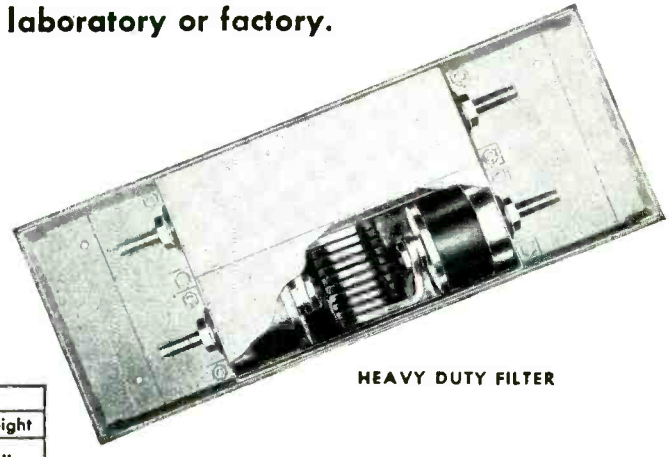


TOBE

Screen Booth Filters

isolate test rooms in laboratory or factory.

Installed where the electric power service passes through the screen, these Filterettes provide high attenuation from 150 kc to 400 mc, thus permitting operation of sensitive high-frequency test apparatus in close proximity to electric production equipment, welding generators, repulsion motors, and high-frequency induction heating equipment.



HEAVY DUTY FILTER

SPECIFICATIONS

HEAVY DUTY FILTERS					
Type	Amperes	Volts	Volt. Drop	Freq. Range	Weight
Two Wire	100	500 a-c/d-c	.2 volts per circuit	0.15 to 400 megacycles	40 lbs.
Three Wire	100	500 a-c/d-c	.2 volts per circuit	0.15 to 400 megacycles	65 lbs.
MEDIUM DUTY FILTERS (Two Wire)					
No. 1137	20	110/220 a-c 500 d-c	.5 volts per circuit	0.15 to 20 megacycles	17 lbs.
No. 1116	50	110/220 a-c 500 d-c	.5 volts per circuit	0.15 to 20 megacycles	17 lbs.

Widely used by government, college, and industrial laboratories, Tobe Screen Booth Filters will meet *your* need; Bulletin 472 E , free on request, gives additional data. For information about the complete line of Tobe Filterettes and Capacitors, ask for our general catalog.

Our specialists will advise on construction of screened test rooms and on filter installations.

Mechanical design and assembly conform to practical electrical installation requirements. Outer housings are of welded steel; knockouts at each end accommodate electrical conduits; heavy, threaded studs facilitate attachment of cable lugs.

These units employ non-inductive, mineral-oil impregnated capacitors; the inductors, of large cross section, have low series resistance, hence voltage drop is negligible. Overload ratings are: 150% of ampere rating for one hour; 200% of voltage rating for one minute.

Tobe Screen Booth Filters are standard for the electronics industry; there are sizes for every requirement.

TOBE

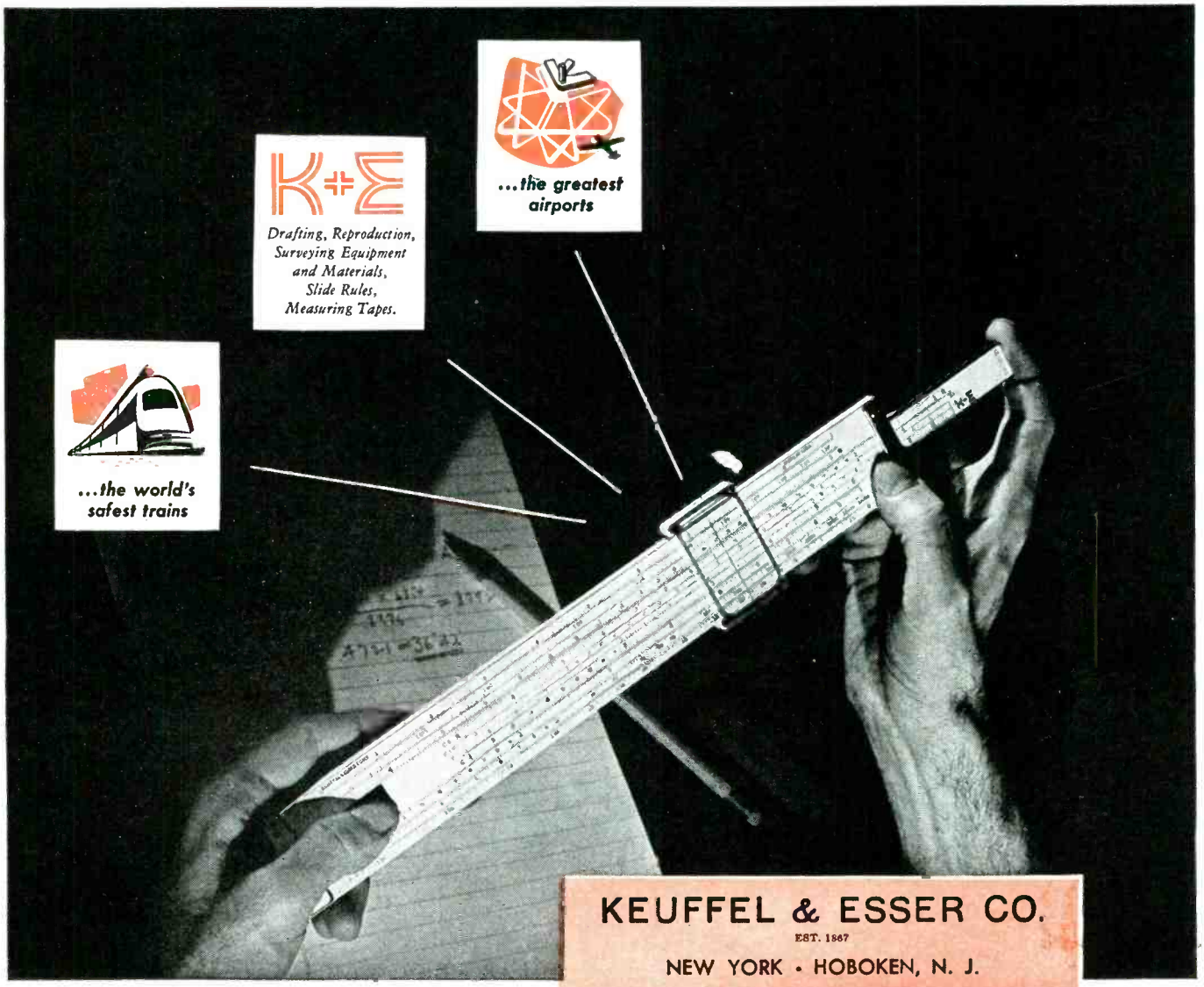
TOBE DEUTSCHMANN *Corporation* CANTON, MASSACHUSETTS

partners in creating

Many brilliant projects have been started with a K & E Slide Rule and the back of an old envelope. But between a new conception and its practical execution of the vital links are always the engineer and the draftsman. For through their techniques they construct the project on paper with unmistakable clarity and precision. In this their drafting instruments and equipment become part of their own hand and brain, and their partners in creating.

For 78 years Keuffel & Esser Co. Slide Rules, drafting equipment and materials have been partners in creating the greatness of America, in making possible our nationwide railway system, giant airports, fine radios for nearly every home . . . So universally is K & E equipment used, it is self-evident that every engineering project of any magnitude has been completed with the help of K & E. Could you wish any surer guidance than this in the selection of your own "engineering partners"?

In slide rules especially, you will find K & E precision invaluable. For it not only brings you a slide rule that is a joy to use, but it adds to your confidence in making every calculation. You will find Don Herold's booklet, "How To Choose A Slide Rule", amusing and very helpful. Write on your letterhead to Keuffel & Esser Co., Hoboken, N. J.



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THE 757A LOUDSPEAKER

IT'S tops for FM and AM Broadcasting—Recording Studios —High Quality Music Distribution and Public Address Systems.

It's breath-taking in its realism over the full frequency range of 60 to 15,000 cycles. It incorporates the famous 728B Loudspeaker and a new high frequency horn. See it at the I.R.E. Radio Show at Grand Central Palace, New York.

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Designed by Bell Telephone Laboratories

Western Electric

— QUALITY COUNTS —

Be sure you're right

with the HAMMARLUND FS·135·C

FREQUENCY STANDARD

Connect up the FS-135-C in your receiver and you have a first-class frequency meter all set to go. You will have the satisfaction of knowing you are obeying F.C.C. rules and you'll get accurate signals every 100 KC's to mark the band edges or make any other checks you want.

You will find the FS-135-C is a cinch to connect and it's so small it fits in any receiver. The ingenious circuit and a special crystal permit variation of the crystal frequency for zero beating with WWV. Once this adjustment is made you practically have a WWV junior built right in your receiver.

See the FS·135·C at your dealer's

HAMMARLUND

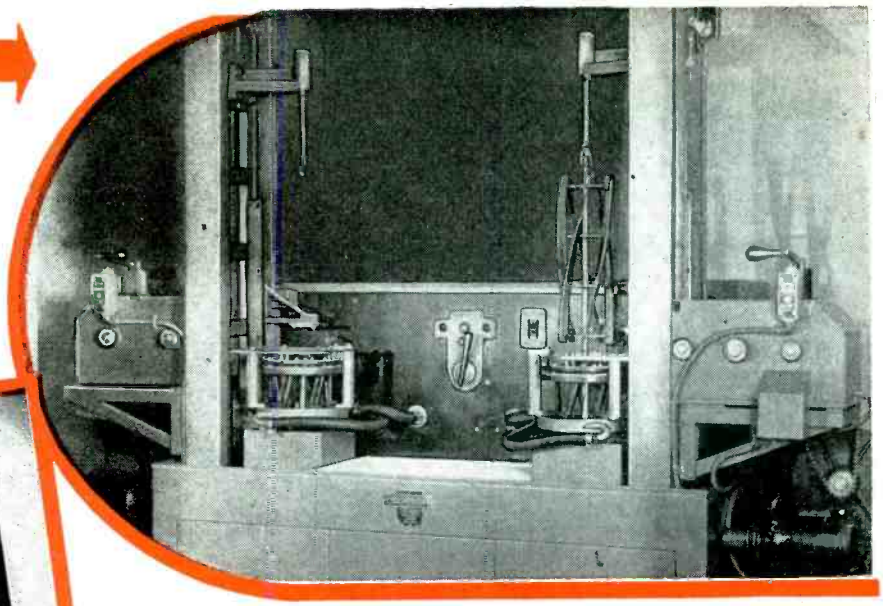
THE SIGN OF QUALITY — ESTABLISHED 1910

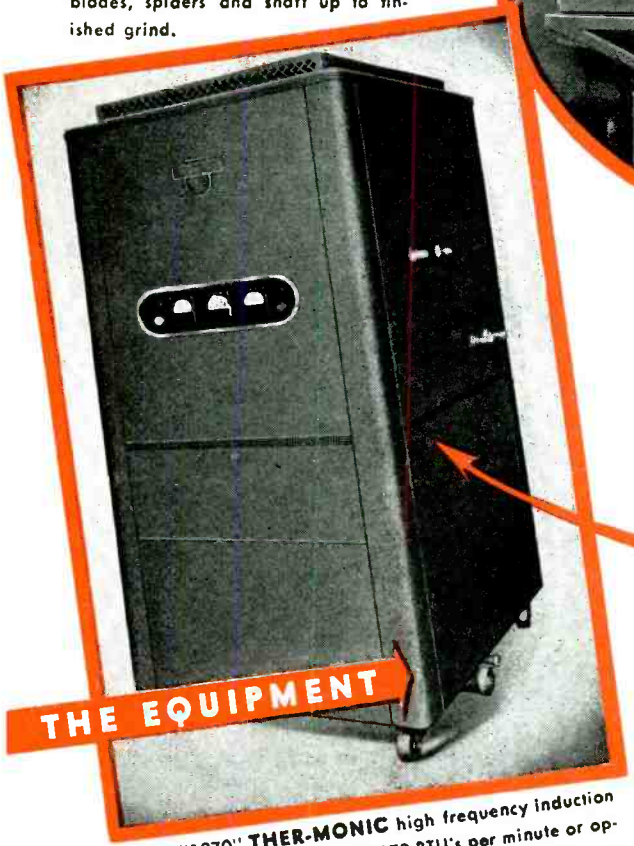
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., NEW YORK 1, N.Y.

MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

THE OPERATION

Induction hardening of 17" five-blade lawn mower reel assemblies at **REO MOTORS INC.**, Lansing, Michigan. Discarded method: 15 per hour. New method: one a minute or 300% gain in production. Problems of scale formation and warpage, formerly costly and unpredictable, now negligible. Additional savings in other departments such as complete assembly of blades, spiders and shaft up to finished grind.

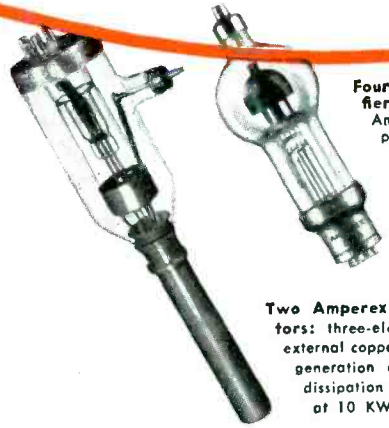




THE EQUIPMENT

Model "1070" **THER-MONIC** high frequency induction generator with an output of 1070 BTU's per minute or approximately 20 KW at a frequency of 375,000 cycles per second. A two-position automatic work table, with simple press-the-button control, speeds the work. All equipment designed and manufactured by **INDUCTION HEATING CORPORATION, NEW YORK 3, N. Y.**

THE AMPEREX TUBES THAT DO THE JOB!



Four Amperex TYPE 575A Rectifiers: Mercury Vapor, High Voltage. An original Amperex contribution particularly noted for reliability and long life. Peak inverse voltage, rating, 15,000; Plate current rating, 1.5 Amps.

Two Amperex TYPE 892 Oscillators: three-electrode, water-cooled external copper anode; standard for generation of HF power. Anode dissipation conservatively rated at 10 KW.

Induction heating may be the answer to your hardening, brazing, melting, forging and annealing problems. In induction heating as in all industrial, communication, rectification, electro-medical, special purpose and experimental equipment, AMPEREX TUBES are vital for performance, long life and economy. As tube specialists concerned with all electronic developments Amperex engineers are in a position to give detached counsel and information.

Write Amperex Application Engineering Department

POWER TUBE SPECIALISTS SINCE 1925

COMMUNICATION
RECTIFICATION
INDUSTRIAL
ELECTRO-MEDICAL
SPECIAL PURPOSE

AMPEREX

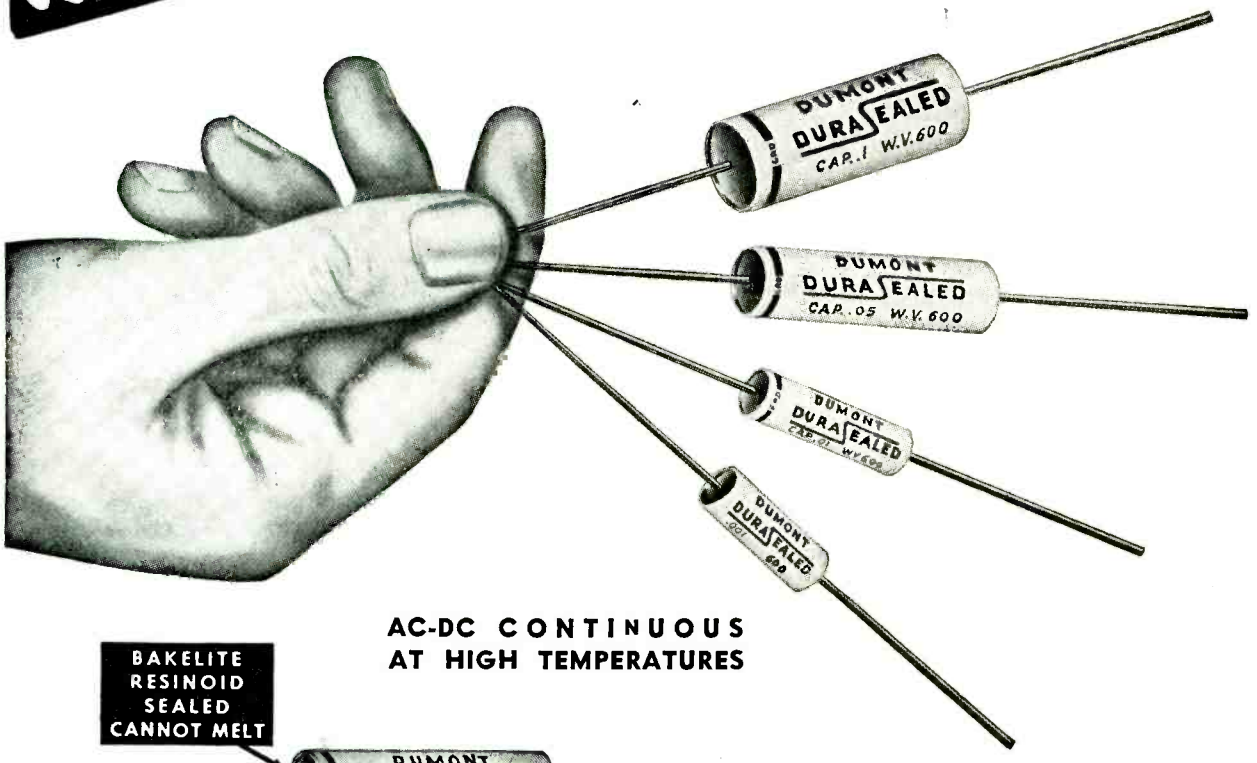
AMPEREX ELECTRONIC CORPORATION

25 WASHINGTON STREET, BROOKLYN 1, N. Y., CABLES: "ARLAB"

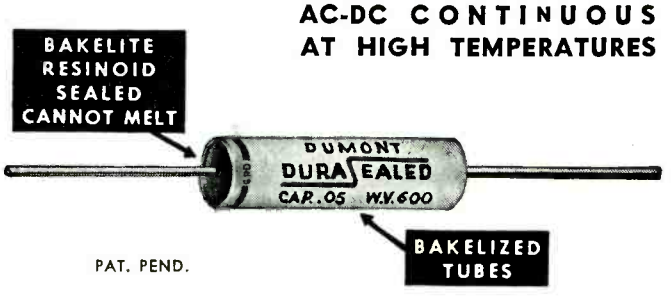
In Canada and Newfoundland: ROGERS MAJESTIC LIMITED, 622 Fleet Street West, Toronto 2B, Canada

AT LAST!

SPECIAL WARTIME DEVELOPMENT NOW AVAILABLE FOR PUBLIC USE . . . TYPE P6 DUMONT *PAPER* CAPACITORS



AC-DC CONTINUOUS AT HIGH TEMPERATURES



PAT. PEND.

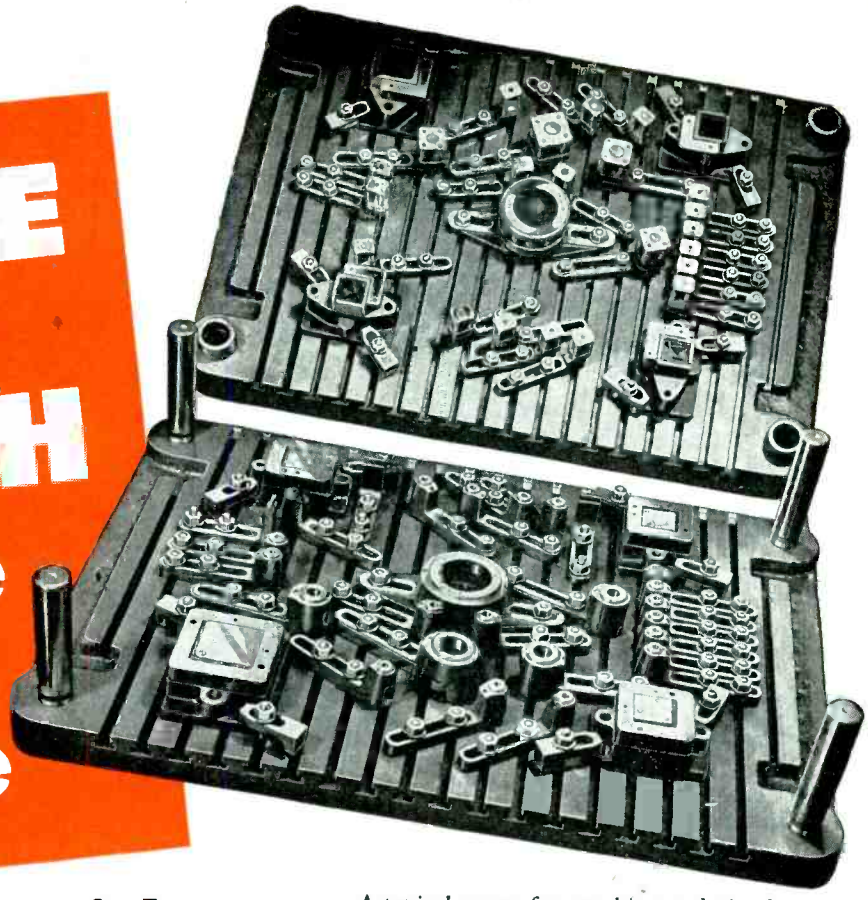
★ Dumont engineers scored in the greatest single achievement in paper tubular capacitors . . . meeting the most exacting requirements. This type P6 has the ends sealed in BAKELITE RESINOID. Leads cannot PULL OUT or MELT OUT. Bakelite treated tubes sealed in vacuum.

★ HEAT PROOF
★ MOISTURE PROOF
★ LONGER LIFE
★ VACUUM SEALED
★ SOLVES SPACE PROBLEMS

DUMONT ELECTRIC CORP.
MFR'S OF CAPACITORS FOR EVERY REQUIREMENT

34 HUBERT STREET NEW YORK, N. Y.

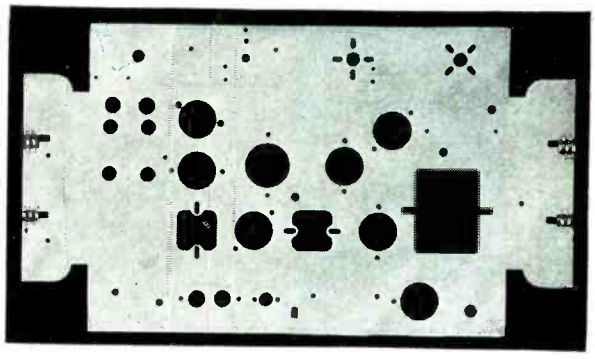
PIERCE and NOTCH at the same time



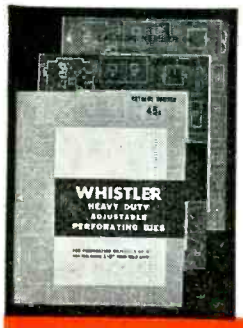
A typical set-up for notching and piercing.

with WHISTLER MULTI-USE Adjustable Dies

Pierced and notched with Whistler multi-use adjustable dies.



You save press time and speed production by combining corner notching dies and group dies in the same set-up with adjustable piercing dies. Press operations are reduced to a minimum. Engineering changes effecting relocation or sizes of holes can be made without delay right on the press.



Whistler multi-use adjustable dies are available from stock... a day or two from your plant ...in all standard sizes from 1/32" to 3" diameters...round, square, ovals and rectangles. Notching and group dies to order. In addition to mighty attractive savings in original die costs there is this important advantage of eliminating weeks of production delay.

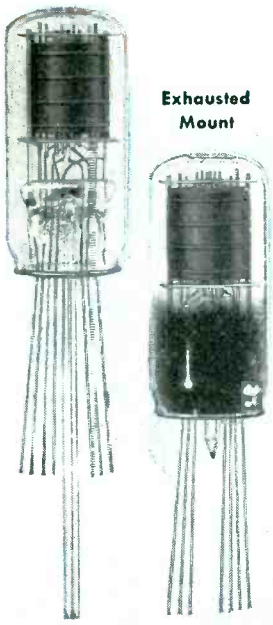
Re-arrange Whistler multi-use adjustable dies in as many different set-ups as your production calls for... you actually make up die sets from units in stock and reduce costs per job to an unbelievably low figure. All parts of like size are interchangeable.

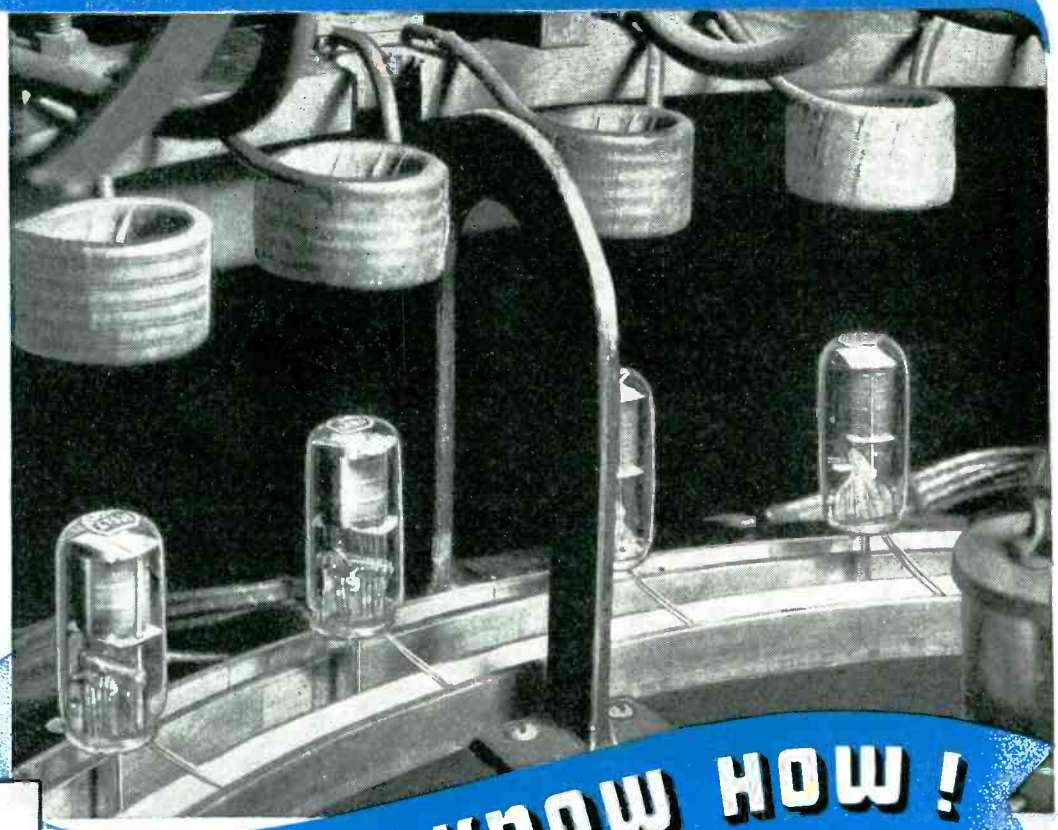
Get all the facts on how Whistler adjustable dies can speed *your* production... cut *your* costs. Write today for the Whistler Catalogs.

S. B. WHISTLER & SONS, Inc.
752-756 MILITARY ROAD BUFFALO 17, N. Y.

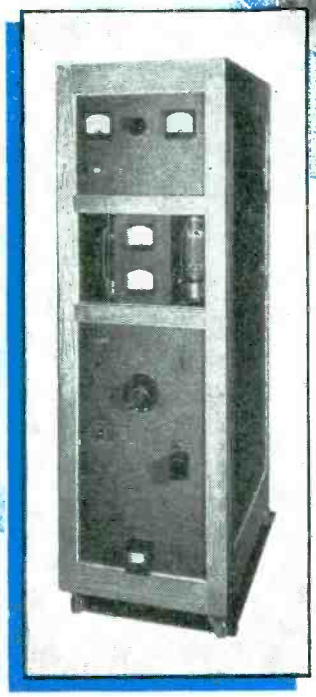
WHISTLER MULTI-USE ADJUSTABLE PERFORATING DIES

MAKING TUBES IS EASY..





If YOU KNOW HOW!



BIG TUBES MAKE LITTLE ONES

That's right. Big power tubes help build little receiving tubes. Secret of the electronic tube is its ability to pass a controlled stream of electrons through a vacuum. During the intricate exhaust process, electronic induction heating assists in creating that vacuum.

The induction heater (small illustration) is a 750-kilocycle, 6-tube, 10-kilowatt power oscillator whose tank coil is coupled to the exhaust coils. Four of these coils poised over Hytron 12SA7GT sealed-in mounts are caught by the camera a split second before the exhaust machine automatically positions them around the mounts.

High frequency current in the coils quickly heats red hot by induction the internal metal parts of the mounts. Gas driven off is sucked through the exhaust tube of each mount by the vacuum pumps. Heater leads riding in the two circular tracks supply filament power to activate each cathode. Also by induction heating, "getters" are flashed to absorb residual gasses. Fingers of gas flame finally melt and seal off the exhaust tubes.

An intricate machine—assisted by electronics itself—performs the ticklish exhaust job easily, speedily. Again know-how supplants the element of human error with the infallibility of the machine. Machine-paced, a sequence of finely-controlled precision operations gives you Hytron tubes of typically uniform quality.

SPECIALISTS IN RADIO RECEIVING TUBES SINCE 1921

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS

Have you received your copy of the new, comprehensive Hytron Miniature Tube Reference Guide? If not, write for it today.

Knows how to solve 'Impossible' transformer problems

Here's a typical case. The head of a large manufacturing organization came to the K-V Transformer Company, presented his problem, gave his specifications to the K-V engineers, and left. Instantly the wheels were put into motion . . . a memo was circulated . . .

HERE'S THE ASSIGNMENT:

HERE ARE THE PROBLEMS IT POSED:

1. Less than 0.5 mu capacitance between windings
2. Minimum capacitance unbalance of the secondary to ground
3. Frequency response ± 1DB from 800 to 30,000 c.p.s.
4. Linear phase shift characteristic throughout frequency range
5. Leakage reactance of secondary sections to be balanced within 1%
6. Insertion loss less than 1.0DB
7. High permeability shielding

HERE'S THE SOLUTION:

This was all in a day's work at K-V Transformer Company! Every day we receive and solve similar problems. Perhaps we can help you. Our experience and ability is always at your service. We offer:

- ADVANCED ENGINEERING AT LOW COST
- MANUFACTURING KNOWLEDGE
- ELECTRICAL AND MECHANICAL STABILITY
- MODEL SHOP AND PRODUCTION FACILITIES
- RIGID INSPECTION AND QUALITY CONTROL
- SPEEDIER DELIVERY

TRANSFORMERS of TOMORROW

K-V TRANSFORMER CO.
356 EAST 88th ST. • NEW YORK 28, N. Y.

AUDIO COMPONENTS
WAVE FILTERS
MODULATION TRANSFORMERS
SHIELDED BRIDGE UNITS
PHASE SHIFT DEVICES
HIGH Q INDUCTORS
TELEVISION TRANSFORMERS
ELECTRO-MEDICAL UNITS

every electronics manufacturer

Look what it tells you about the practical core material—Carbonyl Iron Powder

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Microphotographs of Carbonyl Iron Powder
Properties of Carbonyl Iron Powders
Chemical Composition
Particle Size and Density
Electro Magnetic Constants
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- b. core density
- c. iron packing fraction

"HP" Carbonyl Iron Powder
- a. physical characteristics
- b. electro magnetic characteristics
- c. "Q" values

Carbonyl Iron Powders in High Frequency Cores
- a. relative "Q" values of 5 grades
- b. comparison with air-cored coils

Effective Permeability of High-Frequency Iron Cores
Types of Cores Made with Carbonyl Iron Powder
Carbonyl Iron Powders in Powder Metallurgy
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how to get maximum stability

what powder is best for inductance tuning?

how to save up to 60% on coil winding wire

how to get coil "Q" values 170% higher than in air-cored coils

where Carbonyl Iron Powders are used

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Please send me a free copy of "G.A.&F. Carbonyl Iron Powders."

Name _____

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NOTE: If you visit the Institute of Radio Engineers show at Grand Central Palace in New York, March 3-6, you are invited to stop at the G.A.&F. Carbonyl Iron Powder exhibit.

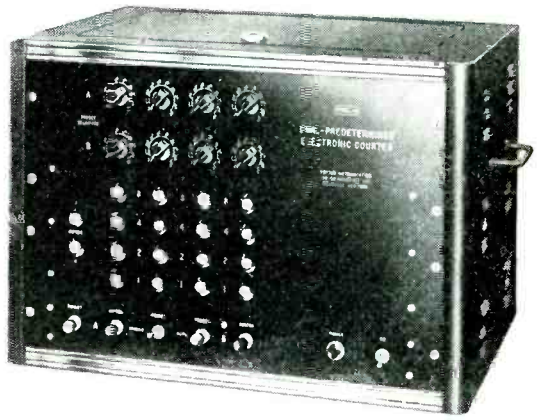
A POTTER ELECTRONIC COUNTER FOR EVERY

timing
control
counting
sorting
totalizing

NEED

COUNTERS AND SCALERS

For straight high-speed counting and frequency dividing i.e. radiation counting-machine operations



DUAL PREDETERMINED COUNTERS

For controlling two sequential operations at high rates i.e. zipper manufacture

SINGLE PREDETERMINED COUNTERS

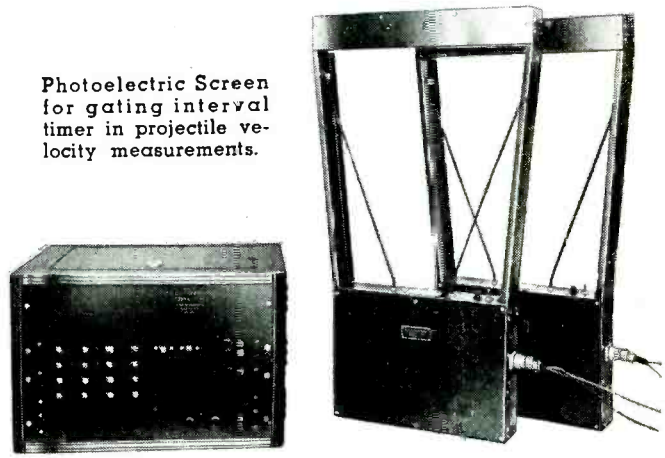
For high speed counting and grouping of items for processing or packaging i.e. packaging of pills, buttons, hardware, etc.

CHECK THESE IMPORTANT FEATURES!

- **Speed and Accuracy**
  Will count at rates up to a million per second with absolute accuracy.
- **Versatility**
  Can be used for measurement and control of discrete quantities, length, area, time, velocity and frequency. Can also be used to totalize counts from several sources occurring simultaneously and at random.
- **Flexibility**
  Readily substituted for slower inaccurate mechanical controls—adaptable to all types of input actuations. —Selection of any predetermined count made simply by dial switches. Easy to install and operate.
- **Reliability**
  Sturdy construction using simple straight forward reliable circuits and high quality components. Assures maximum trouble free continuous operation. — No moving parts to wear out —

If you have a specific application problem or wish additional information on Potter Electronic Counter Circuits, write Potter Instrument Company, Dept. 6A.

Photoelectric Screen for gating interval timer in projectile velocity measurements.

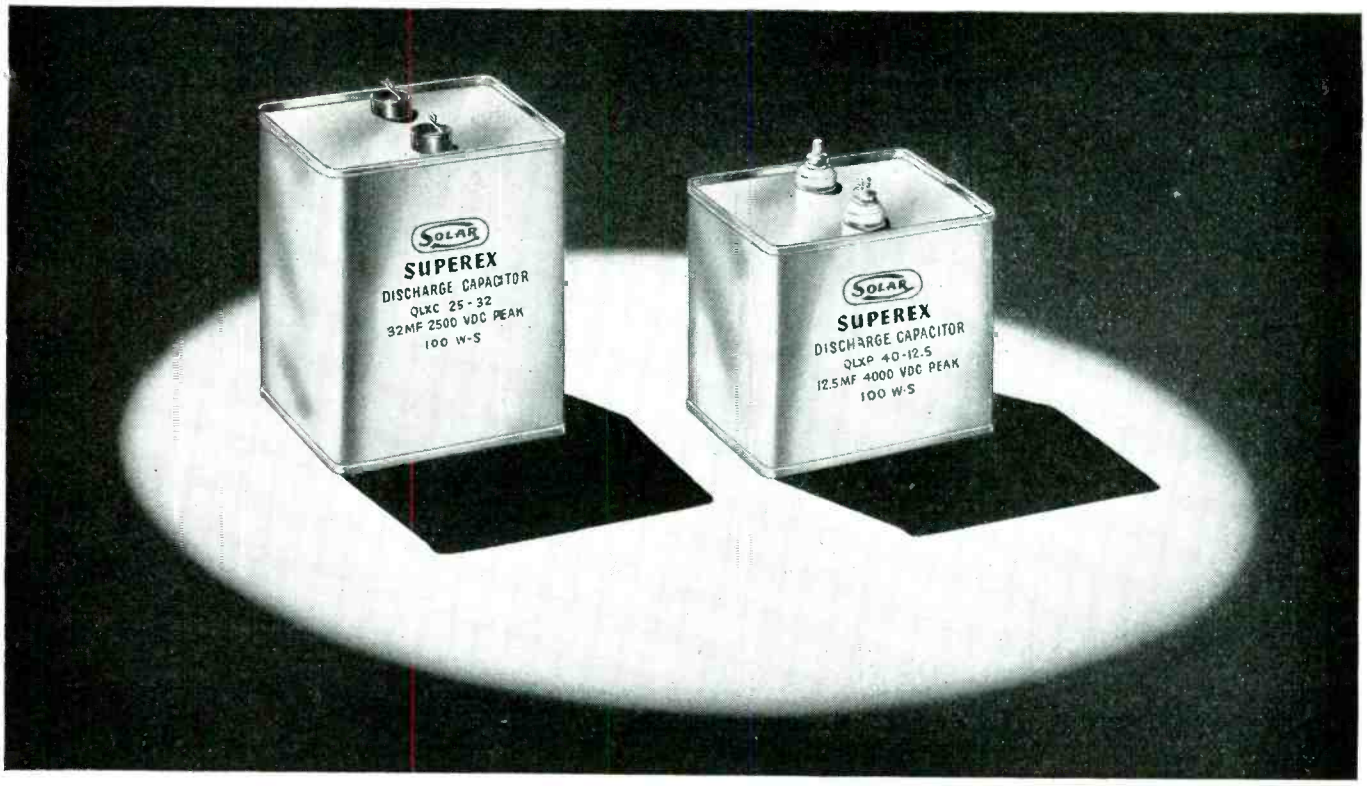


INTERVAL TIMERS

For measuring or predetermining intervals with micro-second accuracy i.e. projectile velocities-accurate time base generator.

INSTRUMENT Potter COMPANY

POTTER INSTRUMENT COMPANY • 136-56 ROOSEVELT AVENUE • FLUSHING, N. Y.



STOREHOUSES . . .
for BOTTLED LIGHTNING

Check these advantages of* SUPEREX* *Discharge Capacitors

- ✓ RATED FOR DEPENDABILITY
- ✓ **EXCELLENT ENERGY-STORAGE TO WEIGHT RATIO**
- ✓ **BUILT FOR THE APPLICATION**
  Short, heavy, internal leads
  Low inherent inductance
  Special construction to minimize discharge stresses
- ✓ **RELIABLE HERMETIC SEALS**
- ✓ **CORROSION-RESISTANT GRAY LACQUER FINISH OVER HEAVY-GAGE TERNEPLATE CONTAINERS**

Man-made lightning flashes for high-speed photography, display signs, traffic and marine beacons, airport signals, and a host of other electronic pulsed lighting applications, all have their heart in the discharge of capacitor-stored energy through a flashtube.

Pulsed lighting, capacitor-discharge welding, and all other energy-storage applications where dependability is a must are the fields in which Solar **SUPEREX*** Discharge Capacitors stand supreme.

You'll find preferred listings, with dimensions, complete rating information and a handy watt-second—microfarad—voltage chart in Bulletin SPD-300. Write for it today.

Solar Manufacturing Corporation
285 Madison Avenue, New York 17, N. Y.

★ *Trade Mark*

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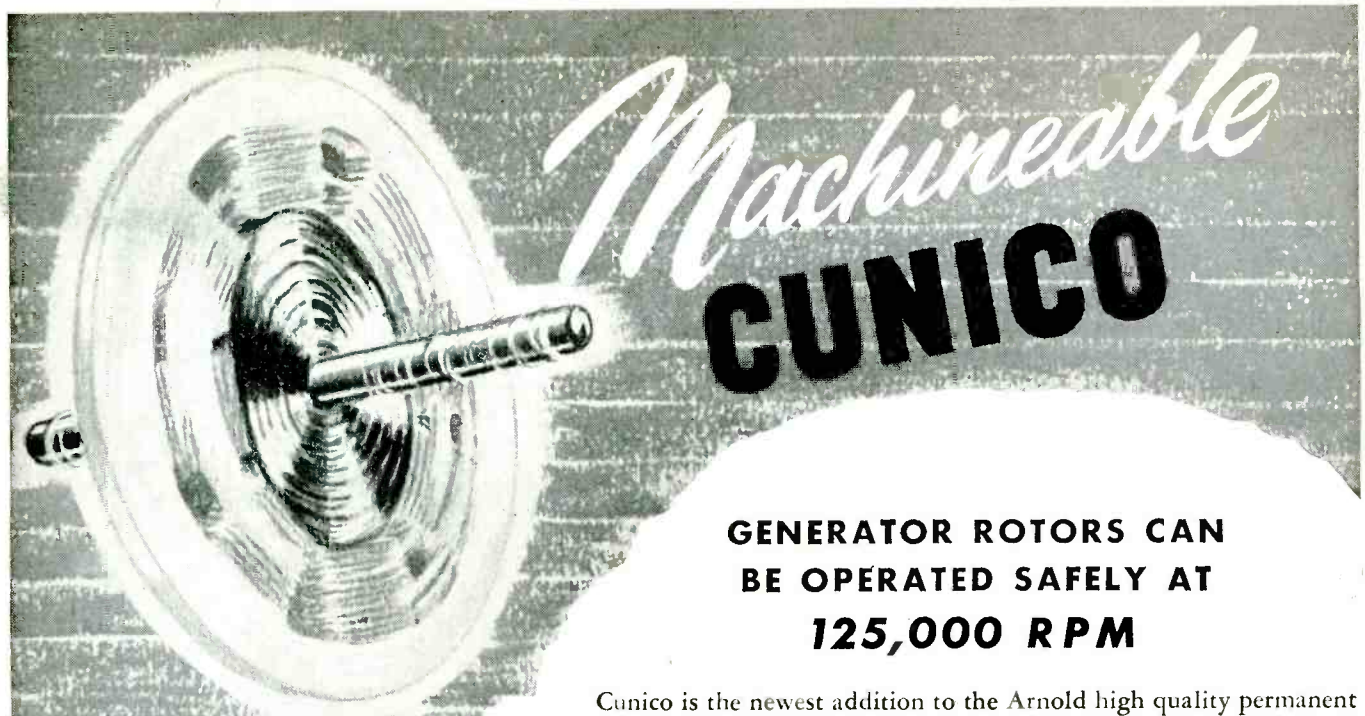
"Quality Above All"

SOLAR

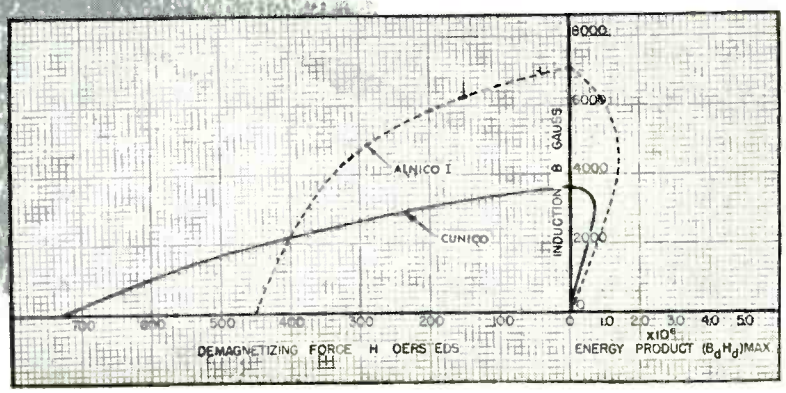


Machineable CUNICO

GENERATOR ROTORS CAN BE OPERATED SAFELY AT *125,000 RPM*

Cunico is the newest addition to the Arnold high quality permanent magnet line. It is a copper nickel cobalt alloy which has very high coercive force. Ductile, machineable and malleable, Cunico can be fabricated into a wide variety of simple and complex designs. Drawing, cutting, machining, punching and screw machine operations are practical.

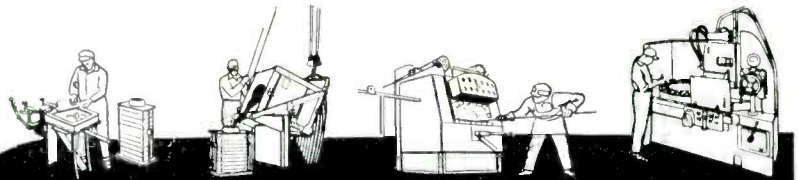
Cunico can be magnetized in any direction, and is most efficient where a large cross section is available to produce sufficient total flux. Generator rotors are a typical application. A relatively short length is required to maintain the flux because of its high coercive force.



CUNICO CAN BE PRODUCED IN THE FOLLOWING SHAPES AND APPROXIMATE SIZES:

BARS—¼" to 1" square
STRIPS—2" maximum width x .015" to .312" thickness
RODS—¼" to 1" in diameter
WIRE—No. 2 to No. 24 AWG sizes
CASTINGS—Maximum section 1" thick

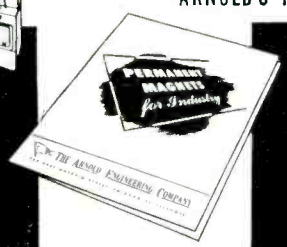
Write today for details.



THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS
Specialists in the manufacture of ALNICO PERMANENT MAGNETS

ARNOLD'S TECHNICAL BULLETIN



"Permanent Magnets for Industry" suggests many ways in which the war-born improvements in permanent magnets can be most valuable to you. Send for it!

The Sun Oil Company invites immediate inquiries on two new, high quality microcrystalline waxes—SUNWAX 1290 Brown and SUNWAX 1290 Yellow.

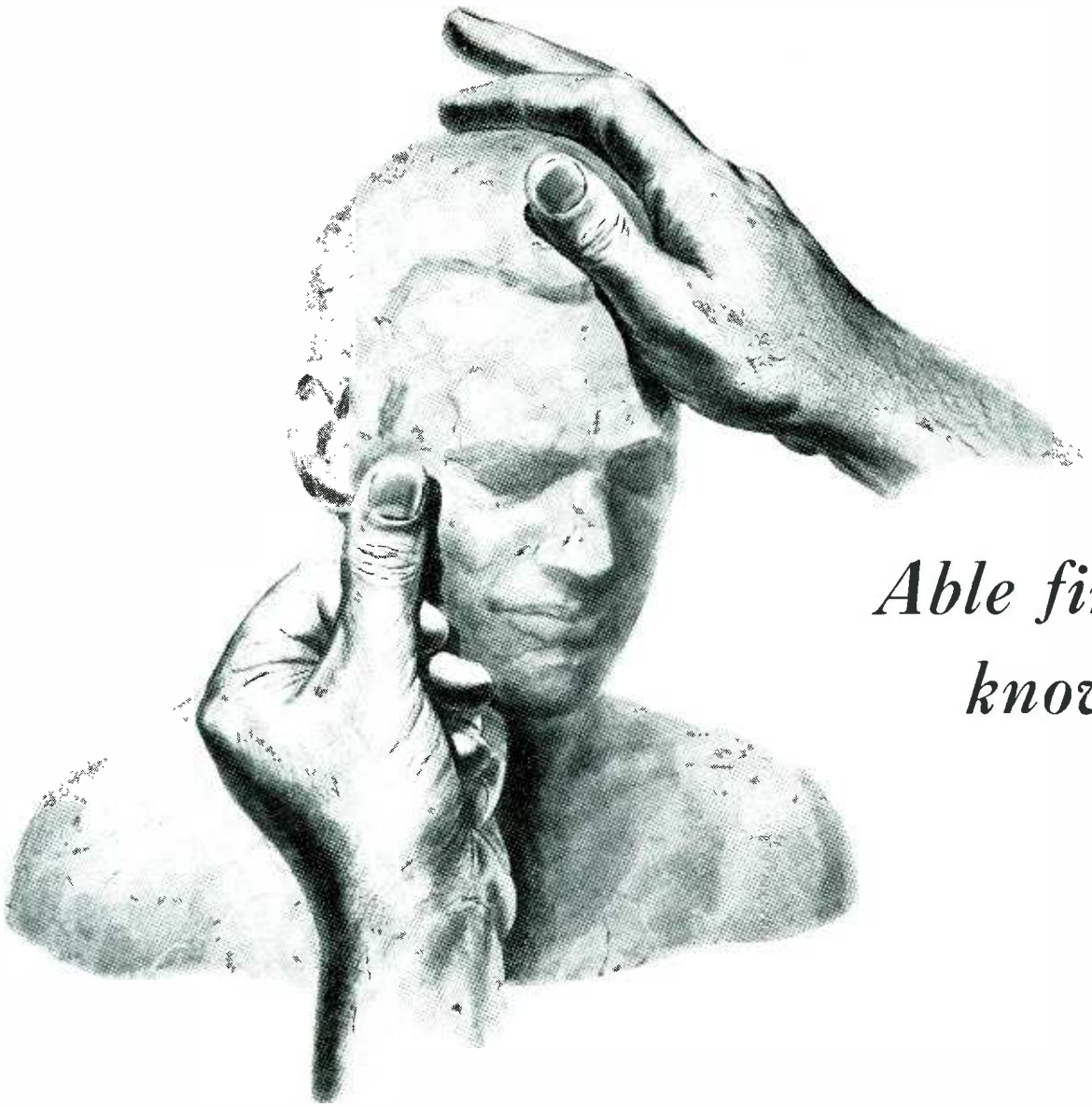
These new Sun waxes were developed for use in the paper-impregnation, packaging, electrical, electronic, paint and chemical industries . . . wherever resiliency, high melting point, and high resistance to shock or shattering are required. They are tenacious and uniform in physical characteristics. Approximate specifications for both types are:

MELTING POINT (ASTM D127-30)—175°-185°F.

PENETRATION (ASTM D5-25)—15 MAX.

For full information call your nearest Sun office or write Dept. CE3, Sun Oil Company, Philadelphia 3, Pa.

SUNOCO **SUN INDUSTRIAL PRODUCTS**



Able fingers know!

Like sculpture, draftsmanship is dependent upon the *right* medium in the right fingers—Typhonite Eldorado pencils put smoother, crisper lines in your drawings—leave professional satisfaction in your heart.

DIXON'S TYPHONITE

ELDORADO

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PENCIL SALES DEPT. 59-J-3, JOSEPH DIXON CRUCIBLE CO., JERSEY CITY 3, N. J.

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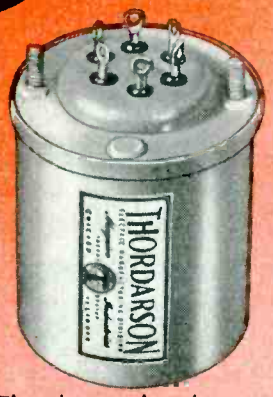
Transformers

A guarantee of Quality Performance Since 1895!



For over half a century Thordarson has been manufacturing the finest in transformer equipment. The oldest company in the field, it has pioneered many new developments, including the superior core and coil materials now used throughout its entire line. This vigorous policy of research and development, together with an unusually high standard of production, has made the name Thordarson a guarantee of quality . . . an assurance of trouble-free performance among engineers everywhere.

Thordarson's engineering staff and Thordarson's field men are prepared to assist you with your transformer problems. We are especially equipped to handle those types of transformers which require a high degree of engineering skill and which must be built to very rigid specifications. Send us complete details as to your requirements.

P. S. Deliveries aren't too bad these days, either!

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The clock on the studio wall and the important warning signal below it are two ever-present reminders on which radio broadcasting depends.

Today, approximately half the time this warning signal appears in the broadcasting stations throughout the country, the studio clock is measuring the time of transcribed programs. This large proportion of broadcast time devoted to recorded programs is a significant tribute to the advancement in the quality of sound recording and reproduction.

In this spectacular trend of broadcasting, AUDIODISCS have played a basic role. These recording discs are the ones most extensively used for instantaneous recording, for the original sound recording in making pressings and for the Master discs used in the electroplating process.

If it's worth recording—it's worthy of an AUDIODISC. See your local AUDIODISC distributor or write:

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Export Department: Rocke International Corp., 13 E. 40th Street, New York 16, N.Y.

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they speak for themselves audiodiscs

PUNCTURE PROOF

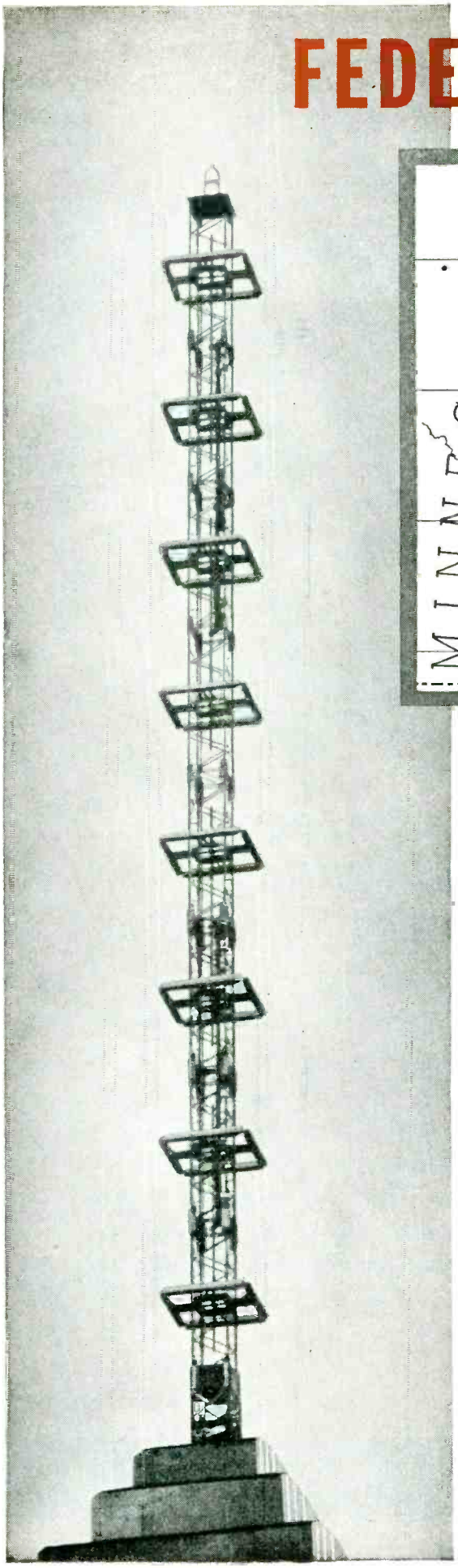
LAPP GAS-FILLED CONDENSER OFFERS NON-DETERIORATING, UNIFORM PERFORMANCE

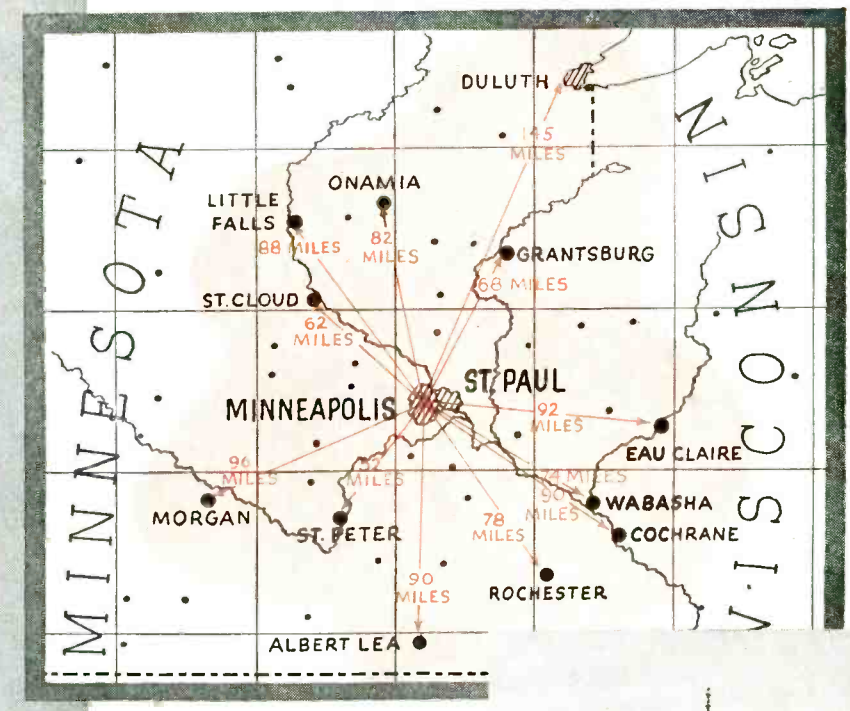
The dielectric of the Lapp condenser is an inert gas, non-deteriorating and puncture proof. After years of service, the condenser retains the same margin of security it had when installed in the circuit. Also, it offers lower loss than solid-dielectric units, with corresponding economy of power. Not needing to "warm up," it provides constant capacitance under temperature variation. Variable, adjustable and fixed capacitance units are available, in current ratings up to 500 amperes R.M.S., and voltage ratings up to 60 Kv peak. Fixed units have been made with capacitance up to 60,000 mmf., variable and adjustable units up to 16,000 mmf.

Lapp

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

FEDERAL'S 8-ELEMENT





A survey of surrounding cities indicates a radiation pattern approximately as shown by the shaded area above. Listeners almost 150 miles away reported excellent volume and clarity of reception. The remarkable coverage is due to the power gain of Federal's Square-Loop Antenna. The clarity and tone quality is made possible by the exceptional fidelity and mean carrier stability of Federal's "Frequematic"* Modulator — an exclusive feature of every Federal FM transmitter.

*Trade Mark

Federal's 8-Element Square-Loop Antenna dominates the Minneapolis skyline from the top of the Foshay Tower — highest building in the Northwest. Ruggedly constructed to withstand heavy winds and icing loads, this 80-foot antenna has already proved its dependability in temperatures down to 22 degrees below zero!

Federal Telephone

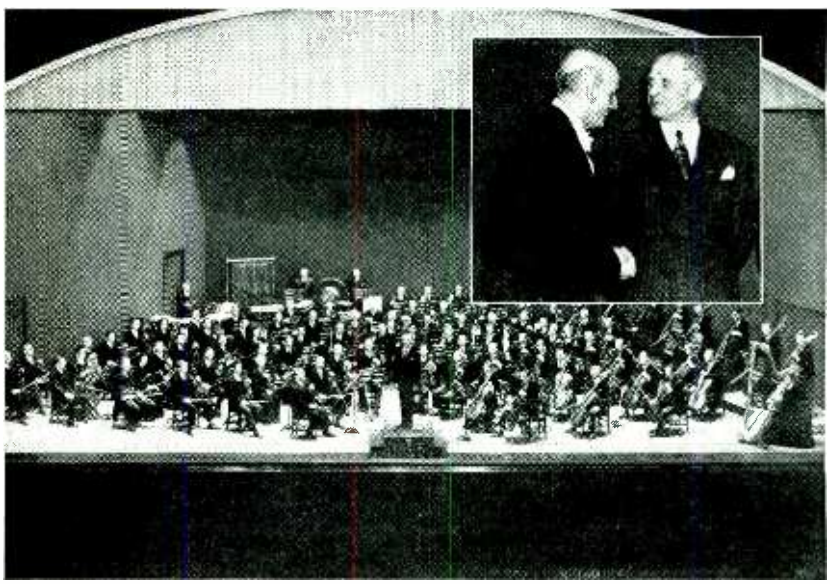
In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N.Y.C.

SQUARE-LOOP FM ANTENNA MAKES WORLD DEBUT!

WTCN-FM, Minneapolis, goes on the air with most efficient FM Antenna installed anywhere . . . boosts 3kw transmitter to 25kw . . . with coverage of 30,000 square miles

FEDERAL'S 8-Element Square-Loop Antenna made radio history with the opening of the Twin Cities FM station, WTCN — the first super-directive antenna of its type and power gain to be installed anywhere. It gives the 3kw Federal transmitter an effective radiated power of 25kw — providing excellent reception over an area of approximately 30,000 square miles. This makes WTCN the world's *most efficient* FM station—and, with an FCC permit for an output of 400kw, it will eventually be one of the country's *most powerful* stations, too. With Federal's high-gain antenna, this maximum rating of 400kw can be achieved with the installation of only a 50kw transmitter!

WTCN is among the FM stations with permits for the most powerful ratings in the country. Others are KWK, St. Louis, with 369kw — and WTMJ, Milwaukee, with 349kw. These three stations have *all* selected *FM by Federal!* And Federal can equip your new FM station, too — from microphone to antenna. Write today for complete information. Dept. B313.



Station WTCN was officially opened by a gala inaugural program featuring the Minneapolis Symphony Orchestra, Dimitri Mitropoulos conducting. With FM by Federal, listeners at home were enabled to hear this famous orchestra with the same brilliance and tonal color as the studio audience. Insert shows Mr. Mitropoulos and Governor Luther W. Youngdahl of Minnesota, at opening of ceremonies.

"Wonderful! Magnificent! A terrific step of progress." This was the comment of the famed conductor, Dimitri Mitropoulos, when he heard his own orchestra over an FM receiver, during an on-the-air rehearsal.

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MITCHELL-RAND in its improvement of Varnished Tubings, took as its starting point the specifications established by the Varnished Tubing Association and the Society for Testing Materials . . . and today produces Varnished Tubings that meet or exceed the known specifications for Dielectric, Tensile Strength, Flexibility, Non-Fraying, High Gloss, Non-Hydroscopic, Resistance to High Temperatures, Oils, Fats, Acids, etc.

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M-R FIBERGLAS *(INORGANIC)* VARNISHED TUBINGS are made in four grades: Standard; Double Saturated; Triple Strength and Impregnated.

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TRIPLE STRENGTH is built up with coats of especially flexible insulation varnish for dielectric ratings up to 2500 volts and is particularly suited where assembly operations include the possibility of rough handling.

IMPREGNATED is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 7000 volts and is unequalled for Long Life Under Most Severe Conditions. *Write For Samples.*

FOR USERS OF COTTON YARN VARNISHED TUBINGS The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fiber yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life. *Write For Samples.*

Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drills, etc.

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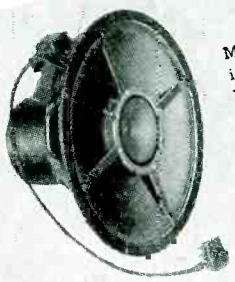
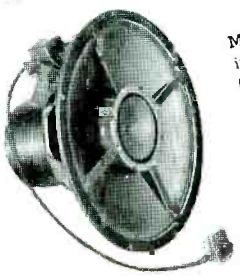
8 REPRODUCERS
3 BASS REFLEX* CABINETS

COAXIAL SPEAKERS

MODEL HNP-51 COAXIAL (ST-122). A 15-inch articulated Coaxial with cone-type l-f unit and horn-type h-f unit. Alnico 5 PM design throughout. Dividing network gives two-way performance. Wide-range response and excellent polar pattern. Ideal for FM receivers, high quality phonographs and similar applications, including monitoring. In Bass Reflex cabinet, response ranges from 50 to 15,000 cps. H-F Range Control lowers cut-off in four steps to suit program quality. Input impedance, 500-600 ohms. Maximum power rating in speech and music systems, 25 watts. List Price, $125.00.



MODEL JAP-60 COAXIAL (ST-600). A 15-inch cone-type Coaxial with PM design. Furnished with H-F Range Control. Nominal input impedance, 500-600 ohms. Maximum power handling capacity in speech and music systems, 20 watts. List Price, $86.00.

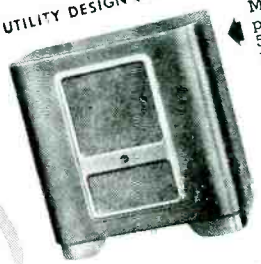


MODEL JHP-52 COAXIAL (ST-601). A 15-inch cone-type Coaxial like Model JAP-60 with efficiency approximately 4 db less. Furnished with H-F Range Control. Input impedance, 500-600 ohms. Power handling capacity in speech and music systems, 15 watts. List Price, $65.00.

MODEL JCP-40 COAXIAL (ST-603). A 12-inch Coaxial at low cost. Ideal replacement and modernizing unit where 12-inch speaker is required. Simplified low-cost bridging network inbuilt. Terminals provided for addition of ST-606 Level Control. Nominal input impedance, 6-8 ohms. Power rating, 10 watts in speech and music systems. List Price, $35.

REPRODUCERS

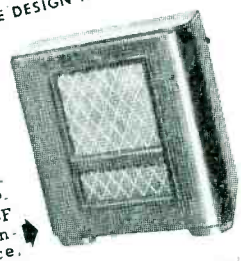
UTILITY DESIGN (Brown Opaque Lacquer)

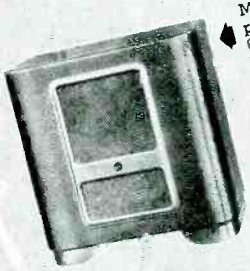


MODEL RA-151. Complete with Model HNP-51 Coaxial and H-F Range Control installed. List Price, $181.15.

MODEL RD-151. Complete with Model HNP-51 Coaxial and H-F Range Control installed. List Price, $201.00.

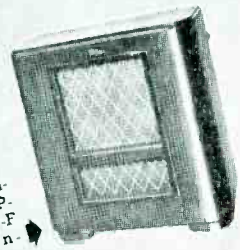
DELUXE DESIGN (Satin Finish Walnut)





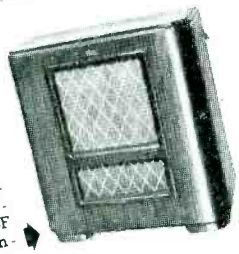
MODEL RA-153. Complete with Model JAP-60 Coaxial and H-F Range Control installed. List Price, $142.15.

MODEL RD-152. Complete with Model JAP-60 Coaxial and H-F Range Control installed. List Price, $162.00.



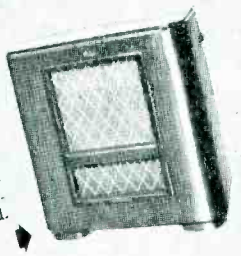
MODEL RA-154. Complete with Model JHP-52 Coaxial and H-F Range Control installed. List Price, $121.15.

MODEL RD-153. Complete with Model JHP-52 Coaxial and H-F Range Control installed. List Price, $141.00.



MODEL RA-124. Complete with Model JCP-40 Coaxial installed. List Price, $94.15.

MODEL RD-122. Complete with Model JCP-40 Coaxial installed. List Price, $114.00.



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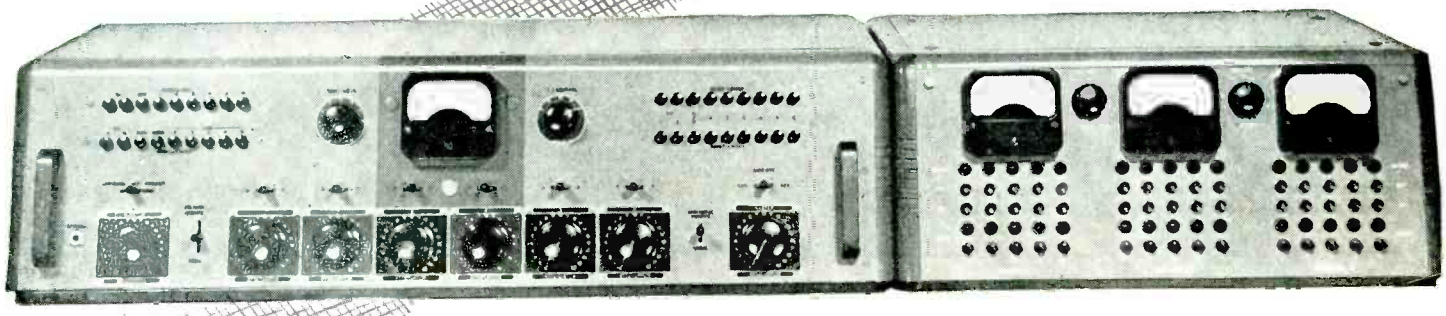
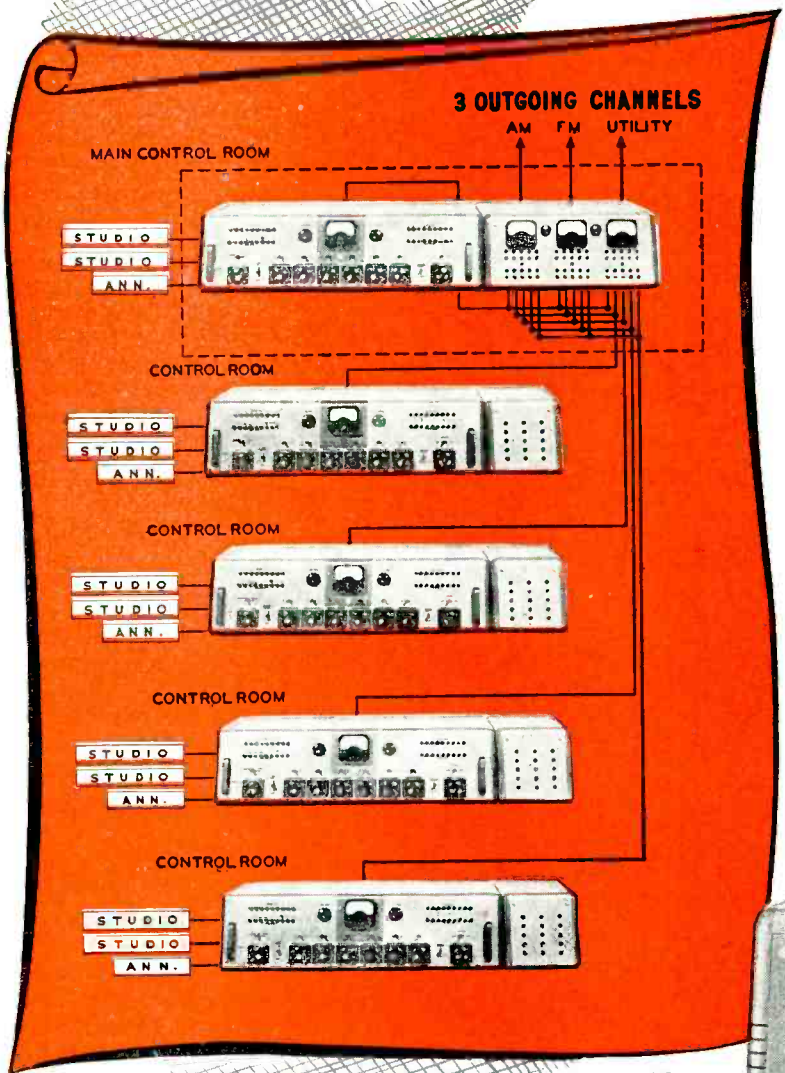


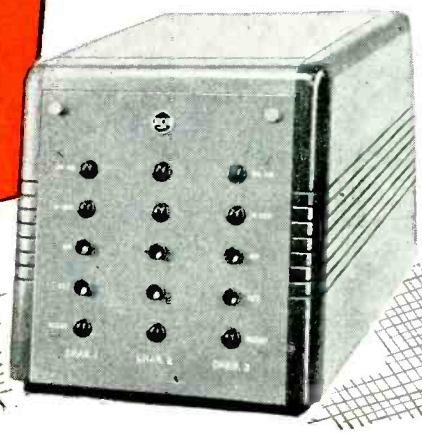


Type BCS-1A Master Switching System

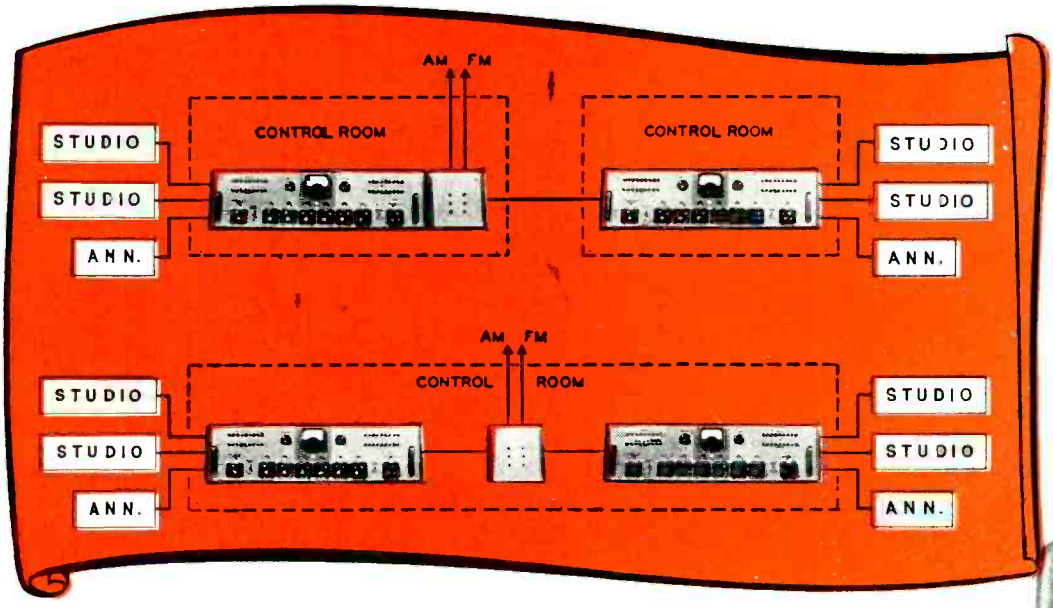
This system consists of one Master Switching Console (above, right—shown with an RCA 76-B4 Consolette) and one or more sub-control units (below). It contains all the relays needed for any combination of switching functions.

Up to five sub-control rooms can be used with the master console, each of which can handle from one to three studios.

Status lights give accurate picture of "On Air," "In Use," "Ready," and "On-Off" conditions in all control rooms for each outgoing line. Unique design features prevent feeding more than one program to any one line, although supporting program material can be handled as remotes from the originating studio. Sub-control units act as relay control stations between studios and master control unit.



switching for AM-FM Programming



Type BCS-2A Switching System

Two studio inputs may be switched independently to either of two outgoing lines. Mechanical interlocking prevents feeding two inputs to same line. Handles up to four studios and two announce booths. Two examples of the layouts possible are shown at left.

These new RCA consolette switching systems co-ordinate all studio-station functions

Here's another example of RCA's program of providing "packaged" broadcast equipments having the flexibility and performance of custom-built jobs.

The two Switching Consoles shown, in connection with standard RCA Consolettes of identical styling, give you sufficient latitude to perform intricate AM, FM and network programming operations—easily, precisely and quickly. Choice of model depends upon the complexity of your station's operating requirements.

The BCS-1A Console is designed for the more elaborate station . . . switching the outputs of as many as five control consolettes to three outgoing lines. Many combinations are practicable. Inputs from studios, network, recording rooms or frequent remotes can be monitored and switched to transmitters or network lines. Electrically interlocking controls have reduced the possibility of switching error to the vanishing point.

Managers of stations requiring only two consolettes will find the RCA Type BCS-2A Console the ideal switching system. Used with two RCA 76-B4 Consolettes, program material from up to four studios and two announce booths is routed to desired outgoing lines (AM and FM, or either transmitter and a network line).

Both types of RCA Switching Systems are designed for long-range station planning. They have sufficient flexibility to take care of future expansion. Complete details may be obtained from Engineering Products Dept., Section 30-C, Radio Corporation of America, Camden, N. J.

RCA

BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

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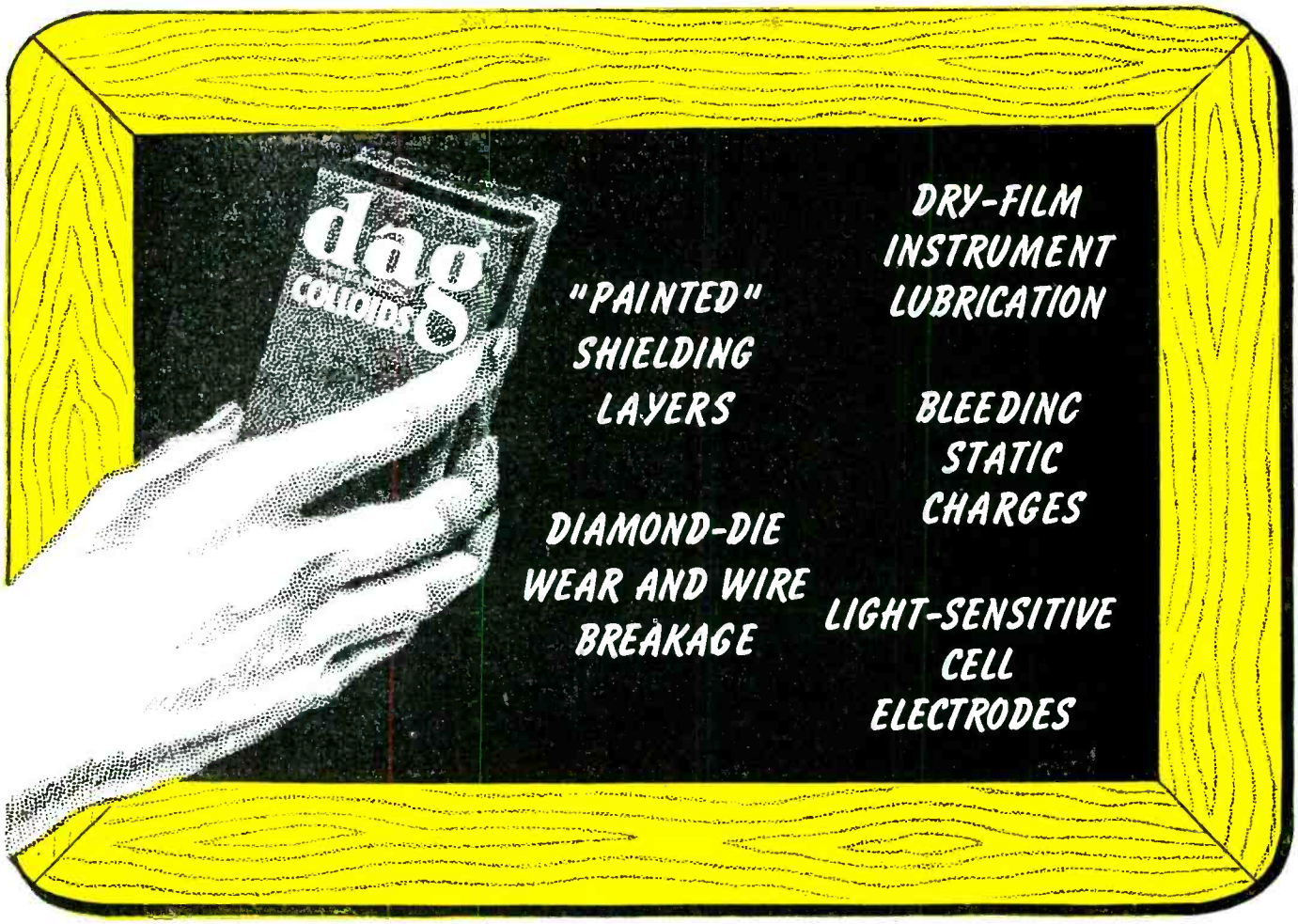

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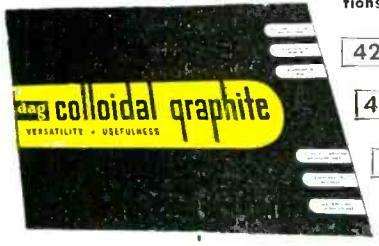
Many years of experience in the development of new uses for **"dag"** colloidal graphite have given Acheson Colloids Corporation the knowledge and skill to help you solve these and many other troublesome problems. There are 18 different dispersions of **"dag"** colloidal graphite, one or more of which will surely be useful to you. The properties of **"dag"** colloidal graphite are perfectly suited for forming electrically conductive films, for coating and impregnation, for conduction of heat and electricity, for resistance to high temperature, and for many other purposes.

Why not send in the coupon below for these fact-filled booklets and discover for yourself what versatile **"dag"** colloidal graphite can do for you?

ACHESON COLLOIDS CORPORATION, Port Huron, Michigan



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- 421 — Facts about **"dag"** colloidal graphite for ASSEMBLING AND RUNNING-IN ENGINES AND MACHINERY. ☐
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- 423 — Facts about **"dag"** colloidal graphite as a HIGH TEMPERATURE LUBRICANT. ☐
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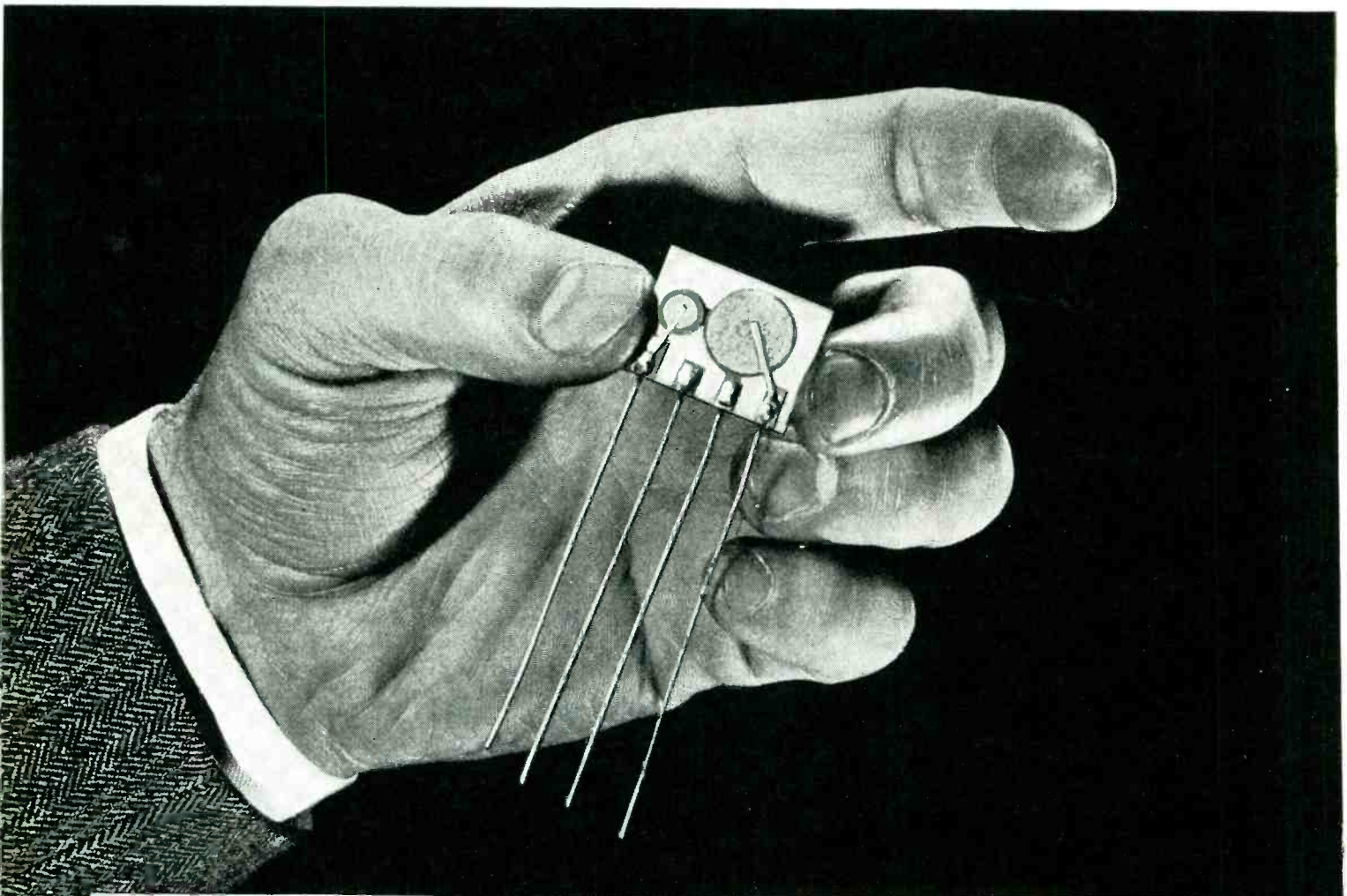
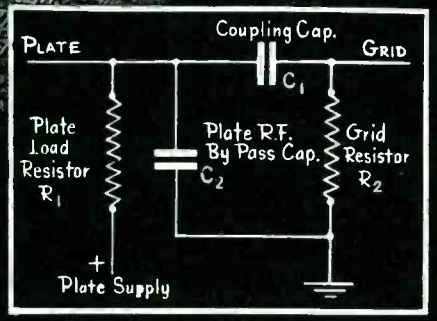
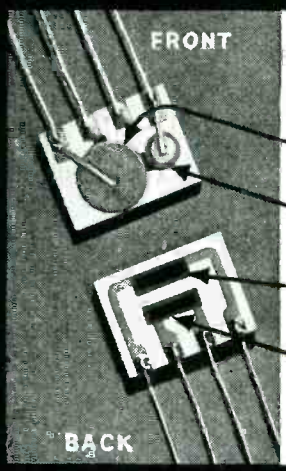
Centralab's Revolutionary New
First Commercial Application of





SO EFFICIENT . . . SO COMPLETE!
Here is the schematic diagram of Centralab's "Couplate". Note: four soldered connections instead of the usual eight or nine!



NOW SEE HOW
THIS REPLACES THIS

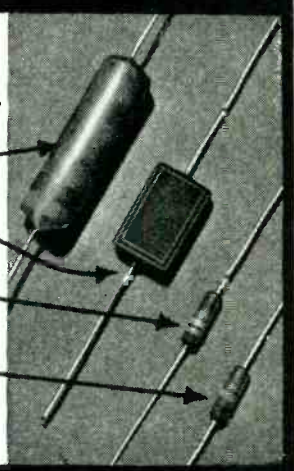
C_1 — Coupling Capacitor, .01 mfd. is standard.

C_2 — Plate R.F. By-Pass Capacitor, 250 mmf. ± 20% is standard.

R_1 — Plate Load Resistor, 250,000 Ohms ± 20% 1/5 watt is standard.

R_2 — Grid Resistor, 500,000 Ohms ± 20% 1/5 watt is standard.

Other Values Available



THE "COUPLATE"

Interstage Coupling Plate . . . the Printed Electronic Circuit!

New Multi-Unit "Couplate" Saves up to Five Soldered Connections . . . Increases Labor Efficiency 50% . . . Assures Fast, Precision Wiring on Interstage Couplings!

AS REVOLUTIONARY as the Multi-Purpose Tube—that's what electronic engineers are saying about Centralab's new *Couplate*. First commercial application of the printed electronic circuit, the *Couplate* marks the beginning of a new and greater era in electronic design and engineering!

Now available to manufacturers for the first time—Centralab's new *Couplate* is a complete interstage coupling circuit which combines into one compact unit the plate load resistor, the grid resistor, the plate by-pass capacitor and the coupling capacitor.

Think of what that means to you in terms of time and labor savings in the production of electronic equipment! Only *four* soldered connections are now required by the *Couplate* instead of the usual eight or nine. That alone gives you: 1) increased employee productivity, 2) automatic decrease in the percentage of wiring errors, 3) important space-saving, 4) lower cost, more compact, more dependable finished equipment than you've ever been able to design and build before!

Integral Ceramic Construction: Each *Couplate* is an integral assembly of "Hi-Kap" capacitors and resistors closely bonded to a steatite ceramic plate and mutually connected by means of metallic silver paths "printed" on the base plate. All leads are always the same length, each plate is an exact duplicate of the original or "master".

Future applications of this "printed" circuit principle are almost unlimited. For all the facts on how the *Couplate* can simplify your production—and cut your costs, write today for Bulletin 943!

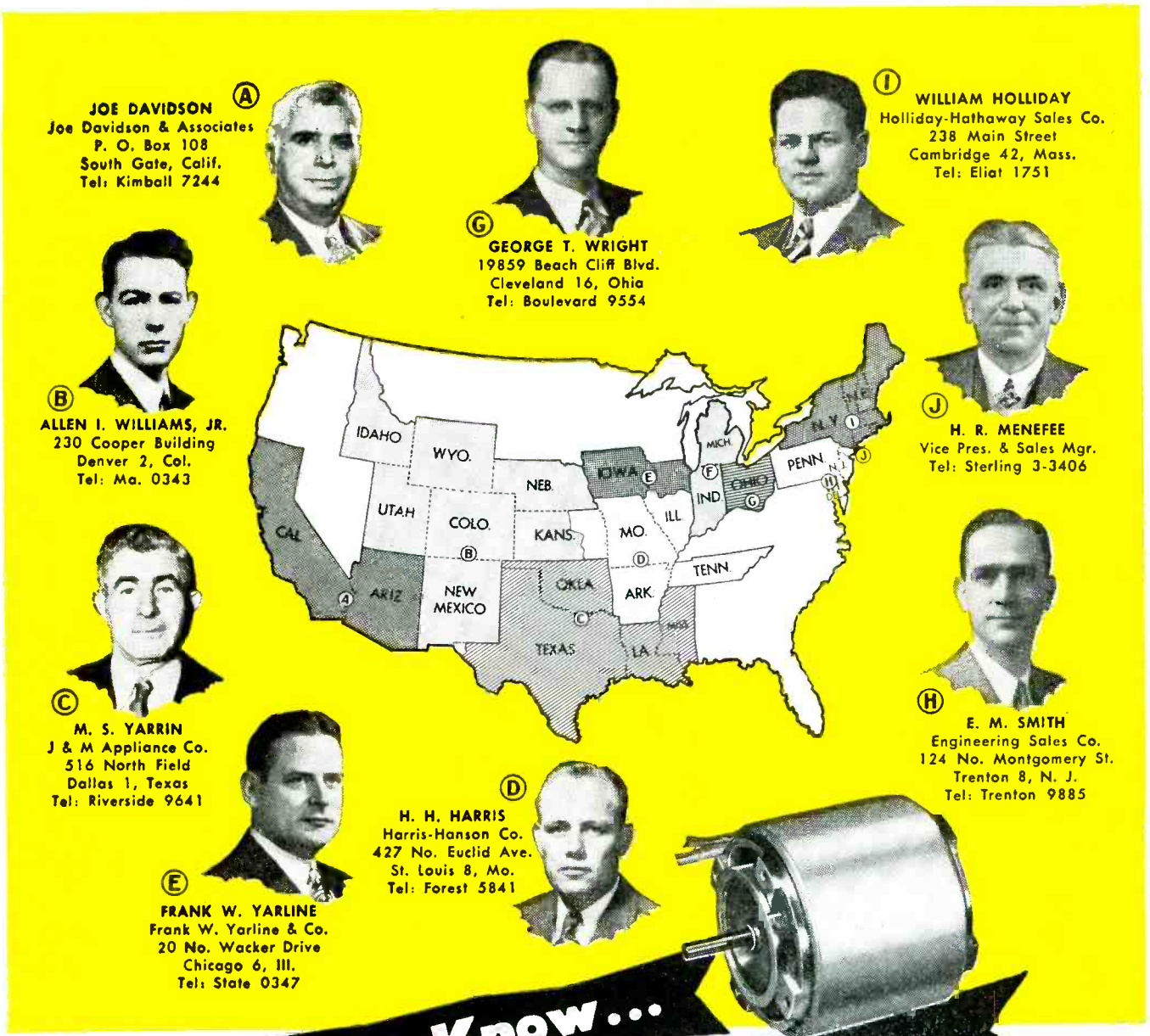
LOOK TO CENTRALAB IN 1947!

First in component research that means lower costs for the electronic industry. Before you place your order, get in touch with Centralab!

Centralab

ERL

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



The Men to Know... For E. A. D. Motors

Salesmen for Eastern Air Devices?

Yes! But more than that, these E. A. D. representatives, thoroughly familiar with the electrical industry, are servicemen as well . . . willing and able to help you with your motor problems.

E. A. D., with its vast experience, modern production facilities and skilled workmanship, stands ready to serve you with precision motor control devices for electrical, electronic and mechanical applications . . . our sales and engineering departments invite your inquiries.

TYPICAL E.A.D. MOTOR APPLICATIONS

- Air Conditioning
- Air Craft Equipment
- Control Apparatus
- Radio & Radar Equipment
- Recorders
- Record Changers
- Television
- Vending Machines

EAD

EASTERN AIR DEVICES, INC.

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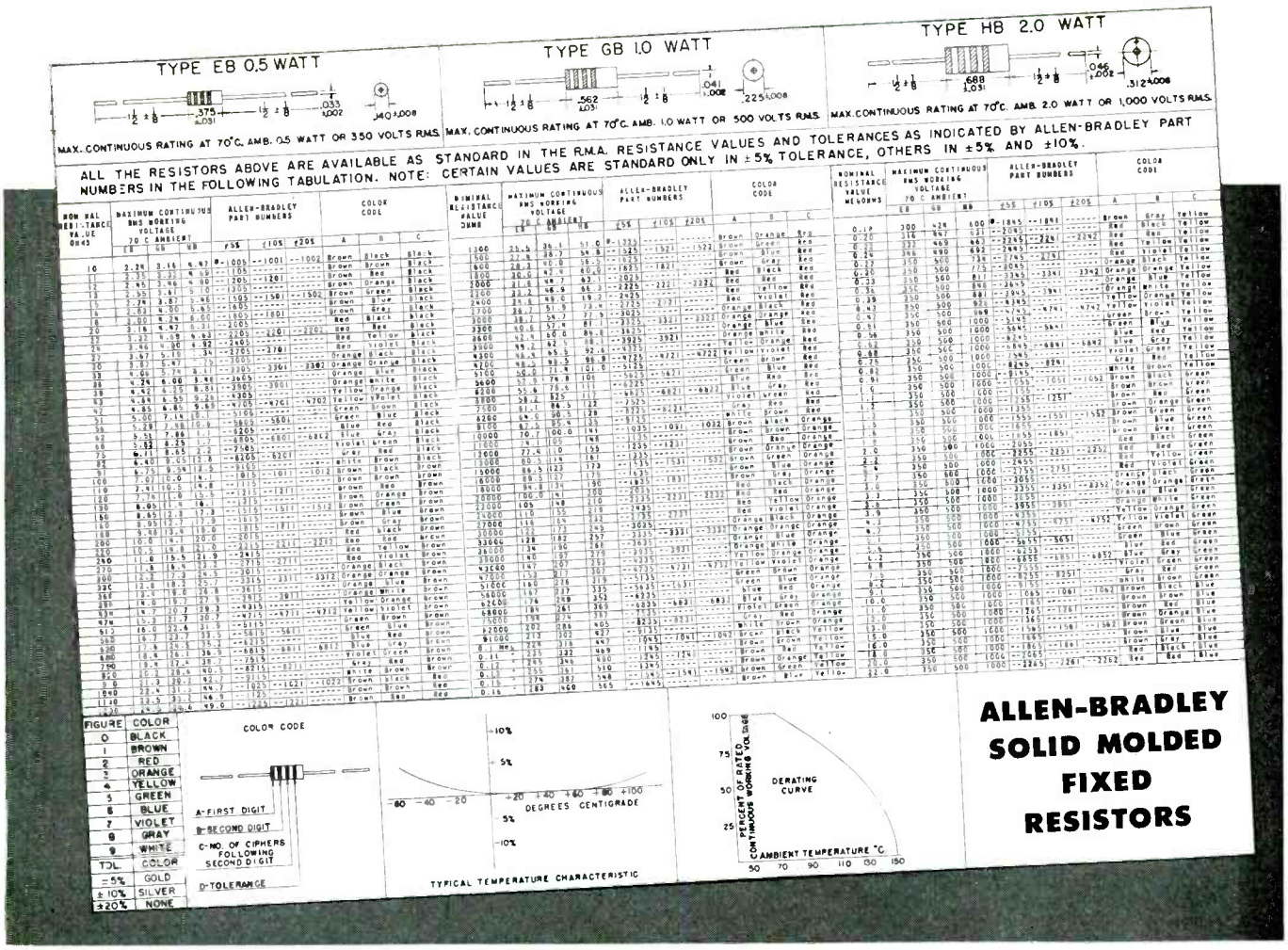
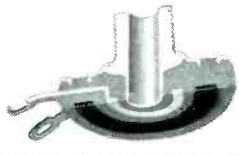


Here's a Handy Reference Chart
for selecting your fixed resistors

TYPE J BRADLEYOMETERS

Continuously Adjustable Resistors with 2 watt rating and high safety factor

The resistor material is molded with insulation, terminals, face plate, and bushing into a one-piece unit. It is not a film or paint type resistor. During manufacture, the resistor material is varied throughout its length to provide the desired resistance-rotation curve. Once molded, the curve does not change. Heat, cold, or moisture cannot affect the dependability of the Type J Bradleyometer.



This Bradleyunit resistor chart is a valuable source of resistor information. It lists over 450 resistors, in accordance with RMA standards, part numbers for various tolerances, voltage, and wattage ratings. Temperature characteristics and derating curves are also included, as well as dimension diagrams for the ½ watt, 1 watt, and 2 watt Bradleyunits. We shall be glad to send you a copy to fit your 8½x11 ring binder.

Bradleyunits will sustain an overload of ten times rating for several minutes without failing. Wax impregnation is unnecessary to pass salt water immersion tests. The leads, tempered near the resistor to prevent sharp bends, are easily soldered. The honeycomb shipping cartons keep the leads straight and speed up assembly operations.

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

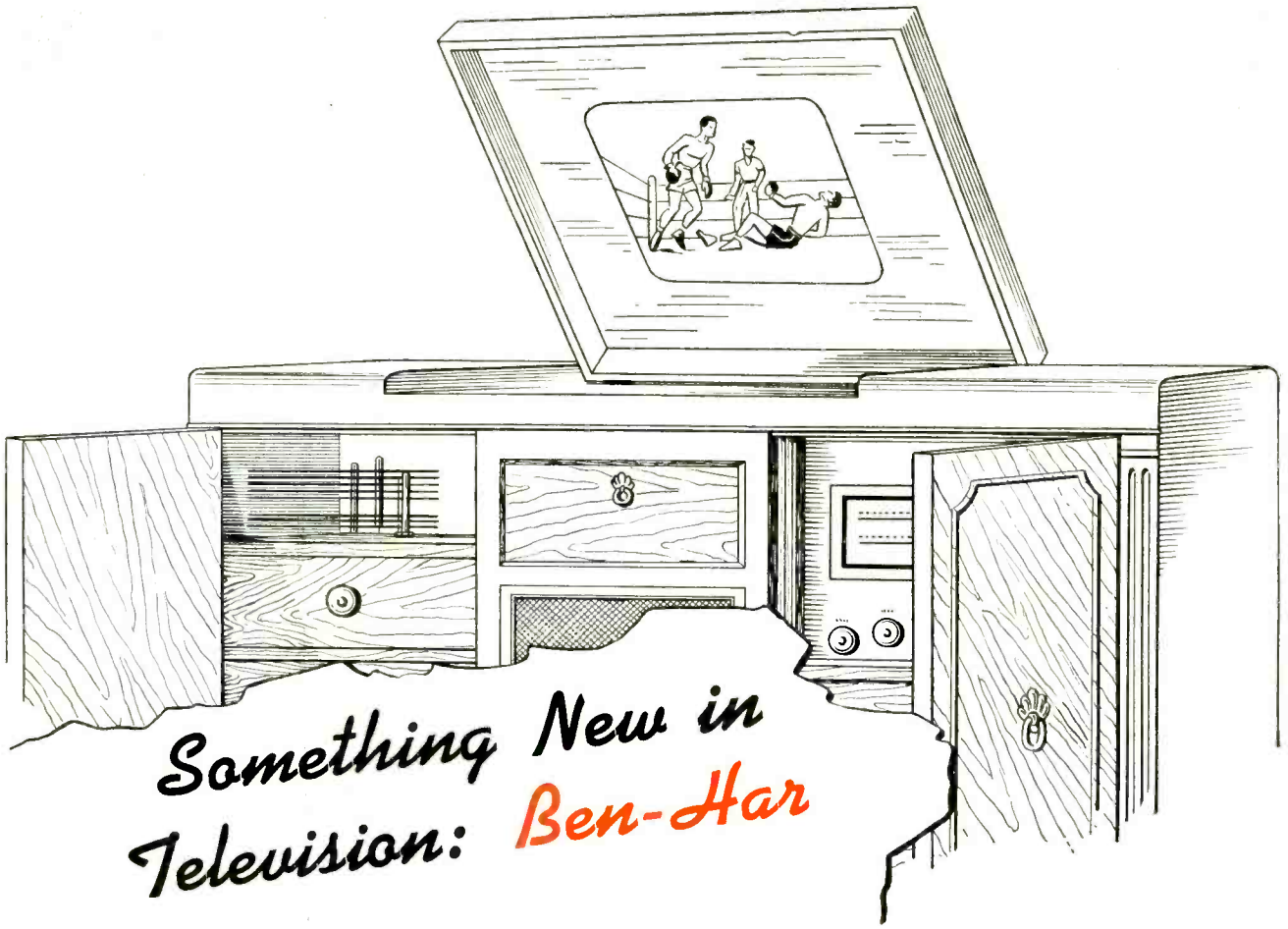
A-B Quality

ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

LET BENTLEY, HARRIS WAR-TIME RESEARCH PAY DIVIDENDS FOR YOU TODAY.



Something New in Television: Ben-Har

One of the leading television laboratories required a flexible, coated insulation of high dielectric strength. They said: "Give us tubing that will not react to heat conducted through wire . . . will not crack or split when bent . . . will not fray at the ends." They asked for a sample of Ben-Har Special Treated Fiberglas Tubing and here is what they found:

"Ben-Har Special Treated Fiberglas Tubing consistently exceeds ASTM specifications for performance. We are now specifying this material in our current television production."

Ben-Har is extremely flexible in comparison with lacquer-coated or varnish-coated Fiberglas tubings. Can be spread to cover knobs or terminals without cracking. Non-fogging. Non-corrosive. Now being used in a wide variety of applications —from hearing aids to electric motors, from watt-hour meters to movie projectors.

Try Ben-Har Special Treated Fiberglas Tubing in your own plant, in your own product—under actual service conditions. Learn why America's leading manufacturers say "never before a tubing like Ben-Har."

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-8, Conshohocken, Pa.

I am interested in Ben-Har Special Treated Fiberglas Tubing_____ for_____
(size) (product)

operating at temperatures of_____°F. at_____volts. Send samples so I can see for myself how Ben-Har will not crack in a bend, will not support combustion.

NAME _____ COMPANY _____

ADDRESS _____

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

☐ Cotton-base Sleeving and Tubing
☐ Non-fraying Fiberglas Sleeving

TWO POPULAR RECTIFIER TUBES

for broadcast, communications, and other work

. . . better built for more hours of topgrade performance!

RATINGS

	GL-8008	GL-673
Cathode voltage	5 v	5 v
current	7.5 amp	10 amp
Typical heating time	30 sec	30 sec
Anode peak inverse voltage	10,000 v	15,000 v
peak current	5 amp	6 amp
avg current	1.25 amp	1.5 amp

Heavy-duty bases, with large pin-contact area, are one of many features that give these mercury-vapor phanotrons the dependability needed for 24-hour broadcast-station use—extra reliability for police-radio, aviation, and other exacting communications work—the steady efficiency required to convert power for small d-c industrial equipment operating on full schedule.

Minimum temperature rise is an especially valuable characteristic of Types GL-8008 and GL-673. Installation of these tubes reduces the cooling problem for broadcast-station and factory engineers.

Less mounting space needed . . . this is an important result of the straight-side envelope design in contrast to the bulb shape of older types. Maintenance men, too, report that the straight-side contour makes Types GL-8008 and GL-673 easier to handle, and helps ward off accidental tube breakage.

Sturdy, shock-resistant . . . these qualities stem from the modern structural design of the GL-8008 and GL-673—their strongly braced cathodes, and their nickel anodes which, lighter in weight than others, put less strain on the seal above them, enabling the latter to withstand shocks and vibration better.

General Electric builds a complete line of phanotron rectifier tubes—15 types in all, matching every broadcasting, communications, or industrial need. Your nearby G-E tube distributor or dealer will be glad to give you prices and full details. Phone him today! *ElectronicsDepartment,GeneralElectric Company, Schenectady 5, N. Y.*

G.E.'s new Transmitting Tube Manual is the most complete book in its field! Profusely illustrated; packed with application data. Over 600 large pages. Price $2, with an annual service charge of $1 for new and revised pages to keep the manual up-to-date. Order direct from General Electric Company.

GENERAL ELECTRIC

161-F3-8850

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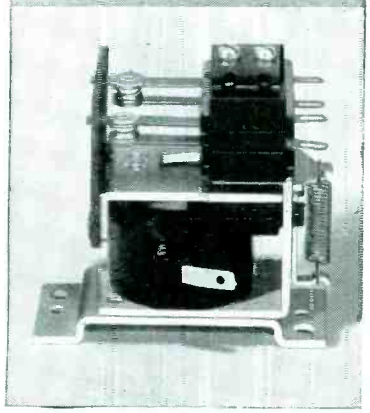
VERSATILE NEW LINE OF... A·C AND D·C RELAYS



EXCEPTIONALLY SMALL AND COMPACT YET EXTREMELY RUGGED!

● R-B-M announces a new line of general purpose magnetic relays, with either A.C. or D.C. shunt coils or series coils, for electronic applications.

Relays are available in standard contact arrangement of single and two pole normally open, normally closed; or double throw with light and heavy contacts. Four and six pole double throw relays are available with 3 ampere contacts at 32 volts or less.

Insert shows two pole, double throw contactor rated 13 amperes, 115 volts, A.C., and 6.5 amperes at 230 volts, A.C. This relay is designed in accordance with Underwriters' specifications and will ultimately carry Underwriters' Approval for Small Devices classification.

For further information write for Bulletin 570. Address Department A-3 . . .

R-B-M DIVISION
ESSEX WIRE CORPORATION
Logansport, Indiana

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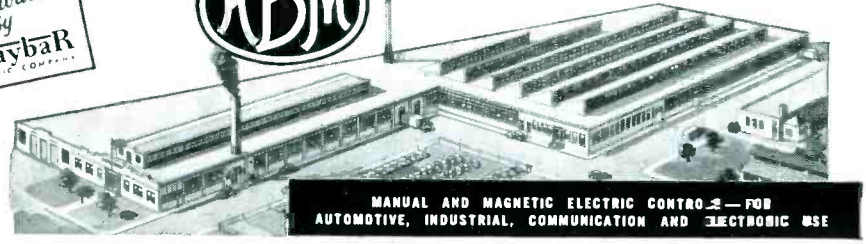
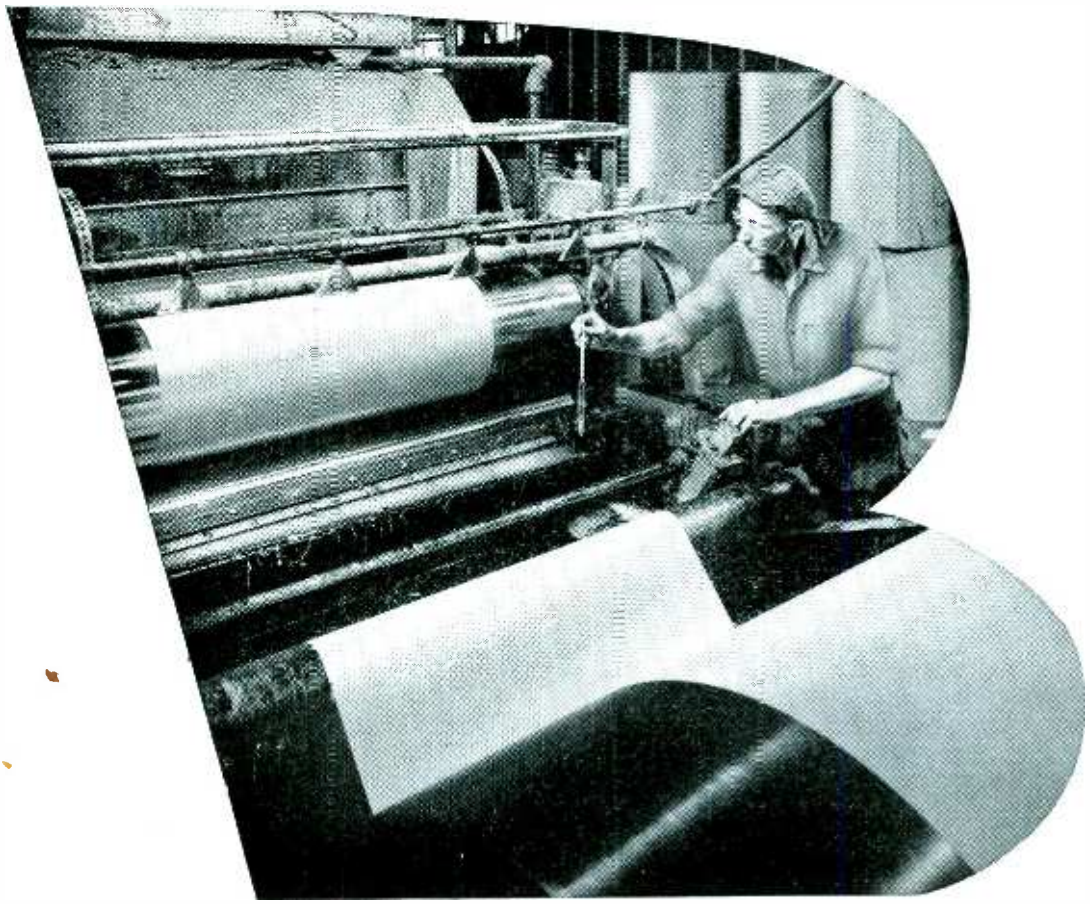


MANUAL AND MAGNETIC ELECTRIC CONTROL — FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

* RICHARDSON MEANS *Versatility* IN PLASTICS



This is where the Base gets the "Business"!

This is the bath in resin . . . the saturation that sets the pace for other things to come. If the control is good . . . and we make sure it is at Richardson . . . your Laminated INSUROK sheets, rods and tubes are well on their way to perfection.

This is as it should be. And maybe this Richardson brand of determination is what has helped us to develop, among many others, Laminated INSUROK T-725. This grade has uniformly low moisture absorption and high insulation resistance under humid conditions. With proper technique, intricate parts can be successfully fabricated. Get the full story. It's interesting!

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***RESEARCH**
. . . a continuous transformation of possibilities into practical ideas in plastics.

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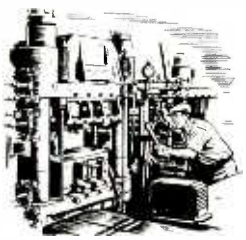
. . . Artistic visualization. Creative engineering. Practical planning for efficient plastics production.

***PRODUCTION**
. . . Complete machine shop facilities for manufacturing our own dies, molds, tools.



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. . . Rubber and bituminous plastics; and synthetic resin plastics . . . Beetle, Bakelite, Durez, etc.

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. . . Complete equipment for drilling, punching, sawing, turning, milling, etc.

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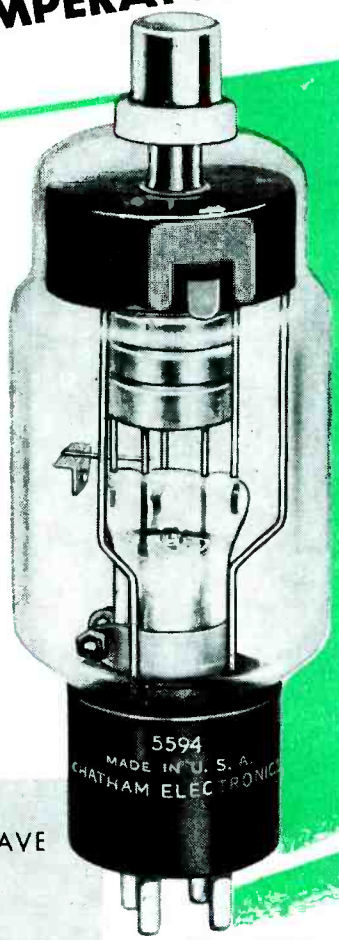
New Xenon Thyratron

FOR A WIDE RANGE OF AMBIENT TEMPERATURE

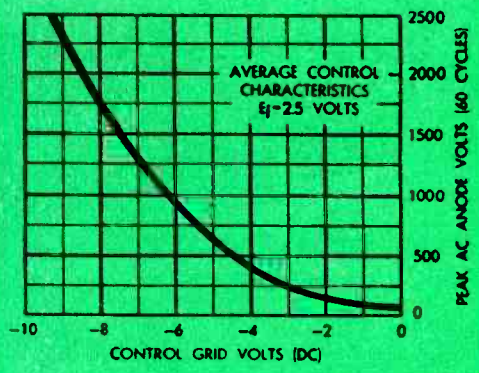
CHATHAM 5594

..requires no heater, blower or thermostat to regulate bulb temperature!



MAXIMUM RATINGS:

PEAK FORWARD ANODE VOLTAGE: 2500 VOLTS
PEAK INVERSE ANODE VOLTAGE: 5000 VOLTS
AVERAGE ANODE CURRENT: 0.5 AMPERES
PEAK ANODE CURRENT: 2.0 AMPERES
FILAMENT VOLTAGE: 2.5 VOLTS
FILAMENT CURRENT: 5.0 AMPERES



WRITE FOR CATALOG

3B28 XENON HALF-WAVE RECTIFIER

Maximum Ratings:
PEAK INVERSE ANODE VOLTAGE 10,000 VOLTS
AVER. ANODE CURRENT .25 AMPS
PEAK ANODE CURRENT 1.0 AMP
AMB. TEMP. RANGE −55°C to +90°C

4B32 XENON HALF-WAVE RECTIFIER

Maximum Ratings:
PEAK INVERSE ANODE VOLTAGE 10,000 VOLTS
AVER. ANODE CURRENT 1.25 AMPS
PEAK ANODE CURRENT 5.0 AMPS
AMB. TEMP. RANGE −55°C to +90°C

Type 5594, an exclusive development of CHATHAM ELECTRONICS, is an Xenon filled thyratron with characteristics suitable for diversified applications. Xenon gas eliminates the need for auxiliary equipment to maintain bulb temperatures and also removes most of the limitations usually associated with mercury vapor rectifiers. The 5594 operates through an ambient temperature range of from —55° C. to +90° C. For complete information on this tube or any other in the complete line of CHATHAM rectifiers and thyratrons, call or write today; there is no obligation.

CHATHAM ELECTRONICS
475 WASHINGTON ST., NEWARK 2, NEW JERSEY

GET SET

FOR COMPETITION

USE alliance MOTORS

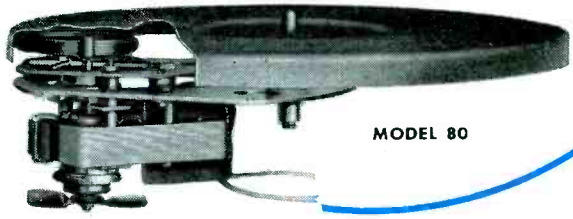
The famous Model 80 Even Speed Alliance Phonomotor operating on 110 or 200 volts is made for 40, 50 or 60 cycles, 16 watts input, 78 RPM. It has no gears—runs at an even speed—has a smooth, quiet, positive friction-rim drive. Amply proportioned bearings with large oil reservoirs assure long life. A slip-type fan gives cool operation—avoids any possible injury.

The Alliance Model K Phonomotor, a 25 cycle companion to the Model 80, operates on 110 volts, 25 cycles at 12 watt input. Motor and idler plate on Alliance phonomotors are all shock mounted to the cabinet mounting plate, to minimize vibration.

Drive your products to market

—use *Alliance Motors* to drive vital component parts. Big advantages for the Alliance Powr-Pakt line are compactness, light weight, versatile performance characteristics, and *mass production* at low cost.

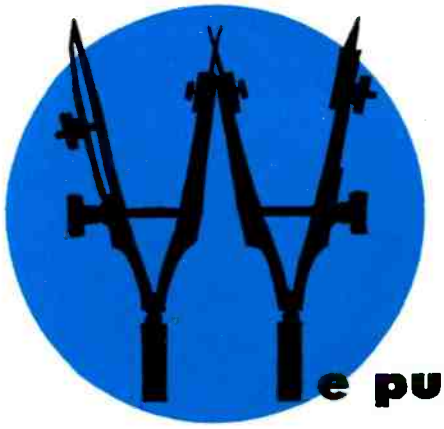
Alliance Powr-Pakt Motors are rated from less than 1/400th h. p. on up to 1/20th h. p. They'll supply just the *right amount of power at strategic points* to impart automatic action, instant control and greater usefulness for your products and processes.



MODEL 80

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO



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TWO *Happy Endings*

TO FUSE-MOUNTING PROBLEMS

These Littelfuse 3AG fuse mountings offer sharply increased safety and convenience. Typical of the complete Littelfuse line of fuses, mountings and accessories, they represent smooth coordination of sound engineering and original thinking. This assures effective circuit protection and lasting satisfaction.

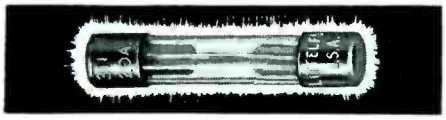
LITTELFUSE 3AG EXTRACTOR POSTS eliminate unsightly exterior fuse clips on appliances, equipment or instruments. The fuse is held in the end of the removable knob. Unscrew it, and the fuse is safely changed without irritating inconvenience. Their dead front construction prevents accidental electrical shocks. Extractor Posts are easy to install. They conserve space in panel layouts—can be ganged in rows with a common bus.

Littelfuse 3AG Extractor Posts are available in finger-operated types with and without 3½" flexible cord or "keep chain," and in a screwdriver type.

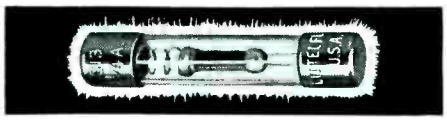
STEEL-COVERED 3AG SIZE FUSE MOUNTINGS prevent accidental damage to fuses, prevent injury by exposed terminals. Available with convenient hinged cover in single and double pole types, and in single pole and spare fuse holder combinations, these mountings all have fatigue-resistant nickel plated phosphor bronze clips. A double-pole type with removable non-hinged cover also is offered.

Both types meet Underwriters' requirements, and solve your fuse-mounting problems with thrift and efficiency. Send for your new Littelfuse catalog number 9 today!

TRIO OF LITTELFUSE "FIRSTS" IN FUSES . . .



QUICK-ACTING 3AG Littelfuses for low time-lag applications. Elements of fractional amperage fuses are protective coated to prevent oxidization, and promote a clean break.



SLO-BLO 3AG Littelfuses have high time-lag to withstand heavy surges—quick on shorts. Anti-fatigue construction. In 1/100 to 20 amp. ratings.

"TINY-MIGHTY" 3AB Littelfuses are bakelite-enclosed, arc-quenching, powder-filled fuses. In 10, 12, and 15 amp. ratings. The smallest Underwriters' Laboratories approved fuses in ratings this high.

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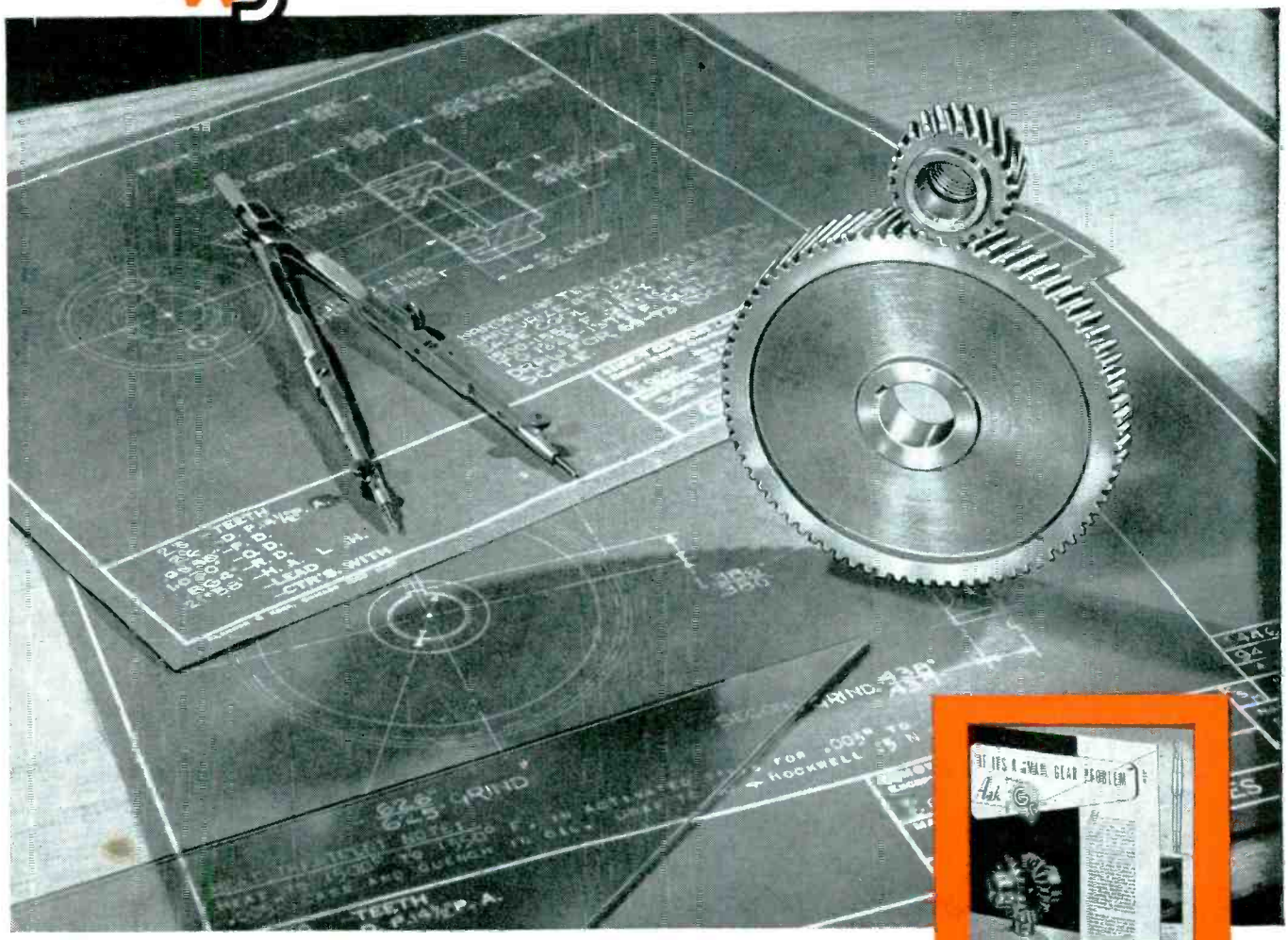
NITE-T-LITE • SWITCH LITE • IGNITION FRITZ • NEON INDICATORS • SWITCHES • CIRCUIT BREAKERS • FUSES, MOUNTINGS AND ACCESSORIES

FRACTIONAL HORSEPOWER GEARING

WHY YOU SHOULD LET G-S MAKE *YOUR* SMALL GEARS



SMOOTHER, better performance and longer life characterize the Small Gears we make. They give *added dependability* to the devices in which they are used. The superior advantages of G-S Small Gears are the result of more than a quarter century of specialization . . years of developing men, materials and machinery to their present high degree of efficiency. Here, the best possible solutions to your small gear problems can be determined by our skilled engineers. Specifications and production procedures, however exacting, will be established and carried out quickly and at moderate cost. Discuss your needs with a G-S Small Gear Specialist. Get suggestions, ideas, and cost estimates. This friendly service doesn't obligate you at all.

The G-S Catalog Bulletin describes many different types and applications of G-S Small Gears. Please ask for a copy on company stationery.

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.375"	.220" to .225"	.090"	.051" to .053"
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Callite engineers have developed — and can now produce in commercial quantities — seamless molybdenum tubing. To the best of our knowledge, this is the first time that seamless moly tubing has been made available on a production basis. All of our experience convinces us that this new development has any number of applications in the field of electrical and electronic manufacture.

May we consult with you? Samples available. Write: Callite Tungsten Corporation, Union City, New Jersey. Branch offices in Chicago and Cleveland.

Callite

MOLY TUBING

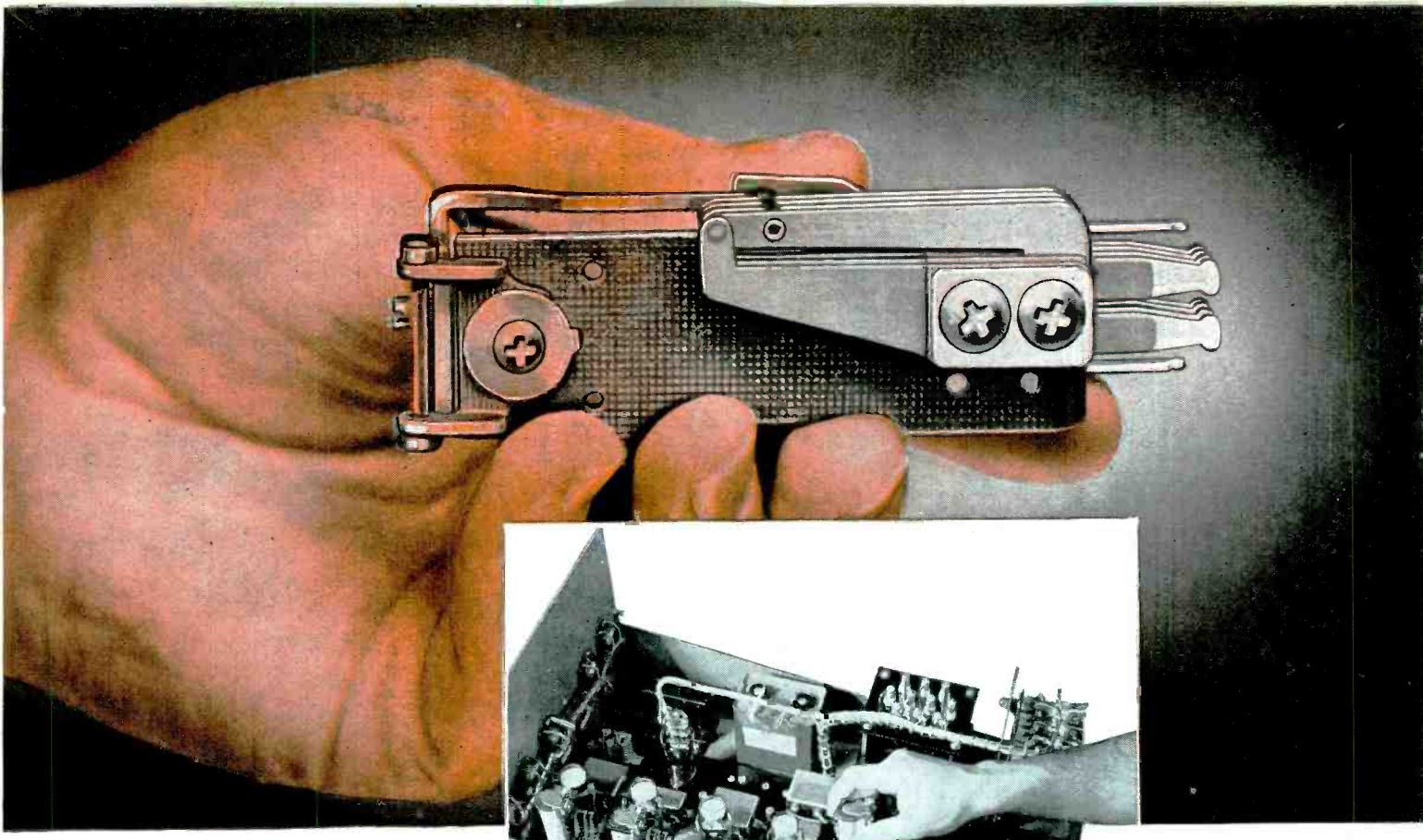


Illustration shows use of Clare Relays in Raytheon Synchronous Control Cabinet

CLARE RELAYS

Help Provide Accurate and Dependable Operation for RAYTHEON Electronic Welding Control

● Resistance welding is speeded up by this new Raytheon Electronic Synchronous Control. Spot, seam or pulsation timing are also provided from the same cabinet.

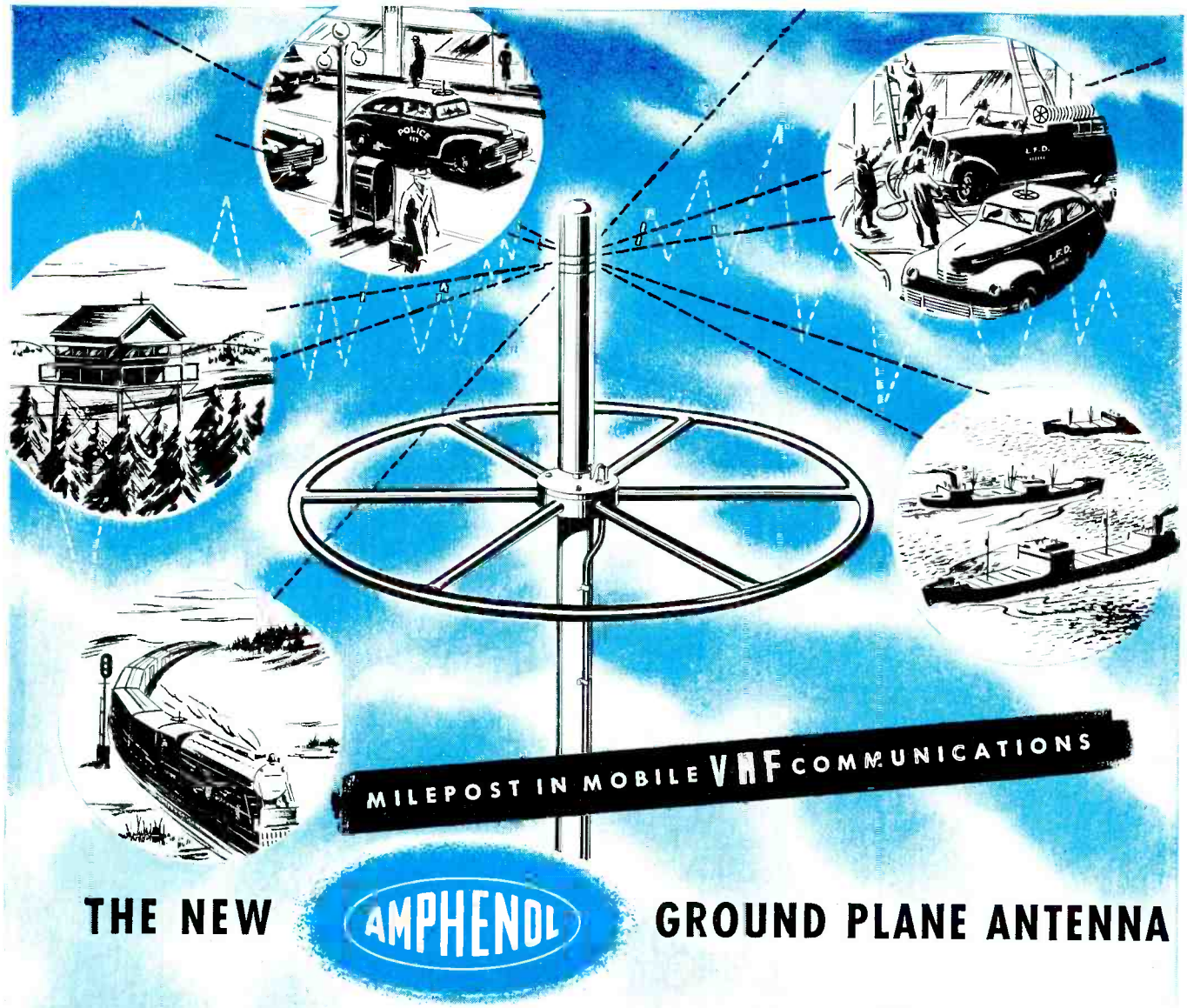
Clare Relays were chosen by Raytheon Manufacturing Company of Waltham, Mass., for this new modern unit because of their accurate, efficient and dependable operation. Clare compact, clean-cut design met Raytheon demands that all components contribute to the ease and convenience of use, the flexibility of application and streamlined appearance.

Four Clare Type "C" d.c. Relays and one Clare Type "A" a.c. Relay, shown in this drawer type sequence timer, are supplied by Clare with coil windings, contacts and all special adjustments to meet exact Raytheon requirements.

This use of standard Clare Relays with modifications to meet the job at hand is what we mean by Clare "custom-building." It is available to you for your unusual relay requirements. Expert Clare sales engineers are located in principal cities. Let us know your problem. Address: C. P. Clare & Co, 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical and Industrial Use



THE NEW AMPHENOL GROUND PLANE ANTENNA

Efficient VHF radio communications is a must in modern railroading. Used to expedite freight and express service, it is cutting hours from schedules, and eliminating waste time and money in switching operations.

Designed principally for use in the 152-162 mc band by railroads for "train-to-fixed-station" and "end-to-end" communications, the new Ground Plane Antenna illustrated is foremost among many new VHF radio components and accessories perfected by Amphenol engineers.

Providing maximum power radiation at low initial cost, this extremely rugged antenna consistently out-performs other antennas under normal and extreme conditions. It is easily and quickly installed, and has been thoroughly tested in main-line railroad installations.

Danger from lightning or contact with power lines is eliminated, as this antenna is at ground potential. The nature of its radiation pattern insures uninterrupted service during sharp "U" or "S" turns.

The Amphenol Ground Plane Antenna is also widely used by police and fire departments, by forestry, geophysical, power and petroleum field crews, for mobile marine installations, and many others. It is available with Ground Plane Skirt, as shown, for installations where a large metallic mounting surface is not available.

Write today for complete technical data on the Ground Plane Antenna, or for engineering aid in solving your VHF radio communications problems.

Depend upon AMPHENOL Quality

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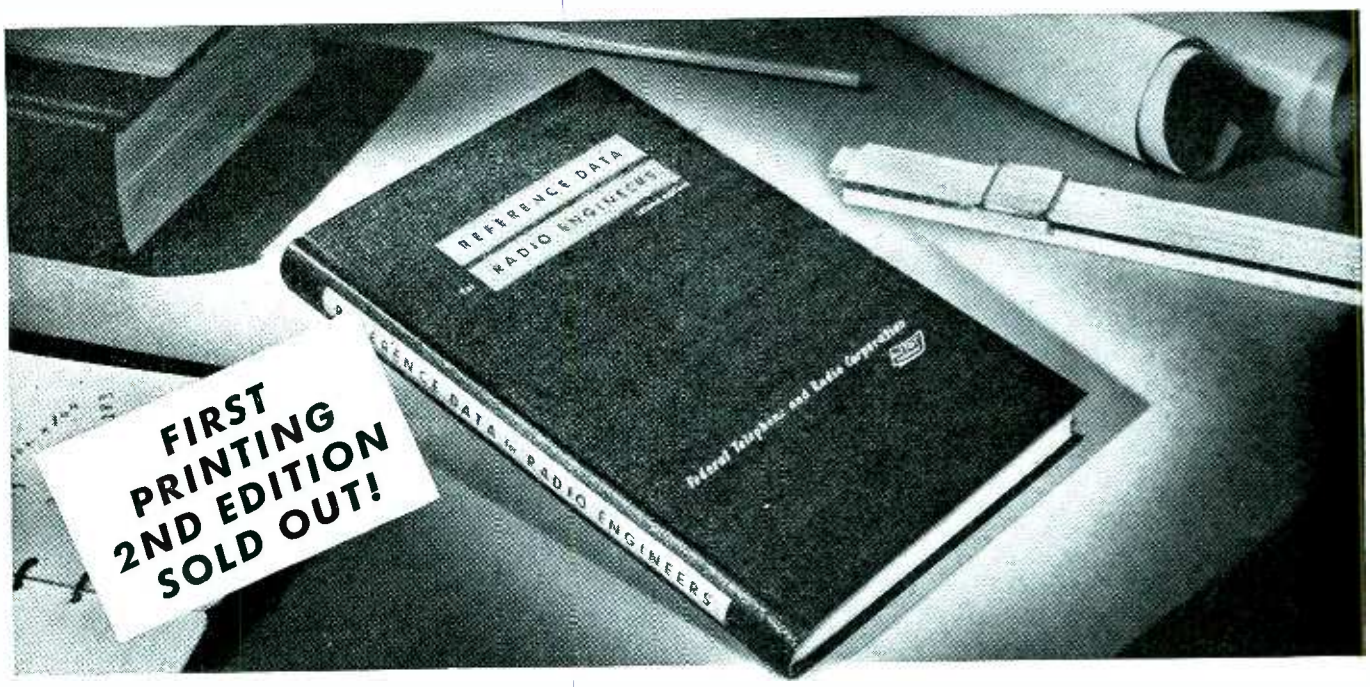

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The new, Second Edition of "Reference Data for Radio Engineers" in green cloth binding, revised and enlarged to include much new data developed during the war, is ready—in a new printing, just completed. Many purchasers have taken advantage of the low quantity price for group orders of 12 or more. To order any number, merely fill in the convenient coupon.

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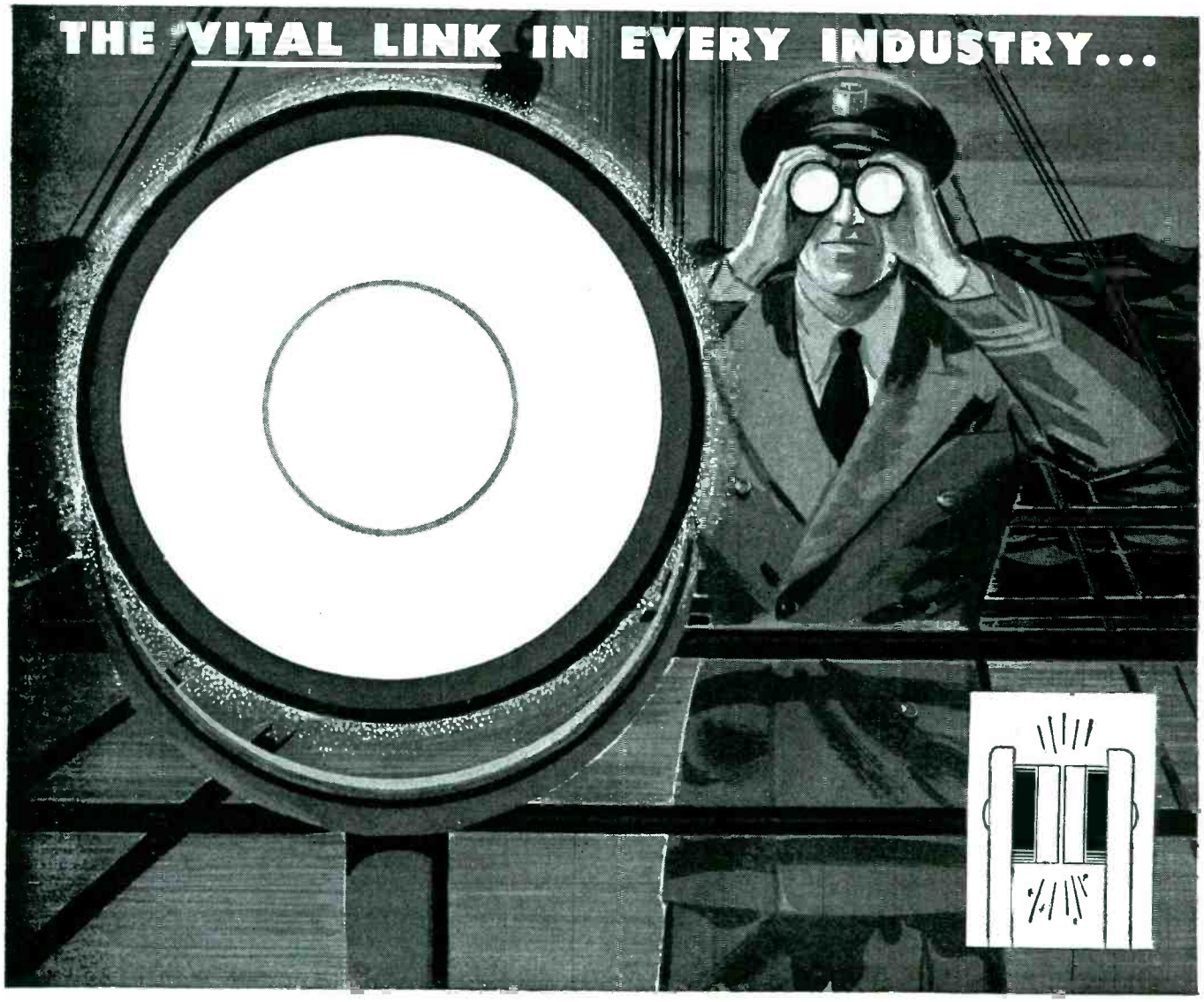

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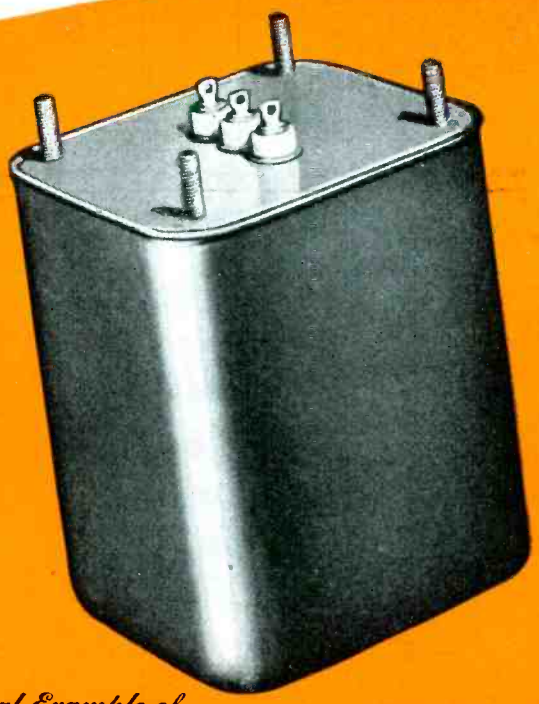
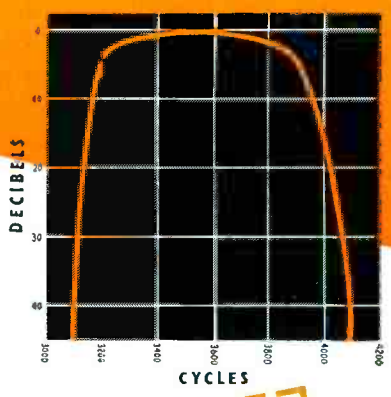


Typical Example of
C. T. FILTER DESIGN



BAND PASS FILTER. Mid-band frequency 3550 cycles. Low frequency cut-off at 3160 cycles, high frequency cut-off at 3990 cycles. Nominal impedance of 600 ohms. Attenuation 40 DB at 3110 cycles and 4080 cycles. Case dimensions, 4.3" x 3.6" x 3.3".

Chicago Transformer's engineering and manufacturing facilities are now available to design and build wave filters on quantity orders. Any specific filter problem within the range governed by commercial limits in condensers is welcomed.

Known for their sharp discrimination, and for delivering maximum output, compact and efficient C. T. filters are recognized as leaders. Salient feature of C. T. filter engineering is the use of toroid coils wound on powdered nickel alloy cores. Their characteristic small size, low loss, and ease of balancing with capacitors assure superior performance with unusual compactness.

Mounting the units in drawn steel cases, using C. T.'s *Sealed in Steel* construction, assures effective shielding and long-lasting dependability.

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High Q
Stability
Accurate Inductance
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Compactness

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TOROID COILS

wound to specification

Compact toroid coils are highly efficient in high Q choke applications, as well as in wave filters.

Chicago Transformer's toroid coil winding facilities are currently open to a number of orders from those desiring to purchase coils only.

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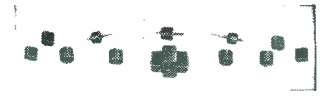
ELECTRONICS

Designers

4 improved magnet materials add design possibilities

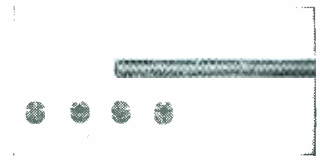
Augmenting the many sintered and cast Alnico alloys, 4 additional General Electric magnet materials greatly extend magnet design possibilities.



1

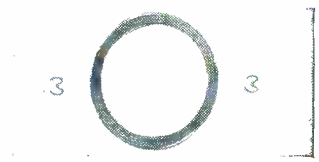
1. VECTOLITE. This light-weight, high-resistance magnet material is a combination of iron oxide and cobalt oxide. High in coercive force, it is finding wide application as a rotor magnet for d-c selsyns and in many types of moving magnet instruments. A number of shapes are shown in illustration 1.

2. CUNICO. An alloy of copper, nickel and cobalt, Cunico is malleable, ductile, and machinable and is supplied in wire, strip, or rod stock. Illustration 2 shows a rod of Cunico, and screw-machine magnets machined from it.



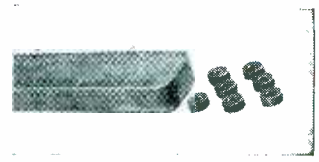
2

3. CUNIFE. Cunife has all the physical advantages of Cunico. However, this alloy of copper, nickel and iron has directional properties, and to secure best magnetic results must be magnetized only along the direction in which the material has been worked. It is supplied in wire stock in round, square, and rectangular form. Ductility of Cunife is shown in illustration 3.



3

4. SILMANAL. High in coercive force, this alloy of silver, manganese, and aluminum is most useful in instruments where service in strong electrical fields is necessary. The Silmanal magnets in illustration 4 were rolled, punched, and machined from the ingot shown. For more information about these magnetic materials, write for Bulletin GES-3337.



4

RELAYS THAT ARE REALLY SENSITIVE

For electronic applications where switching functions must be performed by small amounts of power, General Electric has a complete line of current-sensitive, d-c relays. These relays are built to withstand shock and vibration and will operate in ambient temperatures from −70F to 200F. They cover the range from 10 mw to 180 mw; 0.47 ma to 1470 ma; 0.07 ohms to 67,000

ohms coil resistance; and weigh from 0.1 to 0.7 pound. Contact ratings from 12 volts to 110 volts a-c/d-c with a contact rating at 24 volts d-c of 2.0 amperes non-inductive and 0.5 ampere inductive. Installation is easy with either the plug-in base or the solder-lug terminals. Write for Bulletin GEA-3819.

ONE SWITCH CONTROLS MANY CIRCUITS

For transfer and control switching there is a G-E (Type SB-1) switch to do almost any job. Standard Type SB-1 switches are available from single-stage models to 12-position, 16-stage models. For more complex switching, special models are furnished up to 100 stages.

Precision construction makes operation easy, even in the larger models. Rated at 600 volts, 20 amp continuous, or 250 amp for 3 seconds, the long-lived, cam-operated silver contacts have stood more than 1,000,000 test operations without excessive wear.

Stages are isolated by dielectric bar-

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS

riers. There is ample space for easy connection. Two types of locks permit locking in any position, and standard switches are dead front. Write for Bulletin GEA-1631.

PUTS A LOT OF COIL IN A LITTLE SPACE

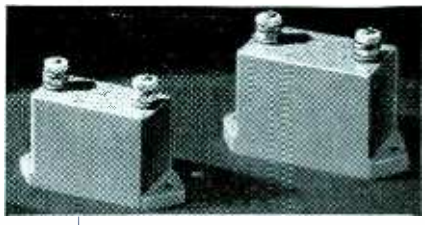
When product design puts a premium on space, G-E Formex* magnet wire lets you wind more compact coils.

Where coils wound in rectangular shapes crack enamel insulation, the tough film on Formex stands up. In fast winding operations, too, Formex takes the punishment. When coils must stand up year after year, depend on Formex, because age has little effect upon this polyvinyl-acetal insulation. Round Formex is available in standard sizes from 6 AWG to 44 AWG and in ultrafine sizes of 1¾, 1½, 1¼ and down to 1 circular mil in copper area. Rectangular Formex is also available. For full information on shapes, sizes and application methods, write for Bulletin GEA-3911.

LECTROFILM CAPACITORS AT NEW LOW PRICES

Circuit designers now have complete freedom to use either high or low capacities in r-f blocking and by-pass applications — without paying a premium for high capacity—because General Electric case-style 65 Lectrofilm* capacitors are now all at one new price, approxi-

*Reg. U.S. Pat. Off.



mately half of the previous level! Similarly, all listed ratings of case 70 designs are offered at one new, low price.

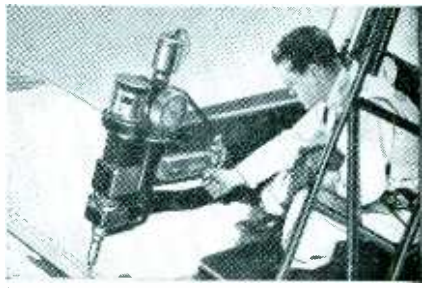
General Electric's development of Lectrofilm, a new capacitor dielectric, and the advanced methods used in manufacturing these capacitors have resulted directly in these new low prices. Lectrofilm capacitors are now the answer to new circuit economies, better circuit designs, lower over-all equipment costs. Bulletin GEA-4295.

TO SELL RADIO LISTENING BY THE HOUR

Dispensing 2 hours of use for each coin deposited, the General Electric Type TSC-9 coin-switch mechanism is suitable for installation in table-model radios such as hotels provide for guests. Powered by the widely used, reliable Telechron motor, and with silver contacts rated 2 amp, 110 volts a-c, the switch is constructed for long, maintenance-free service. The Type TSC-9 switch may be connected to allow intermittent use of the radio until the time paid for has been exhausted. As many as 6 coins, providing a maximum of 12 hours use, may be deposited at one time. A continuous coin counter registers deposits up to $25.

TRAINS BETTER WELDERS IN LESS TIME

Visual methods of employee education have proved their ability to increase output and decrease rejects. Now General Electric has produced a new, full-color, sound movie that uses animated drawings to teach the principles and applications of spot, projection, and seam resistance welding. The film takes you inside fifteen different industrial plants, and shows more than 100 applications of resistance welding where it is speeding production and cutting costs. Ac-



companying the film is an interesting "refresher" bulletin covering the salient points of the film.

Ask your local General Electric office to lend you (This Is Resistance Welding); no charge or obligation to you.

GENERAL ELECTRIC COMPANY, Sec. A 642-14
Apparatus Dept., Schenectady 5, N. Y.

Please send me:

- ....GES-3337 (Magnet materials)
- ....GEA-3819 (Current-sensitive relays)
- ....GEA-1631 (Type SB-1 switches)
- ....GEA-3911 (Formex magnet wire)
- ....GEA-4295 (Lectrofilm capacitors)

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

Name _____

Company _____

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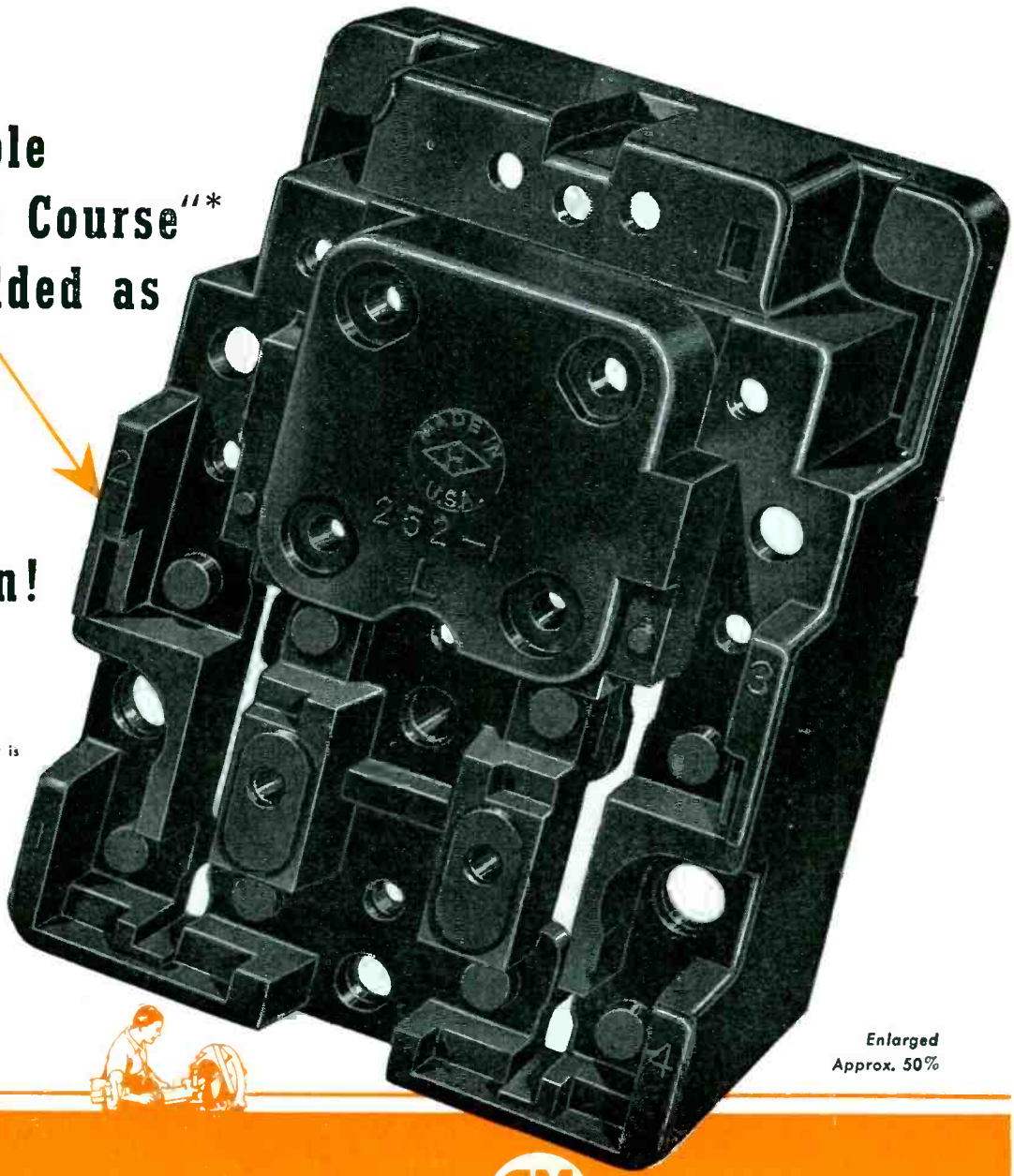
8010

This "18 Hole Obstacle Course"* was molded as ONE piece in ONE operation!



* Actually this pictured unit is a Switch Base . . . molded for the Hart Manufacturing Company, Hartford, Conn.

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Molded of general purpose phenolic material, the above complicated Switch Base required the utmost skill in mold design . . . precise mold construction . . . and over-all plastic know-how. Though the "obstacles" were many, the course was "par'd" . . . and another Consolidated triumph was scored!

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THIS REMARKABLE new cathode-ray oscilloscope is packed with features previously found only in large and expensive laboratory equipment. The WO-79A has:

- A wide frequency range — flat (±2 db) from 10 cycles to 5 megacycles.
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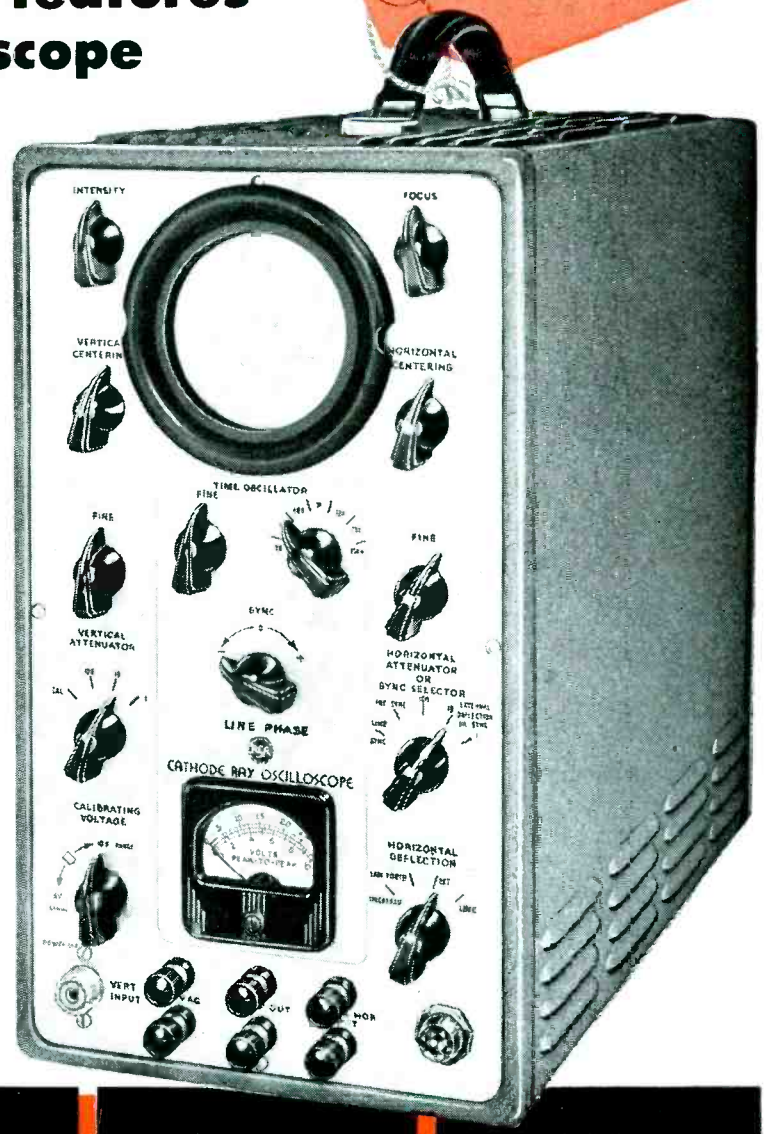
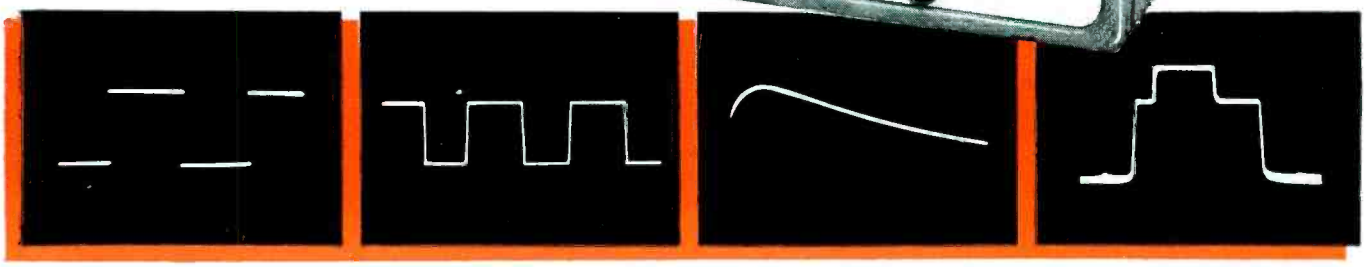
- A vertical deflection sensitivity of 0.18 rms volts per inch.
- A horizontal deflection twice the screen diameter—permits signal expansion and centering of any portion of a complex wave-form for close study.
- A calibration meter for voltage measurement.
- A new cathode-ray tube featuring small bright spot and distortionless focusing.

Traces produced by this three-inch scope are strong, sharp, easy to photograph. Extremely short, steep-fronted pulses and high-speed transients can be closely examined. Voltages produced by television synchronizing and deflection circuits, ignition systems, pulse generators, radar equipment and industrial devices can be quickly and accurately measured.

A new, eight-page bulletin on the WO-79A fully describes the many pace-setting innovations incorporated in this portable time-saver. Detailed application information is given on how these features can be used by the laboratory technician, service engineer, and broadcaster to simplify test and measuring problems. Be sure to get a copy. Write: Dept. 30-C, Test and Measuring Equipment Section, Radio Corporation of America, Camden, New Jersey.





A 30-cycle square wave as seen on the WO-79A. There is no visible curvature. The frequency response of the instrument is flat down to 10 cycles.

How a 100-kc square wave looks on the WO-79A. Note that overshoot is insignificant. The vertical amplifier is flat to 5 mc. Traces are bright, easy to photograph.

Wave-form resulting from condenser discharge. Internal synchronization and expansion as high as 500 times enables the WO-79A to produce a trace like this.

The WO-79A is helpful in television work. This trace of a horizontal sync pulse has been expanded to show details of pedestal. Note clarity of front and back porches.

RCA

TEST AND MEASURING EQUIPMENT

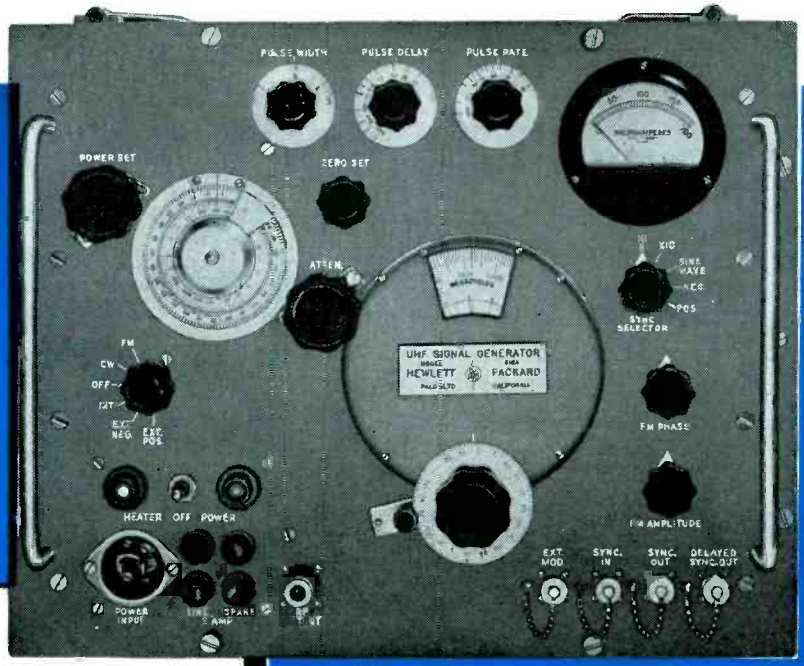
RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

PROUDLY PRESENTS

MODEL 616A UHF SIGNAL GENERATOR



NOW! for the first time

Fast, direct readings 1800 to 4000 mc

Here for the first time is an uhf signal generator that combines direct reading scales, simplified controls, and c-w, pulsed, or a limited f-m output with a wide frequency range and a rugged, compact design.

Direct Reading, Direct Control

Carrier frequency in mc may be directly *set* and *read* on the large central frequency dial. R-f output from the reflex klystron oscillator is also *directly set* and *directly read*, in microvolts or db, on the simplified output dial. No calibration charts or interpolations are necessary. And because the unique coupling device causes oscillator repeller voltage to automatically track frequency changes, no voltage adjustments are necessary during operation. Even the bolometer circuit is automatically compensated for temperature changes.

C-W, F-M, or Pulsed Output

R-f output ranging from 0.1 volt to 0.1 microvolt is available. Output may be continuous or pulsed, or frequency modulated at power supply frequency. Maximum deviation is approximately ±5 megacycles. Pulse modulation may be supplied from an external source or provided internally. Pulse rate is variable between 40 and 4000 cps, and pulse width ranges from 1 to 10 microseconds. Internal pulsing may be accurately synchronized with either positive or negative external pulses, or external sine waves. R-f pulse may be delayed 3 to 300 micro-seconds with respect to the external synchronizing pulse. Output trigger pulses are also available. They may be simultaneous with the r-f pulse or delayable from 3 to 300 microseconds with respect to the r-f pulse.

Wide Range, Great Stability

A twist-of-the-wrist precision tunes the *-hp-* Model 616A to any frequency between 1800 and 4000 mc. Accuracy of calibration is within ±1% and stability is of the order of 0.005% per degree centigrade in ambient temperature. Line voltage changes of ±10% cause frequency changes of less than 0.02%. 1380

Wide Applicability

The *-hp-* Model 616A UHF Generator is ideal wherever precision ultra-high frequencies are needed for measuring purposes. Some of its many uses include determining of receiver sensitivity, signal-noise or standing-wave ratios, conversion gain, alignment, antenna or transmission line characteristics. The instrument is light and compact, occupying minimum bench space. It is unusually rugged of design for long-term, trouble-free operation. Repairs and replacements, when necessary, are made extremely easy by straight-forward circuit layout and ready accessibility of all components.

The *-hp-* Model 616A UHF Signal Generator is available for early delivery. Write or wire today for full technical details.

HEWLETT-PACKARD COMPANY
1380A Page Mill Road, Palo Alto, California
Export Agents: FRAZAR AND HANSEN
301 Clay Street, San Francisco 11, California, U.S.A.

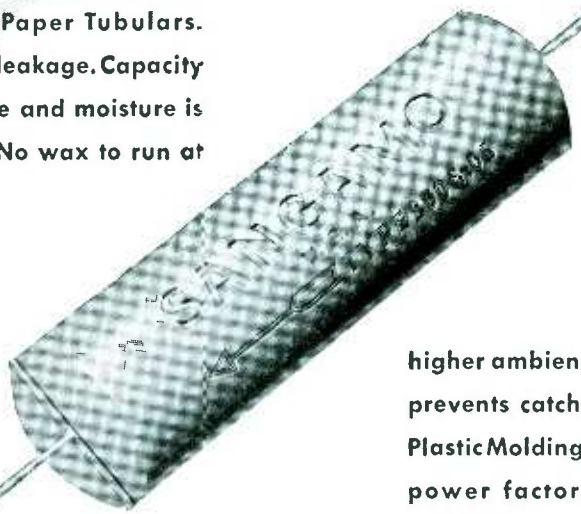
hp laboratory instruments
FOR SPEED AND ACCURACY

Audio Frequency Oscillators *Signal Generators* *Vacuum Tube Voltmeters*
Noise and Distortion Analyzers *Wave Analyzers* *Frequency Meters*
Square Wave Generators *Frequency Standards* *Attenuators* *Electronic Tachometers*

SANGAMO PAPER TUBULAR CAPACITORS ARE NOW MOLDED in PLASTIC

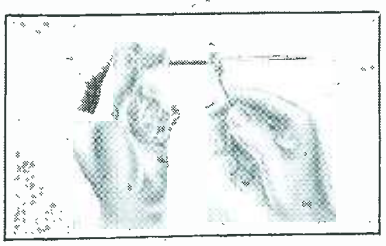
...just like micas!

Paper Tubular Capacitors, molded in Thermo-Setting Plastic! Designed for use in all circuits calling for Paper Tubulars. Plastic Molding means no leakage. Capacity values remain more stable and moisture is completely sealed out. No wax to run at higher ambient temperatures. Smooth finish prevents catching dirt and dust. All in all, Plastic Molding assures longer life and lower power factor. Specify Sangamo Plastic Molded Capacitors wherever you use Paper Tubulars.

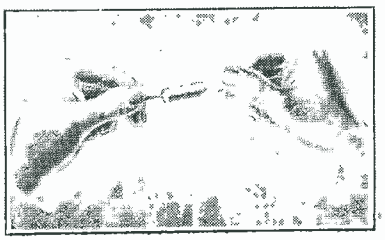


...try these tests WITH SANGAMO PLASTIC TUBULARS ....

WRITE NOW for the New Sangamo Capacitor Catalog for full information on the Sangamo Line.

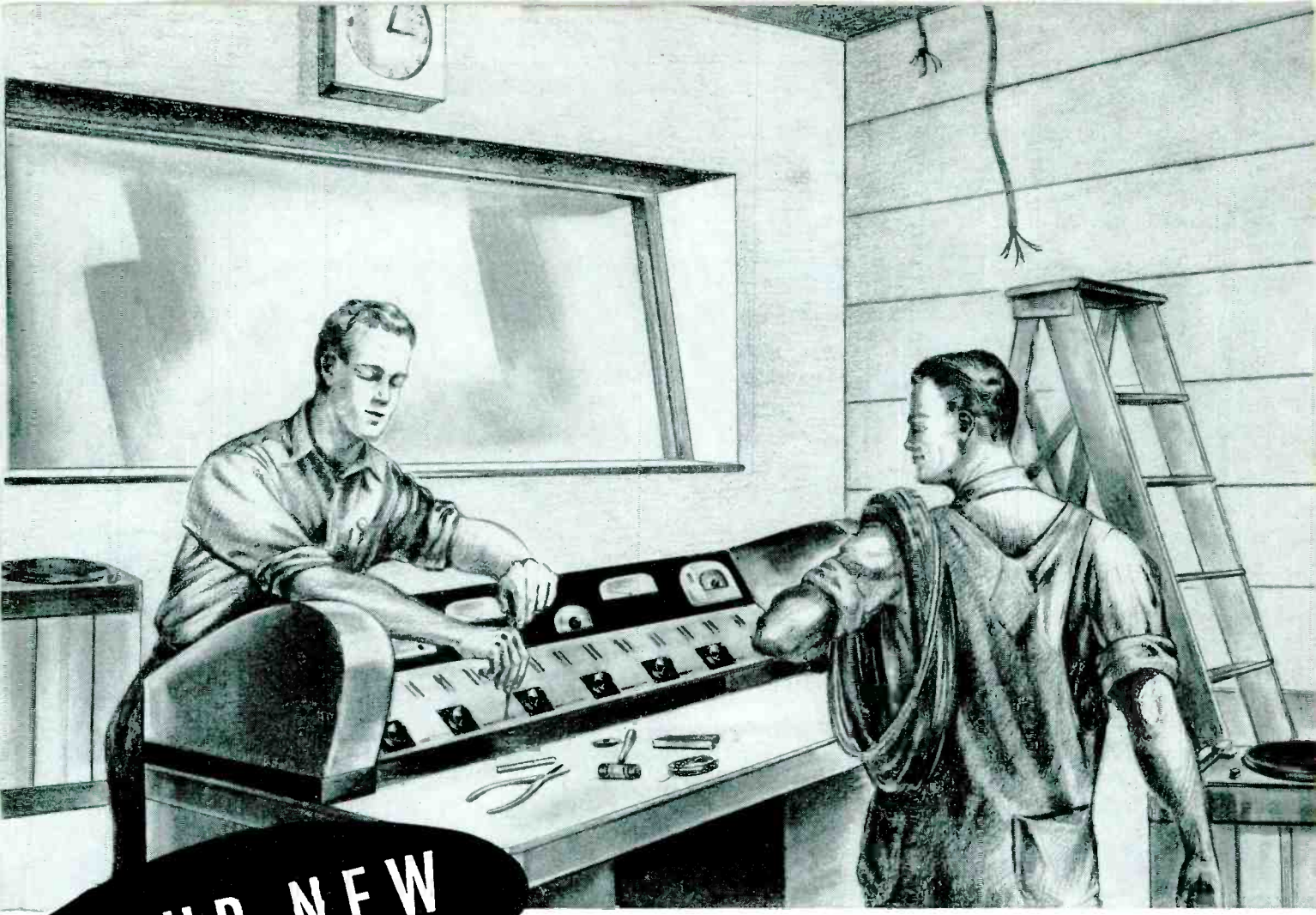


NO WAX TO MELT....even heat as intense as is encountered in soldering, will not cause leakage in the case or at the lead joint.



LEADS WILL NOT PULL OUT...Plastic Molding so tightly seals the leads in place, that under all conditions of normal use, leads will stay put.

SANGAMO ELECTRIC COMPANY SPRINGFIELD ILLINOIS



YOUR NEW STUDIOS.....EQUIPPED BY *Langevin*

WILL BE EXACTLY WHAT YOU NEED
EXACTLY WHAT YOU WANT

Custom Built Langevin audio facilities for broadcast studios are designed and manufactured to fit the requirements and specifications of the individual broadcaster.

Using Langevin FM quality amplifiers as the basic building blocks, complete audio facilities, including the type console you want, can be engineered and fabricated in our "custom built" department. The Langevin service also includes on-the-job installation supervision, if desired.

In many cases a Langevin custom built audio system, tailored to fit your needs, is no more costly than a combination of standard packaged speech input units.

A Langevin Audio Facilities Engineer is always on call . . .

Let him help you with your equipment planning . . .

The Langevin Company
INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK, 37 W. 65 St., 23 · SAN FRANCISCO, 1050 Howard St., 3 · LOS ANGELES, 1000 N. Seward St., 38

HERE'S REAL CONTACT EFFICIENCY!

SILVER-GRAPHITE

30% HARDER FOR LONGER LIFE . . .
GREATLY IMPROVED CONTACT DROP

This new Stackpole material is 30% harder than conventional Silver-Graphite contact types. It greatly prolongs contact life under short circuit conditions, assures far better contact drop, and tremendously improves wearing qualities. It contains from 3½% to 10% graphite and can be made in practically any needed contact shape or size for a wide variety of circuit breaker, contactor and relay applications. On particularly difficult high-amperage applications the use of one of these contacts operating against an FW-41 silver-tungsten contact may provide truly outstanding efficiency.

SILVER-TUNGSTEN

STACKPOLE FW-41 FORMULA
HANDLES HIGH AMPERAGES

Through the efficiency of this Stackpole silver-tungsten contact material, the interrupting capacity of a circuit breaker made by a leading manufacturer was increased from 10,000 to 15,000 amperes. On special test, it interrupted 21,000 amperes without apparent harm to the contacts! Not only that, but Stackpole's FW-41 contact formula paved the way to constructing this same circuit breaker to a size one-third smaller by volume and with half as many parts! Write for details.

NOTE: Stackpole Contacts are sold only for original equipment purposes — not as replacements.

Write for Stackpole Contact Catalog and Data Book No. 12

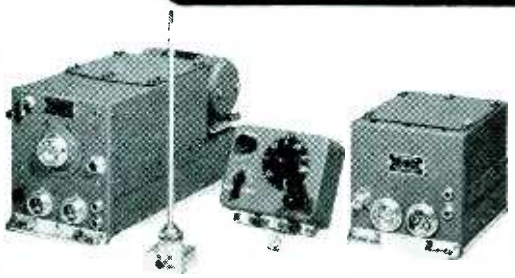
STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE

BRUSHES AND CONTACTS (All molded carbon, graphite, and metal composition types) • RARE METAL CONTACTS • SINTERED ALNICO II • WELDING CARBONS • MOLDED IRON CORES • PACKING, PISTON and SEAL RINGS • CHEMICAL CARBONS, etc.

AIRCRAFT RADIO CORPORATION

Among the A.R.C. RADIO COMMUNICATION AND NAVIGATION SYSTEMS are



TYPE 11 SYSTEM
Range Receiver and VHF Transmitter.
or **TYPE 17 SYSTEM**
VHF Receiver and VHF Transmitter.

TYPE 15
VHF Omni-Directional
Range Receiving Equipment.

Among the A.R.C. ELECTRONIC COMPONENTS AND ACCESSORIES are

"MUSIC-BOX" TYPE SELECTOR SWITCHES →

For low-voltage control circuits.
Unusually positive detent action.
Lever-type control handle.

← **CERAMIC-INSULATED PLUGS AND RECEPTACLES**

- 24 combinations.
- 2 to 19 contacts.

← **CERAMIC-INSULATED MINIATURE DC RELAYS**

1¼" long.
SPST, SPDT, DPST, SPST-SPDT, and DPDT.

DRY ELECTROLYTIC SEALED CONDENSERS →

Terminals mounted on mica.
No bakelite-rubber seals.

MINIATURE PIN-PLUG CONNECTORS →

Specially designed to minimize spring fatigue.

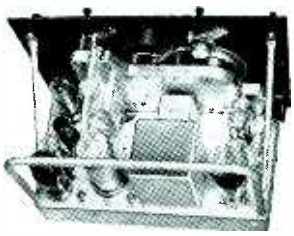
← **SNAPSLIDE FASTENERS**

7/16" wide size, for heavy loads.
¼" wide size, for light loads.

Among the A.R.C. MICROWAVE UNITS AND ACCESSORIES are

TYPE H-10 TEST SET
for the 1.2 cm band

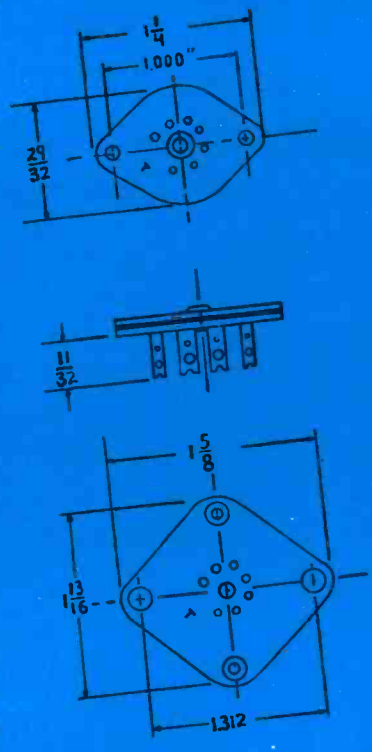
and various assemblies for the 10 cm, 3.3 cm, and 1.2 cm bands.



Aircraft Radio Corporation
Boonton, N. J.

FRANKLIN ANNOUNCES

TWO NEW MINIATURE LAMINATED SOCKETS



57 A 11 . . . for 1" between mounting centers

57 A 12 . . . for 1-5/16" between mounting centers

57 A 11 and 57 A 12 Miniature Laminated Sockets have spring type contacts that GRIP and hold the tube securely without the need for locking devices. These contacts, being longer and spaced wider apart, permit greater ease in soldering thus lower production costs. 57 A 12 is interchangeable with Octal Sockets of like mounting center enabling chassis design for use with either.

and for TELEVISION the DUO DECAL

ELECTRONIC COMPONENTS

A. W. FRANKLIN MFG. CORP.

43-20 34th STREET · LONG ISLAND CITY 1, NEW YORK

SOCKETS • TERMINAL STRIPS • PLUGS • SWITCHES • PLASTIC FABRICATION • METAL STAMPINGS • ASSEMBLIES

Your Cable Problems *stated here*

★ ANSONIA ★ Ankoseal *answers here*

We have designed many cables which have solved a multitude of problems. When you come to Ansonia for something original in cables, our engineers will turn out a product to meet your specific requirements.

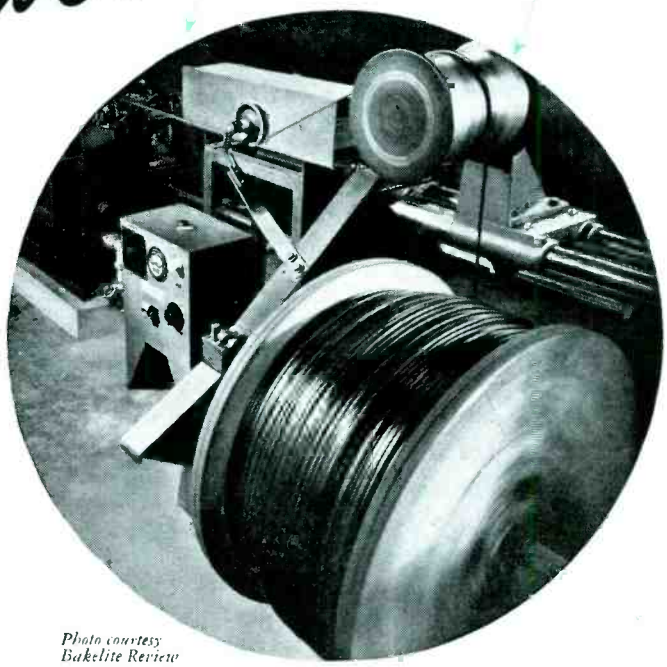
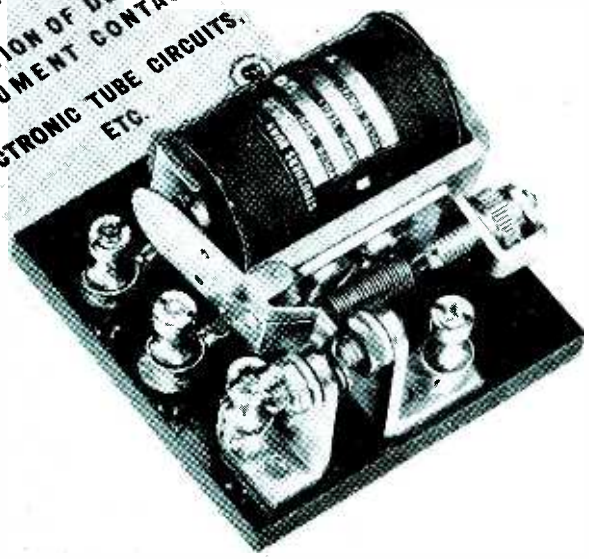


Photo courtesy Bakelite Review

THE ANSONIA ELECTRICAL DIVISION
ANSONIA, CONNECTICUT *of*
NOMA ELECTRIC CORPORATION

BURGLAR ALARM SYSTEMS
FIRE ALARM CIRCUITS
HIGH SPEED KEYING
TEMPERATURE CONTROL OF INCUBATORS
PROTECTION OF DELICATE INSTRUMENT CONTACTS
ELECTRONIC TUBE CIRCUITS, ETC.



SENSITIVE LOW-POWER RELAYS in a newly improved design

FOR USE ON AC AND DC

Engineering superiority in every mechanical and electrical detail makes Struthers-Dunn Type 112 Relays far and away "tops" for sensitivity and durability for low-power operation on the order of a few milliwatts • A "fool-proof" micrometer adjustment assures exceptionally reliable setting of the contact spring • All parts are of low-inertia, quick-acting design • Contacts are easy to adjust and stay "put" once adjusted • Coils are well insulated and vacuum impregnated • These new relays are built throughout for easier installation, higher sensitivity, longer life • Available in single-pole double-throw and double-pole double-throw contact combinations.

Write for Data Bulletin 112.

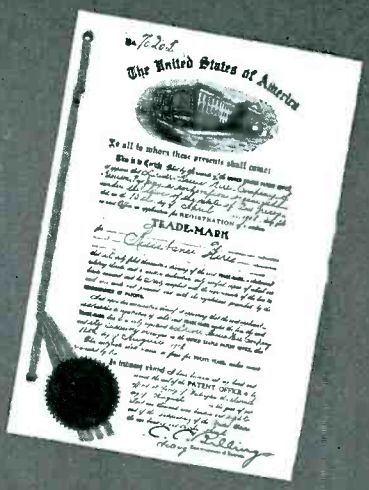
S-D
5,327 RELAY TYPES

STRUTHERS-DUNN

STRUTHERS-DUNN, Inc., 150 No. 13th St., Phila. 7, Pa.

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS
DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL
NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

A Statement of Major Importance regarding



Nichrome*

Electrical Resistance Wire

FROM TIME TO TIME, a product is developed which—by virtue of its originality, overall superiority and general acceptance—meets with instantaneous and lasting success. In so doing, it establishes itself as the standard of quality by which all other similar products are judged.

In industry, an outstanding example of this is NICHROME.

NICHROME is a nickel-chromium alloy electrical resistance wire which is made *only* by *Driver-Harris Co.* Further, it is a *trade mark*, officially registered by the U.S. Patent Office on August 11, 1908 more than thirty-eight years ago. Its leadership in the electrical resistance field brilliantly reflects the highly specialized knowledge of technical processes and precise metallurgical controls which have made possible Driver-Harris' outstanding alloy developments for more than 47 years.

Although there are several excellent nickel-chromium alloy combinations, there is only one NICHROME—and it is made only by the Driver-Harris Co.

Remember this when next you buy electrical resistance wire. Be sure your supplier understands that you want the *genuine* NICHROME made only by *Driver-Harris,* for no other company manufactures NICHROME.

SPECIAL PURPOSE ALLOYS SINCE 1899

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.

The Curve is UP

FOR ELECTRONIC-HEATING INSTALLATIONS!

Profit BY DESIGNING YOUR EQUIPMENT AROUND HIGH-EFFICIENCY G-E TUBES LIKE THE NEW, COMPACT GL-592 POWER TRIODE...

THERE'S good business ahead—as well as *now*—for builders of electronic-heating equipment! And the heart of this equipment is the tubes. As industry finds wider applications for high-frequency heating—develops revolutionary new processes, like stitching plastic sheets electronically and cooking foods in seconds instead of minutes or hours—General Electric keeps step by its tube research. *For every high-frequency heating application, there's a G-E tube ready to do the job!*

Type GL-592—NEW efficient power triode—typifies G-E progress. Designers today are considering higher frequencies for dielectric-type heating . . . and the GL-592 will operate up to 110 megacycles at max ratings! Many heating jobs call for small to medium-size installations, with economy paramount. So the GL-592—besides being low in first cost—*conserves power* with its anode input of 600 watts and dissipation of 200 watts!

The tube is sturdily built for hard service. Cathode, grid, and anode are solidly mounted and braced. All leads are short. Fernico metal-to-glass seals make possible (1) elimination of a base with its dielectric losses, (2) the non-soldered anode terminal that withstands high temperatures. All contacts are silver-plated for efficiency.

Whether your heating application be induction or dielectric—whether large or small—*G.E. has the right electronic tube for you.* And G-E tube engineers are glad to work closely with your designers. See your nearest G-E office, or write to *Electronics Dept., General Electric Company, Schenectady 5, N.Y.*

RATINGS

Cathode voltage	10 v
Cathode current	5 amp
Max anode ratings:	
voltage	3,500 v
current	250 ma
input	600 w
dissipation	200 w
Type of cooling	forced-air

● The G-E line of power triodes for high-frequency heating is complete, covering every need and application. There are 17 types. Max anode voltages range from 2,000 v to 20,000 v—current from 250 ma to 10 amp—dissipation from 125 w to 100 kw. Prices and details on any or all types are available on request.

GENERAL ELECTRIC

162-E6-6550

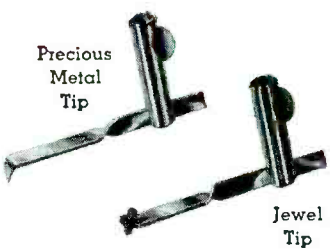
FIRST AND GREATEST NAME IN ELECTRONICS

One for the Record

"ON THE QT"

Astatic introduces another entirely NEW and improved PHONOGRAPH CARTRIDGE...the Model "QT."

THIS "QUIET TALK" CARTRIDGE IS DESIGNED ESPECIALLY FOR HOME USE AND IS EQUIPPED WITH A *REPLACEABLE* NEEDLE OF THE MOST ADVANCED TYPE.



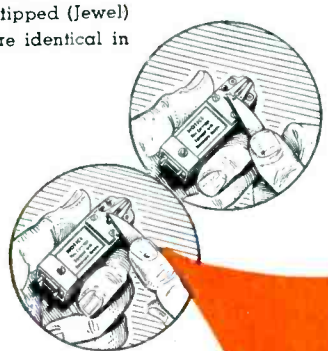
THE improved design of this needle, allowing appreciably more vertical compliance than has heretofore been possible, results in a VAST REDUCTION in the amount of surface noise which is ordinarily radiated directly from the needle. Pleasing reproduction and the absence of acoustic noise, together with low order of distortion, make the "QT" Cartridge ideally suited for home use.

TYPE "QT" AVAILABLE IN TWO MODELS

Model "QT-M" is supplied with precious metal-tipped stylus; Model "QT-J" with sapphire-tipped (Jewel) stylus. Both models are identical in every other respect.

Simple Method Devised for the Removal and Insertion of Needles

Needles in the "QT" Cartridge may be removed quickly by placing knife blade beneath needle and prying gently upward. Replacements are made by inserting shank of needle in socket and pressing down gently.



WE'LL SEE YOU AT THE CONVENTION!

Astatic's complete line of products will be on display at the National I.R.E. Convention, at Grand Central Palace, New York City, March 3 to 6, inclusive.

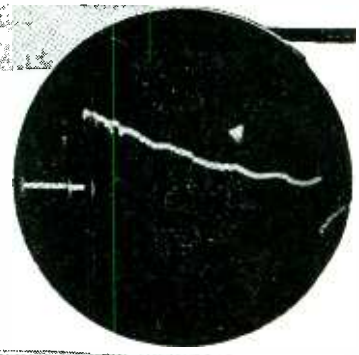
"QT" Literature is Available

THE Astatic CORPORATION
ASTATIC
CONNEAUT, OHIO
IN CANADA CANADIAN ASTATIC LTD. TORONTO ONTARIO

Astatic Crystal Devices Manufactured under Brush Development Co. patents.

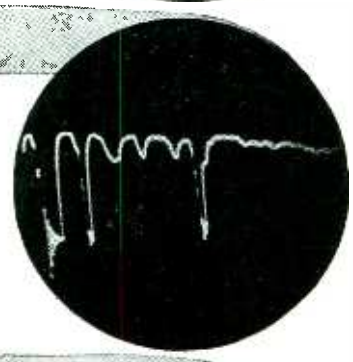
DU MONT CATHODE-RAY *Oscillography* PLAYS AN IMPORTANT ROLE IN INDUSTRY

FENCE-CHARGING EQUIPMENT



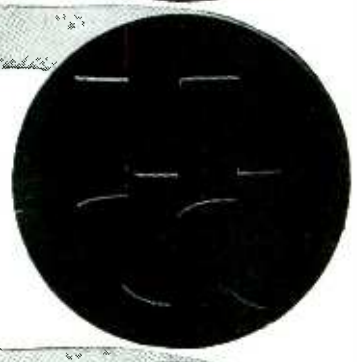
In designing or testing devices for supplying short electrical shock pulses to a fence conductor, it is essential to know the maximum voltage, shape and duration of each pulse, as well as the repetition rate. The Type 247 Cathode-ray Oscillograph is ideal for this application.

POWER EQUIPMENT



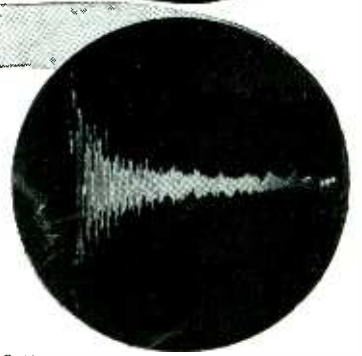
A detailed examination of the closing action of relay contacts may easily be made when using a Type 247 Oscillograph. This will reveal whether the contact closing is positive or subject to rebounce. The duration of the entire bouncing period can be accurately determined by superimposing time markers on the applied signal, and the effects of corrective adjustments may be instantly observed.

AUDIO AND VIDEO AMPLIFIERS



There is no quicker way to determine phase, frequency and amplitude distortion in an amplifier than by applying a square-wave signal to the amplifier input and visually observing the output waveform. Both the input and output signal waveforms may be viewed simultaneously on the Type 5SP Cathode-ray Tube when driven by two Type 208-B, 241, 247 or 248 Oscillographs, or most combinations of these types.

ACOUSTICS

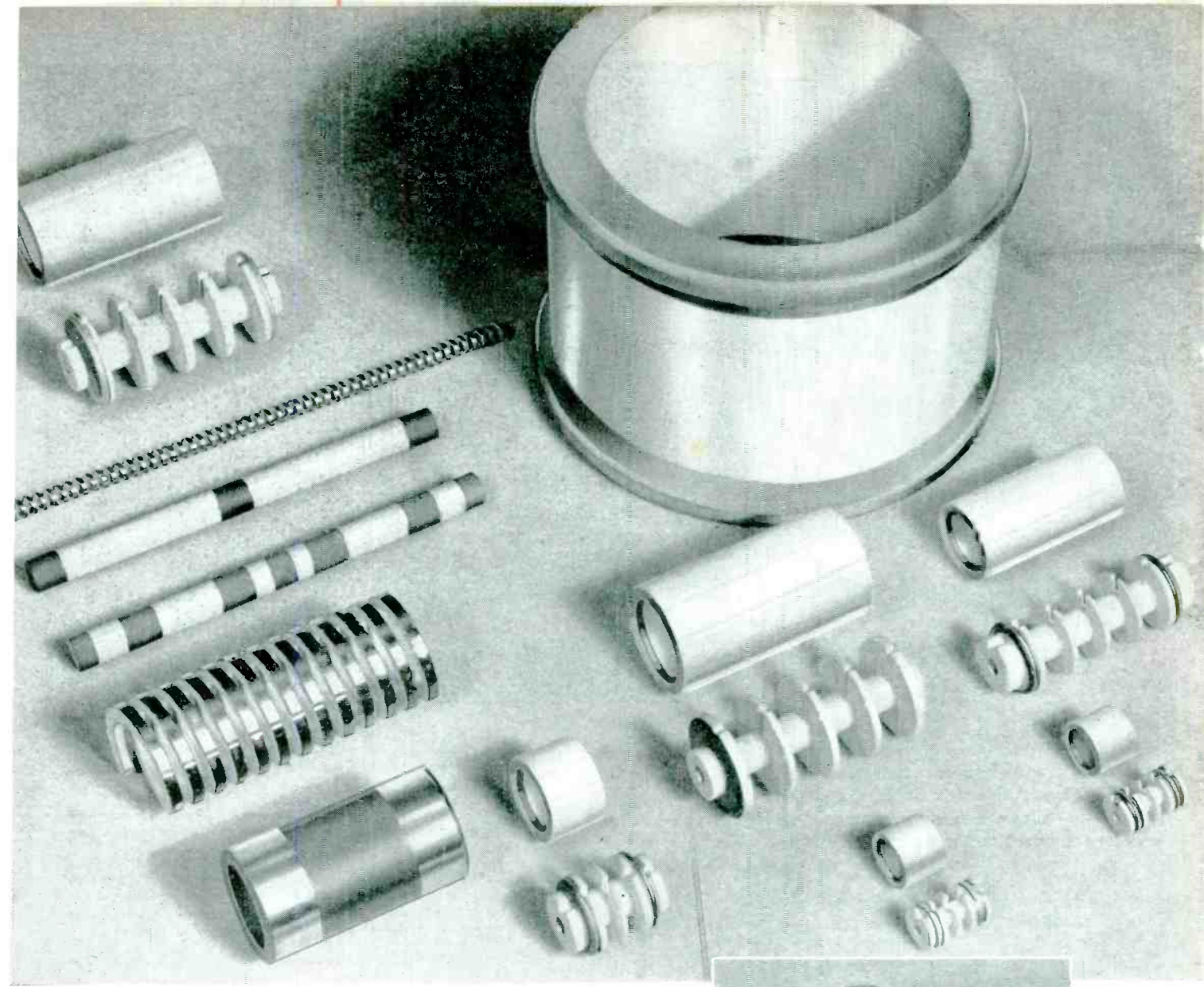


By using a Type 208-B combined with a Type 215 Sweep Generator or by using a Type 247 Cathode-ray Oscillograph when conducting a reverberation test, accurate information may be obtained as to the damping time of sound waves. It is also possible to plot any "dead spots". If remedial measures for either condition are necessary, the effects of the corrections can be seen instantly.

DU MONT CATHODE-RAY EQUIPMENT MAY BE THE LOGICAL ANSWER TO YOUR PROBLEM!

DUMONT *Precision Electronics & Television*

ALLEN B. DU MONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK

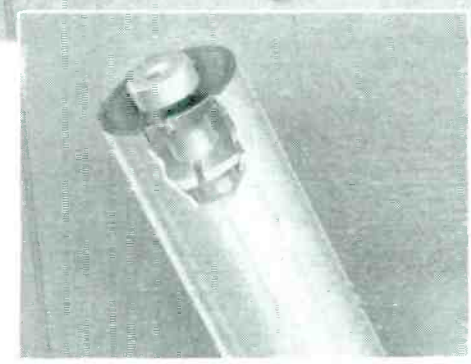


Metalized ALSiMAG

TRADE MARK

CUSTOM MADE TECHNICAL CERAMICS

For bonding metal to ceramics . . . or ceramics to ceramics



Sectional view shows method of hermetically sealing Shallcross precision resistors using AlSiMag metalized cores and AlSiMag metalized shells.

Prompt deliveries of Metalized AlSiMag Ceramics are currently available due to completion of expanded facilities for this work.

Metalized AlSiMag Ceramics create a mechanically strong join because the metal is fired to the ceramic. According to your requirements, silver, gold or platinum is used. Where desirable, copper or silver plating is added to build up metal to the optimum thickness for the individual application.

Metalized AlSiMag Ceramics can be soft solder sealed to other metalized AlSiMag Ceramics or to any metal which can be easily wet. Hermetic seals with a high degree of permanence are readily accomplished.

American Lava Corporation engineers will be glad to cooperate in developing the ceramic and the metalizing specifications which are best suited to your requirement.

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENNESSEE

45th YEAR OF CERAMIC LEADERSHIP

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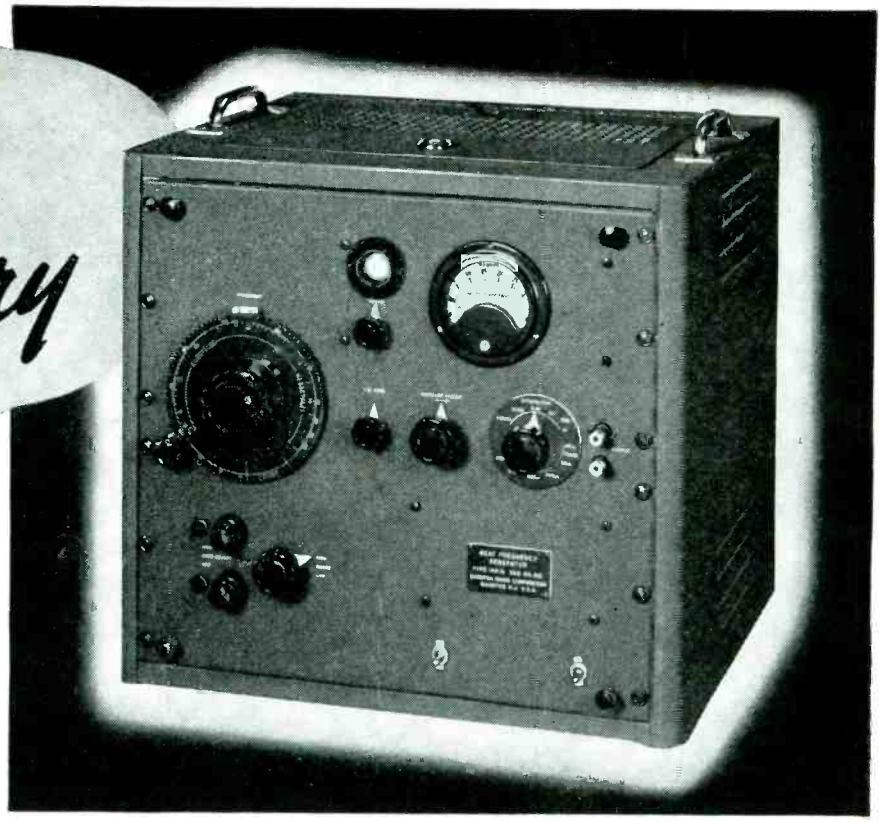
For the Laboratory



BEAT FREQUENCY GENERATOR

TYPE 140-A

This instrument has found universal acceptance because of its wide frequency coverage from 20 cycles to 5 megacycles. A five step decade attenuator provides a means by which extremely small output voltages can be accurately set and a six position switch enables any one of a variety of output impedances to be quickly selected.

SPECIFICATIONS:

FREQUENCY RANGE: 20 cycles to 5 megacycles in two ranges. Low range: 20 to 30,000 cycles. High range: 30 kc to 5 megacycles.

FREQUENCY CALIBRATION: Accuracy ±2 cycles up to 100 cycles, ±2% above 100 cycles.

STABILITY: About 5 cycles drift below 1000 cycles. On low range, drift becomes negligible percentage with increasing frequency. On high range, drift is 3% or less.

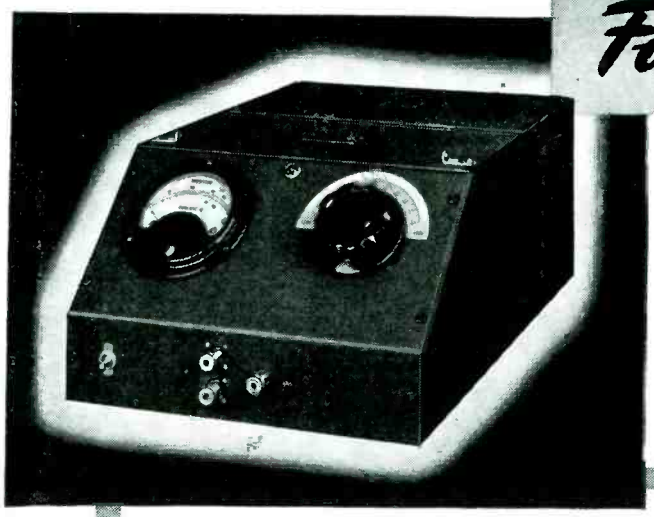
ADJUSTMENT: High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1 inch cathode ray tube.

OUTPUT POWER AND IMPEDANCES: Rated power output: One watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both high and low frequency ranges from an output impedance of 1000 ohms.

DISTORTION: 5% or less at 1 watt output, 2% or less for ½ voltage output.

VOLTMETER ACCURACY: ±3% of full scale reading.

For further details write for Catalog D



For the Production Line

QX-CHECKER *TYPE 110-A*

This production-test instrument is specifically designed to compare relative losses or Q simultaneously with inductance or capacitance in one operation and with a single setting. Built to laboratory precision standards, the QX-Checker is a sturdy, foolproof instrument for use in production work by any usual factory personnel.

SPECIFICATIONS:

FREQUENCY RANGE: 100 kc to 25 mc in 6 ranges using plug-in coils.

ACCURACY OF COIL CHECKS: May be checked against standard to within about 0.2% with coil values of 10 microhenries to 10 millihenries and Q of 100 or greater.

CAPACITANCE RANGE: Capacitance values ranging between approximately 2-1000 mmf may be checked against a standard to an accuracy of a few tenths of one mmf if the Q of the capacitor is high.

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C-D's experience in designing and building noise suppressors is unequalled in the capacitor industry. We are now manufacturing hundreds of types of noise filters for electrical appliances and equipment. It's possible, of course, that the exact unit for solving *your* noise problem is not included. In that case, our engineers are ready and anxious to design and build the suppressor best suited to your specific requirements—*better, faster, more economically. Consult with them.*

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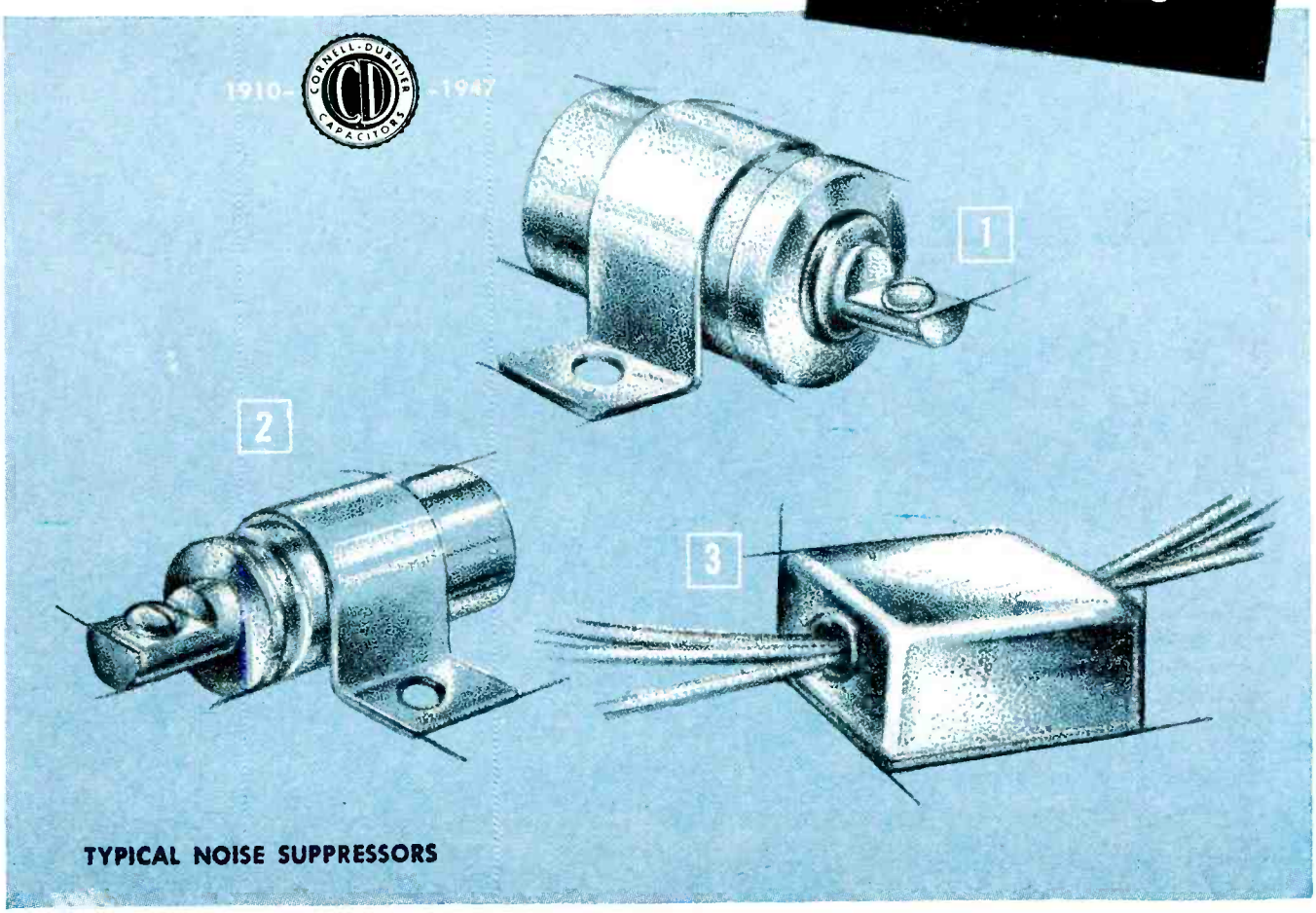

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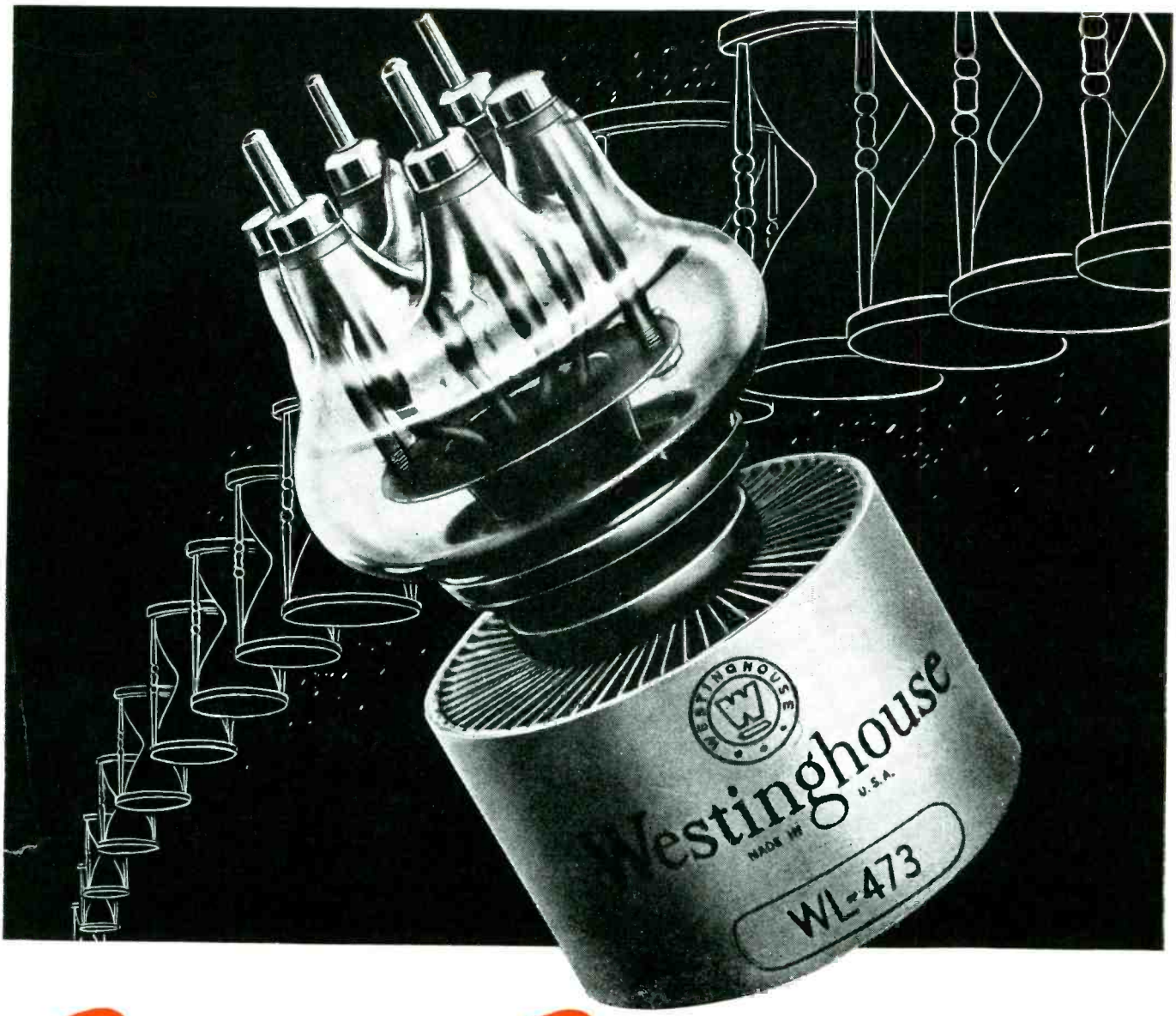
CAPACITORS #1 AND 2

Two of the Type MC Filter Capacitors designed for heavy duty service on buses, trucks, etc. for spark and noise suppression. Mechanically rugged, oil filled and impregnated and hermetically sealed.

CAPACITOR #3

A general purpose filter effectively controls radio noise energy created by fluorescent lamps. This capacitive – inductive type filter is compact and can be quickly installed in a variety of positions. Convenient leads simplify installation.



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This rugged Westinghouse pliotron WL-473 is being successfully used in R-F heating equipment and FM transmitters by many of the country's most prominent manufacturers of electronic equipment. It has established a fine reputation for dependable operation in rigorous industrial service.

In order to render prompt and efficient replacement tube service, Westinghouse *Quality Controlled* tubes are stocked in Westinghouse district warehouses and with Westinghouse distributors throughout the country.

For the best performance of your electronic equipment, be sure to order Westinghouse Electronic Tubes. For further information consult your nearest Westinghouse office or any Westinghouse Electronic Tube distributor.

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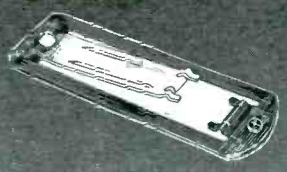
UNIMAX IS UNIFORM

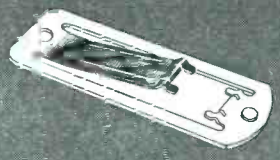
This simple electro-mechanical structure . . . the critical element of the UNIMAX Precision Switch . . . embodies the necessary features for consistency of response to actuating force.

The switching member is a strip of heat-treated beryllium copper with a silver button contact at the free end.



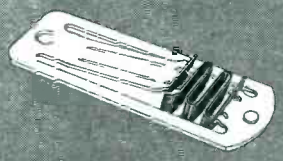
This one-piece switch blade, secured to a heavy brass insert in the phenolic base, withstands millions of flexures without fracture, and has low electrical resistance to carry full rated current without overheating.

The actuating member is a rigid tongue integral with the switch blade.



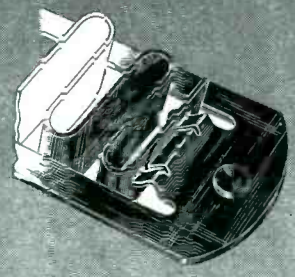
The dimensions, form, and position of the actuating member are strictly controlled to assure accurate conformity to performance requirements.

The stress-inducement spring is a convolute of extremely flat gradient and low stress.



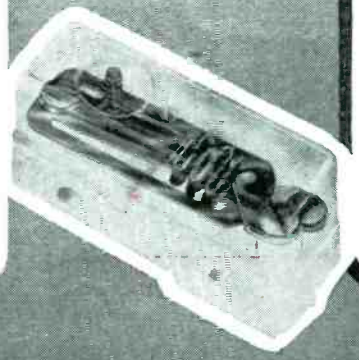
The flat gradient of the stress-inducement spring assures negligible change in stress thru-out the working range, thus providing consistency of characteristics during the long life of the switch.

The stress-inducement spring is proportioned for stability. Knife-edge pivots are provided between the spring and the actuating and switching elements.



This folded, flat spring is rigid in its longitudinal plane and its long, side elements with knife-edge bearings provide lateral rigidity; thus the spring resists deformation in any but the desired direction. The stability of the spring and the negligible friction in the knife-edge bearings contribute to consistency of operating point and to low differential operating force.

The entire UNIMAX is constructed of components held to close tolerances in fabrication and assembly. Hence it is truly a *precision* switch.



The design and structure of UNIMAX make it an inherently dependable product, suited to most requirements for compact, precision switches. To receive new UNIMAX data, as released, mail this coupon TODAY.

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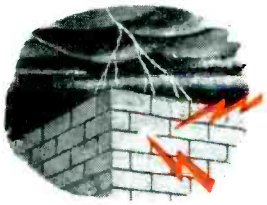
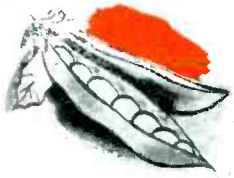


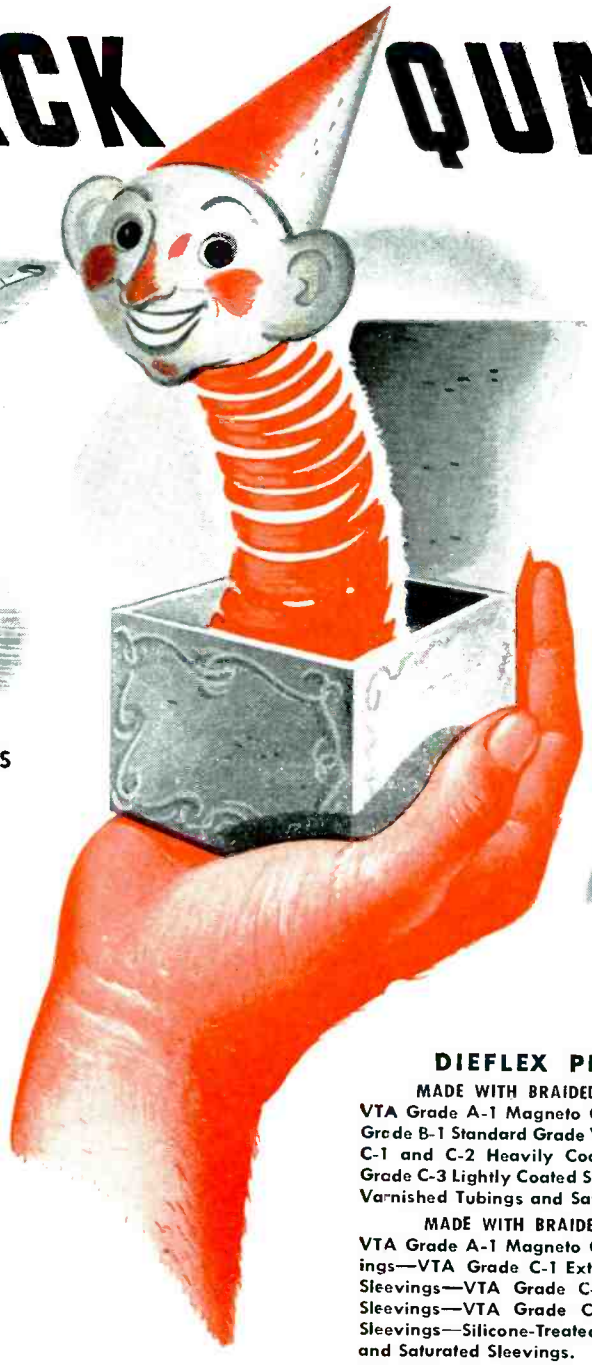
DIELECTRIC STRENGTH

COMPLETENESS OF LINE

SMOOTH INSIDE BORE



UNIFORMITY OF PRODUCT



An important factor in both cost and high production of electrical devices is ease of assembly. Dieflex varnished tubings and saturated sleevings are non-fraying products with unusually good push-back characteristics. It is easy to solder and join connections and to splice with Dieflex due to these push-back and non-fraying qualities.

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INDUSTRY-WIDE BARGAINING...

Death Trap for Business, Suicide for Free Labor

IF CONGRESS is to succeed in its present efforts to prevent strikes in key industries from devastating the nation, it will have to put a crimp in industry-wide collective bargaining. This kind of bargaining is designed to apply agreements between employers and organized workers on wages and working conditions to an entire industry.

Further, if extension of this type of bargaining is not curbed, there is reason to believe that it will undermine the freedom of both American business enterprise and American wage earners. For, while increasing the destructive power of labor disputes, the general spread of industry-wide bargaining would so concentrate the fixing of wages—by far the largest element in the cost of production—that government regulation would be a next short step. With that step taken, freedom for business enterprise and freedom for labor would be well on the way out.

Unfortunately, industry-wide bargaining is commonly regarded as presenting a general conflict between organized labor and employers, with unions favoring it and employers opposed to it. This mistaken notion raises the heat of much of the discussion without increasing the light. The fact is there is no such general conflict. Employers and organized workers are on both sides of the argument about industry-wide collective bargaining. For example, while some union leaders are characterizing as labor baiters all those who raise the slightest question as to the desirability of industry-wide bargaining, organized workers in the air transport industry are strenuously opposing that type of bargaining; and the employers are advocating it.

Some Employers Like It

The reason there is in fact no clear cut issue between employers and unions over industry-wide bargaining is readily understandable. It presents certain advantages to both sides in the bargaining process. For example, union advocates of such bargaining generally stress the fact that industry-wide agreement on wages protects wage standards from being undercut by lower wage areas and lower wage employers. By much the same token, however, employers who like it often emphasize the fact that industry-wide bargaining may save certain well-managed and prosperous companies from being singled out for particularly heavy wage exactions. This general point has been underlined in both the full-fashioned hosiery industry and the West Coast paper and pulp industry. There, local unions, affiliated with international unions, have protested that industry-wide collective bargaining prevents them from getting from especially prosperous employers wages as high as they could get if allowed to go it alone in collective bargaining.

So long as employers remain subject to the federal antitrust laws while unions are exempted, the balance of power in industry-wide bargaining would seem to be heavily weighted on the side of the unions. If, for example, employers were to announce an intention to match an industry-wide wage increase by an industry-wide price increase, there is no doubt that they would promptly be indicted for violation of the federal antitrust laws. Even so, the fact remains that some employers favor industry-wide bargaining while some segments of organized labor are against it.

A Clear Cut Public Issue

The industry-wide bargaining issue as it affects the public, however, is clear cut. It is concentration of economic power (in the hands of both unions and management) which can make industrial conflict devastating to the public welfare. At least five times within about a year—in steel, on the railroads, in the maritime industry and twice in the soft coal industry—strikes prompted by union efforts to impose industry-wide agreement about wages and working conditions have paralyzed large parts of the nation's economic life.

In soft coal about 90% of the production workers are members of the United Mine Workers. In steel

about 80% of the production workers are members of the United Steelworkers, C. I. O. In some other key industries there is a comparable degree of concentration of union control. In the face of such concentration many employers see no alternative but to get together on their side for industry-wide bargaining. But when they do so in key industries, the odds are lengthened that failure to agree on wages and related matters, will result in generally ruinous conflict. If agreement is reached, the chances are increased that it will take too little account of the welfare of the consuming public.

It is possible to have industry-wide bargaining on many subjects other than wages. *But the main interest is wages; and the main drive is toward industry-wide and ultimately nation-wide uniformity. Such uniformity is the deadly enemy of industrial decentralization and the pioneering expansion of industry in new areas.* Why pioneer, with inexperienced workers, if the wage rate must be uniform for the whole industry? Moreover, it would also be hard to conceive of a more effective way to put a blight on local efforts to improve industrial relations than to make wage rates and other working conditions uniform throughout the industry and then the nation. *However, among many other dangers, the overshadowing danger in industry-wide bargaining lies in its concentration of economic power.*

Wages Monopolized

On the average, the cost of labor accounts for about two-thirds of the total cost of all industrial products. The universal spread of industry-wide bargaining would thus concentrate in relatively few hands control of the greater part of the cost of industrial production. There is no reason to believe that even without disastrous strikes, such concentration would long continue free from government regulation. That would turn more earth for the graves of American business enterprise and American working men's freedom.

Those who believe that industry-wide bargaining serves the public well—and many sincere people do—stress the fact that, on the whole, it has worked in the industries where it has been tried over a considerable period. Most of the industries of which this is true, however, are not key industries. The pottery industry, the glassware industry, and the silk and rayon dyeing industry—to cite a few in which industry-wide bargaining has been practiced with considerable success—are important industries. But they are not industries in which strikes would have a ruinous impact on the nation. In contrast, a strike in the soft coal industry as the result of a breakdown of industry-wide negotiations quickly becomes a national disaster. The dangers inherent in industry-wide bargaining are multiplied accordingly.

England No Guide

Those who think extension of industry-wide bargaining would be good for the public often emphasize the fact that it has worked smoothly in England, where it has been extensively practiced. *Not the least of the things it has smoothed in England, however, is the transfer from private enterprise to state socialism of industries in which industry-wide bargaining by monopolistic unions and employer groups had so badly undercut competition that private enterprise had lost much of its justification.* A general extension of industry-wide bargaining could be expected to have the same consequences in this country.

The best way to curb industry-wide bargaining is a question which lies beyond this discussion. *Much would be accomplished if the federal government would discontinue its active promotion of industry-wide adjustments, in the fields of both labor and management, at which it has been busy ever since N. R. A. days. Still more would be accomplished if the federal antitrust laws were applied with even-handed justice both to unions and employers—a course urged in the 53rd editorial in this series.* Perhaps a definite limitation of the scope of labor agreements would also be necessary.

The effects of industry-wide bargaining in increasing the extent of public regulation of industry will vary. They will, of course, be less pronounced in railroads and other public utilities, which are already extensively regulated, than they will be elsewhere. For unregulated industries, however, industry-wide bargaining carries the threat of extensive regulation and, along the way, of industrial conflict devastating to the public. In these excited times, to say what I have said here is to invite characterization by overheated partizans as a foe of legitimate union progress. That is perhaps not so bad, however, as to qualify as a pall bearer for both American business enterprise and some of the basic freedoms of American working men. That may well be the fate of those who blindly accept the expansion of industry-wide collective bargaining as being "in tune with the times."

President McGraw-Hill Publishing Company, Inc.

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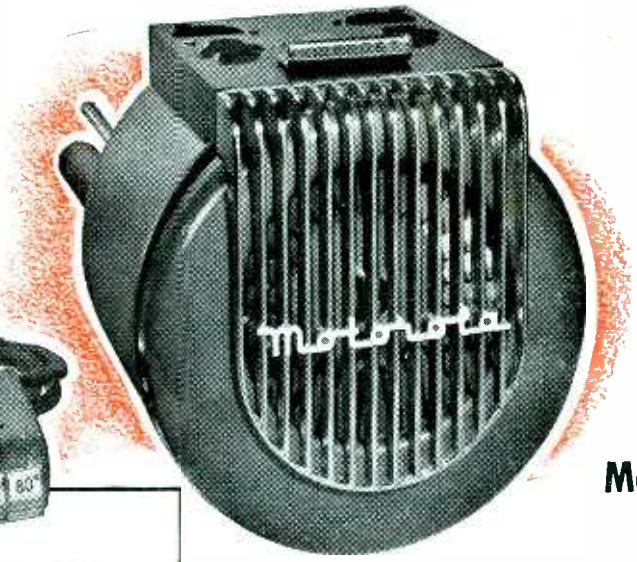
BEFORE You Leave the "Mock-up" Stage



Just as the Galvin Manufacturing Corp. did with their new Motorola Auto Heater

★ **These 14 Fasteners did the Trick**

Our new Bulletin No. 214 goes into detail on this Motorola job and is available for the asking. Since you may be able to use to advantage many of the fastening ideas illustrated, write for a copy today.

To take full advantage of the SPEED NUT System of Fastening, Galvin engineers brought the "mock-up" and prints of their new Motorola Heater to Tinnerman for a fastening analysis *before* building tools and dies. They sat right in with Tinnerman development engineers who went over the heater part by part—explored every possible production short cut—planned its assembly from start to finish.

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FASTEST THING IN FASTENINGS ***MORE THAN 4000 SHAPES AND SIZES***

BUSINESS BRIEFS

By W. W. MacDONALD

Marine Radio Equipment should be as hot as a stove this summer. Mixing business with pleasure (we have a subminiature auxiliary sloop out on Long Island Sound), we took in the boat show at New York's Grand Central Palace. At least a dozen manufacturers of ship-to-shore phones, d-f equipment, underwater sounding devices and other electronic navigational instruments exhibited and interest in their gear was running high.

Speaking Of The Palace, IRE'S ambitious exhibit there this month will just about fill two of the three available floors. Originally planned for a New York armory, the shindig quickly outgrew its quarters and is certain to be highly successful. It will not, however, be a sellout. A few potential exhibitors were discouraged by the higher-than-usual booth cost and the three-buck admission charge for non-members. (The Palace's take must be considerable.)

Selenium Rectifiers will replace notoriously short-lived 117-volt tubes in the majority of 3-way portables built this year. Chief engineers with whom we have talked in the past month say cooler operation and instant starting are distinct advantages in this type of receiver.

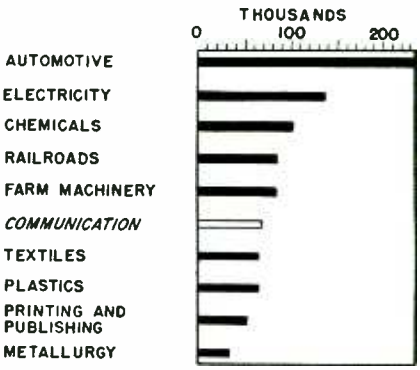
In other types of sets such rectifiers are not expected seriously to challenge the tube at this time despite the fact that they are smaller and deliver more output voltage. They will, however, be seen in a number of straight phonographs above the jitterbug-portable class, and in some ac-dc consolettes, consoles and even combinations designed for the medium-priced market.

Factors which at least temporarily limit the acceptance of the ingenious little discs, particularly for use in ac-dc table-type receivers, include the somewhat higher overall cost (when substituted for a tube in a 5-tube set a dropping resistor must be added to the heater string), the difficulty of handling pilot lights, and uncertainty about shelf-life.

A Three-Day Trip to New England convinces us that textile machinery manufacturers are progressive. Looms in particular do not lend themselves to electronic control as readily as do certain other machines but we did see some very practical laboratory applications of stroboscopes and high-speed cameras using the Edgerton principle. And an application of strain gages about which we can say no more at this writing.

Total Output Capacity of the 3,000-odd electronic induction and dielectric heating units in use in the United States in 1946 is estimated to be over 42,000 kw. These figures are from a NEMA brief recently filed with the FCC. The Association is planning a 1947 survey on the subject.

Patents issued to ten major industries up to November 1946 break down as shown in the following chart:



The National Patent Council, from whom the figures were obtained, says the Communication bar includes 22,750 patents for telephony, 14,491 for radio, 10,114 for telegraphy, and 408 for electric signalling.

Miniature Tubes will show up in more broadcast-band sets this year than a lot of people expect. It seems that while they cost a few pennies more than conventional types when socket cost is

Designed for

Industrial
Heating

Communications
Airline
Police
Emergency
Broadcast

Medical
Diathermy

Experimental r-f

EIMAC 4-750A POWER TETRODE Electrical Characteristics	
Filament: Thoriated tungsten	
Voltage	7.5 volt
Current	20 amp
Direct Interelectrode capacitances (av.)	
Grid-plate	.24 μμf
Input	26.85 μμf
Output	7.78 μμf
Maximum Ratings	
D-C Plate Voltage	6000 max. volts
D-C Plate Current	700 max. ma.
Plate Dissipation	750 max. watts

Here's a new Eimac tetrode—the power step-up you have been asking to have added to the Eimac line.

Capable of 2-kw power output at 4000 plate volts, with less than 15 watts of grid drive, the 4-750A opens a new field of possibilities to designers of electronic equipment. A pair of these tetrodes, driven by low cost, low-power tubes, will supply more than 4-kw output.

A potential workhorse for communications and industrial use, the 4-750A has the ability to deliver its maximum power over a wide range of frequencies. Inherent characteristics include the familiar attributes of Eimac tetrodes—stability, economy, and dependability.

Complete technical data and performance characteristics will soon be available. Write now for your copy.

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included, manufacturers can sometimes get quicker delivery on them. And at least one tube maker appears willing to cut profit corners in order to support mass production.

Annual Profit of eight industries, expressed as a percentage of investment by RMA excise tax committeeman Joe Gerl (Sonora) is as follows:

Toilet articles 16.52 percent, Automobiles and trucks 15.72, Mechanical refrigerators 13.99, Oil 7.03, Firearms, 5.60, Tires 5.28, Electricity 4.81, Radio receivers 2.67.

Figures are an average based on the four-year period ending December 31, 1938.

Power Companies may prove to be powerful allies in the promotion of television, because the receivers build attractive load. Judging from what utilities have done in the past to promote certain electrical appliances, their help could be considerable.

Commonwealth Edison of Chicago says it looks like the average television receiver will consume 280 watts. Deducting load loss due to the fact that a radio would probably not be used at the same time (deduction for loss of lighting load is not necessary since modern television receivers operate in a normally lighted room) the net load is 215 watts. Assuming that the average television receiver will be in use 3.4 hours in 24, each one would use 731 watts per day.

Antenna Tower Steel is still short but fabricators expect the situation to ease up somewhat this month. Light towers should soon be available 30 to 60 days after placement of orders, heavy ones in 60 to 90 days.

Insulators and wire, rather than steel, are holding up deliveries in some instances.

Embarrassment Of Riches plagues high-frequency heating. So many things can be done with it in industry and elsewhere that engineers are tempted to take a whack at all of them at once.

The smart boys in management

are beginning to realize that while concentration on the half-dozen applications having top-drawer market acceptance may not be romantic the volume pays the rent.

Airplane Crashes have made the flying public jittery, even though few scheduled American flights are involved. Aviation's current headache may be a boon to electronics, speeding international acceptance of PICAO recommendations (p 80, Feb.). Members of Congress are exercising their vocal chords about other safety devices. And we note with satisfaction that a large airline has just bragged in the newspapers that soon all its ships will have radio altimeters.

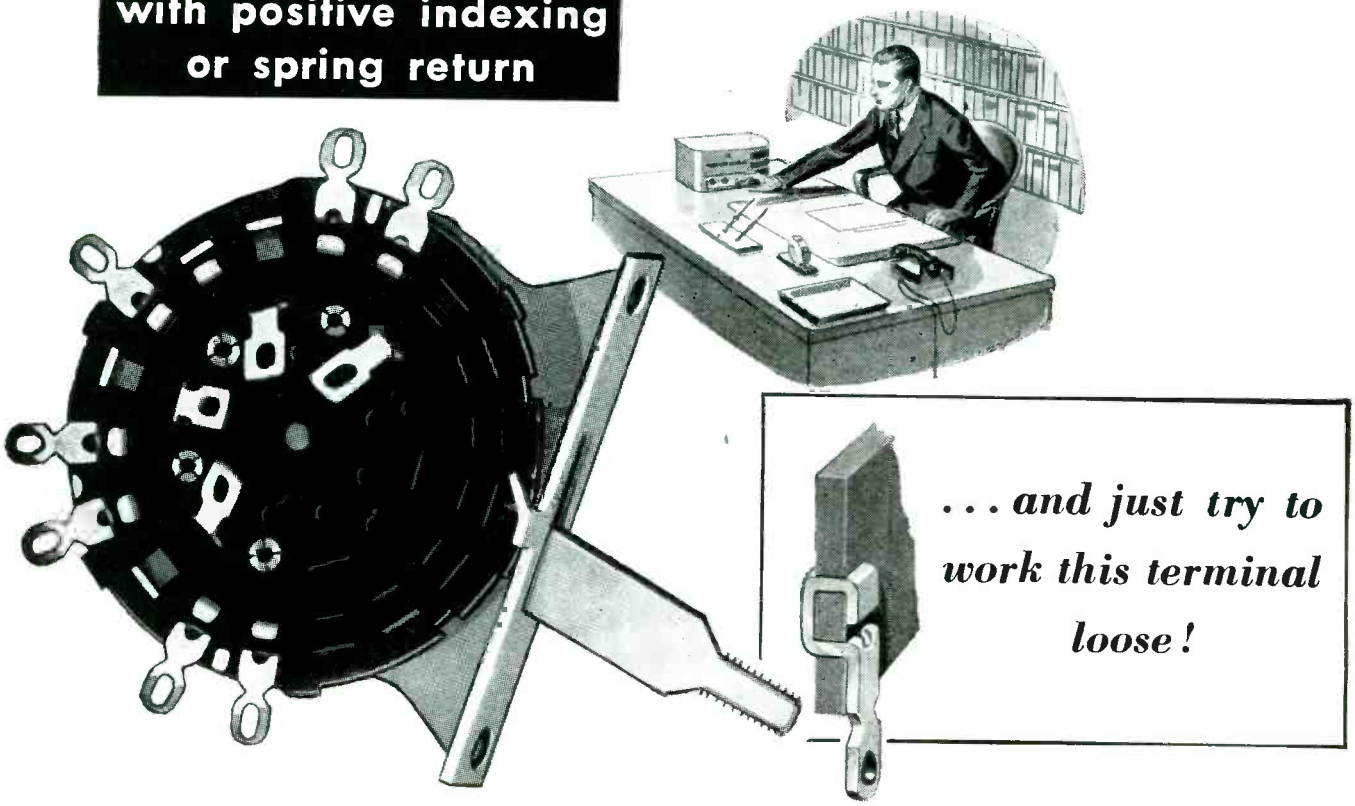
1946 Receiver Production is estimated at 15,000,000 by RMA. The following tabulation does not add up to that because the Association's report service did not get into full swing until several months had elapsed but it does shed light on the relative importance of various receiver types:

TYPE	PRIVATE BRAND	FACTORY
Electric		
Table (under $12.50 billing price)	436,091	1,841,572
Table (over $12.50 billing price)		
AM	1,065,159	4,940,033
AM-FM	.....	13,174
FM (including converters)	.....	2,527
Consoles		
AM	23,644	39,865
AM-FM	851	39,182
Table Radio-Phonos		
AM	139,273	1,076,629
AM-FM	.....	22
Console Radio-Phonos		
AM	104,161	591,089
AM-FM	2,494	123,235
Battery		
Portable AC-DC	105,338	917,351
Table	201,125	503,586
Consoles	3	647
Auto	1,109,508	43,950
Television		
Converters	.....	.....
Radio Table Models	.....	5,070
Radio Consoles		
Direct viewing	.....	1,344
Projection	.....	10
Radio Phonos		
Direct viewing	1	.....
Projection	.....	51
Phonographs		
Phono only	223,886	234,468
With radio attachment	82,706	423,656
TOTAL	3,494,240	10,974,461

We Heard A Speech the other night that somehow tickled us, right from the start. It began: "Members of the youngest profession. . . . .".

A New, Better LEVER ACTION SWITCH!

with positive indexing or spring return

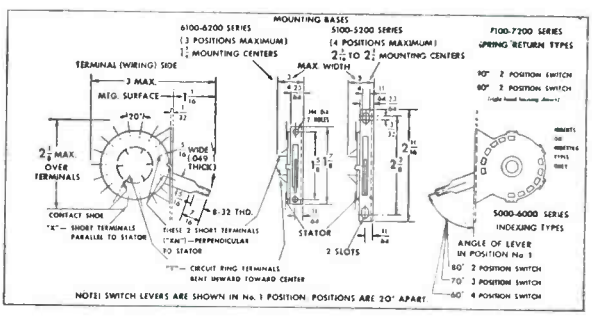


. . . and just try to work this terminal loose!

Although only recently developed and placed on the market, this lever action switch is in big demand. No wonder! It is ideally suited to intercommunications, centralized radio, sound distribution and public address equipment. It gives you a choice of positive indexing *or* spring return. It is as dependable as the leaf spring telephone type switch, yet available at much lower cost.

Consider some of the other "plus" features that set this switch apart: Self-holding terminals of exclusive design are securely clinched to the stator without rivets or eyelets (just try to pull them loose!). All terminals, contacts and ground rings are silver plated for low contact resistance. Constant tension of rotor contact members provides a dependable, self-cleaning action. Insulation is of the highest-grade phenolic.

Positive indexing types of this switch have 48 standard circuit combinations, 24 shorting and 24 positive non-shorting. Spring return types have 17 standard shorting and 17 positive non-shorting circuit combinations. Write for engineering data folder or see your nearest Mallory distributor.



Send for Engineering Data Folder

The Engineering Data Folder for the new Mallory Lever Action Switch contains complete specifications, available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to assist in selection of the particular Mallory Lever Action Switch to best handle the application.

P. R. MALLORY & CO. Inc.

MALLORY SWITCHES

(ELECTRONIC, INDUSTRIAL and APPLIANCE)

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

CROSS TALK

► **GUIDES** . . . The transition of microwaves from military to civilian roles brings up the important matter of waveguide dimensions. During the war, the Army-Navy R-F Cable Coordinating Committee established eight standard sizes of guide. This diversity was necessary because each size is operable over a frequency range of less than two-to-one, whereas the microwave spectrum extends over a range of 15-to-1. Three sizes of guide came into most widespread use, covering the important radar bands at 3000, 10,000 and 30,000 mc. But the civilian spectrum is not so localized. Since the FCC has assigned important services throughout the microwave region, coordination is needed to assure that the bands assigned to the most-used services shall be contained within the coverage of particular sizes of guide. Unfortunately this is not the case. As Moreno has pointed out (ELECTRONICS, p 100, May 1946) several of the fixed-mobile non-government microwave bands can be served only if two sizes of guide are provided for each service. When one considers the complication of providing two sizes of guide, with all the joints and fittings that go with them, for a single line of equipment, it would appear wise to consider either reassigning bands in line with standard waveguide sizes, or alternately, standardizing the wave-guide sizes in terms of assigned services. So far as we have been able to discover, there is no industry or scientific group working on the problem. IRE, ASA, RMA? Who carries the ball?

► **SERENDIPITY** . . . Irving Langmuir, discussing the recent production of man-made snow by dropping dry-ice pellets through clouds, reveals that the discovery was an unlooked-for bonus in a routine investigation. He blamed the good fortune on "serendipity", a word coined by Walpole to mean the gift of finding valuable or agreeable things not sought for. The history of all science, and particularly of electronic science, is studded with such serendipitous occasions. The gift is not arbitrarily bestowed. It comes to those who follow the "procedure of the 10 per cent", a program first brought to our attention by C. J. LeBel: a device (or technique) may be radically improved either by radical redesign, or merely by improving every part (or procedure) by 10 percent. It is on those who conscientiously seek the 10 percent that the goddess of serendipity most often smiles.

► **VETERANS** . . . Among the hundreds of thousands of soldiers and sailors trained in electronics during the war, many sustained wounds and injuries. They, it seems to us, deserve first consideration in plants and laboratories which can use their skills. The Veterans Administration, listed under U. S. Government in your phone book, can put you in touch with qualified applicants, will provide funds for on-the-job training. Records show that the handicapped worker meets the competition of his able-bodied neighbor in production, outdoes him in loyalty to the job.

► **TOO MANY** . . . The use of television as an industrial tool is coming into the news, but it's not all good news. We hear, for example, that television is being used to monitor the water level in the boilers of a power-generating station. Without inquiring into the merits of this particular case, we are impelled to ask: Is this necessary? The simplest television system we know of (Block III) uses 55 tubes in a single transmitter and receiver. Simple telemetering systems, fully capable of monitoring water level or any other single-valued quantity, employ a lot fewer than 55 tubes, or no tubes at all. Television has plenty of uses in industry, as a substitute for the human eye, but not as a substitute for a meter, or even a dozen meters. The cause of electronics in industry is not served by such over-engineered applications. The simpler the circuit and the fewer the tubes, consistent with necessary performance, the better. And if a job can be done well without tubes (we admit to a few of these), that's the way to do it.

FCC Views Television Advances

Color vs black-and-white contest sharpens as industry demonstrates competing equipment at hearing. New monochrome equipment shows great increases in brightness and contrast. "Mixed highs" technique for simultaneous color system revealed

FOR THE FIRST TIME in its long history of adjudicating the standards and allocations of television, The Federal Communications Commission recently brought operating equipment into the court room for a first-hand check on the claims of conflicting systems. The occasion was a three-day session at the District Court House in New York and at the RCA Laboratories in Princeton, during which black-and-white and color systems were demonstrated while technical measurements of the brightness and resolution of the images and their ability to withstand external light were made by engineers.

The major issues under discussion have already been treated in these pages[1, 2]. The Columbia Broadcasting System has petitioned for immediate commercialization of their sequential color system, while the opposition has argued that this system cannot at present offer the same service as the existing black-and-white system. In particular, the Radio Corporation of America has urged that the simultaneous system of color is preferable to the sequential system, since it can be integrated with the present black and white standards, thus avoiding obsolescence of equipment now being sold to the public. The demonstrations were intended to illustrate both sides of the controversy.

Sequential Color Systems

During the first day of the demonstration, CBS and Bendix showed sequential color receivers of identical internal design, picking up both live and film programs from the CBS transmitter about two miles away. It was shown that these pictures (on ten-inch tubes, magnified optically to 12-inch size) had a highlight brightness of 10 to 20 foot-lamberts, and that they had high resistance to external illumination because of the protection afforded by the rotating filter disk. On the second day of the session, DuMont Co. showed black-and-white pictures on a comparative basis. Three sets having 12, 15 and 20-inch tubes with aluminum-backed phosphors, and operating at about 20,000 volts, were shown. The highlight brightness of the 12-inch tube was measured at 500 foot-lamberts and on one occasion as high as 750. A neutral-gray optical filter, admitting about 9 percent of the light and matching the average transmission of the color disks, was placed before the monochrome images and the protection against ambient illumination, similar to that of the color receivers, was demonstrated.

At Princeton, RCA demonstrated its simultaneous color system, producing a 15-by-20-inch picture of about 5 foot-lamberts highlight brightness. The interchangeability of the simultaneous system with the present black-and-white standards was demonstrated by receiving the commercial monochrome

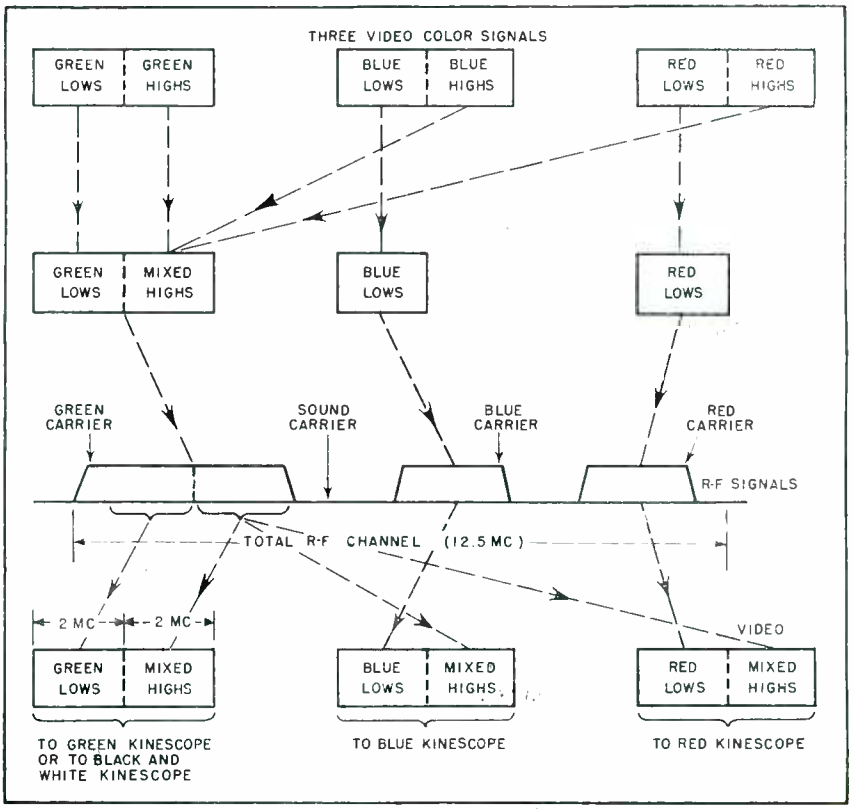


FIG. 1—By transmitting all fine detail of the image through the green channel, RCA mixed-highs system reduces bandwidth requirements of simultaneous system by 2mc. achieves effect of black plate in color printing.

Television enters the court-room. FCC commissioners view Bendix and CBS color receivers side by side with DuMont monochrome units, as Peter Goldmark (at left of woman court reporter) testifies

NBC transmissions from New York on the color receivers, and (by the use of an r-f converter) receiving the color transmissions in monochrome on standard production model monochrome receivers. The channel width employed by RCA was 14.5 mc, as compared with 16 mc for the CBS system.

"Mixed-Highs" System

Following this a new proposal for transmitting color images on a still narrower bandwidth was revealed, the so-called "mixed-highs" system. As shown in Fig. 1, the high video frequencies produced by the three color chains are separated and combined, then transmitted over the green r-f channel, which has full bandwidth. The red and blue channels transmit only the low-frequency components. As a result, the fine detail of the image, reproduced by the high frequencies, is reproduced in shades of gray, whereas the broad areas of the image (larger than $\frac{1}{16}$th to $\frac{1}{8}$th-inch on a 15 by 20-inch screen) are reproduced by the low frequencies of the three channels in their respective colors. This technique is very similar to that employed in color printing, in which the detail of the image is carried by a fourth plate, the so-called black-printer, which carries black ink and reproduces the detail in shades of gray, over three primary colors imprinted by three other plates.

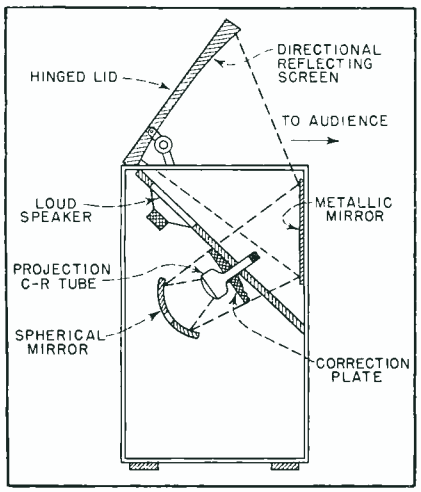


FIG. 2—Projection system of new Philco receiver, shown at Princeton for first time. The directional reflector confines light to eye level, thus increasing brightness and contrast four times over comparable projection units

The system permits a 525-line color image to be transmitted over a 12.5-mc channel, while still preserving conformity of the green channel with the black-and-white standards, so that the green image may be received in monochrome on existing receivers. According to E. W. Engstrom, who conducted the demonstration, no difference between the images of the normal simultaneous system and the mixed-highs system can be seen at a viewing distance greater than four times the picture height. No difference was noted by the viewers when the image was switched from one system to the other.

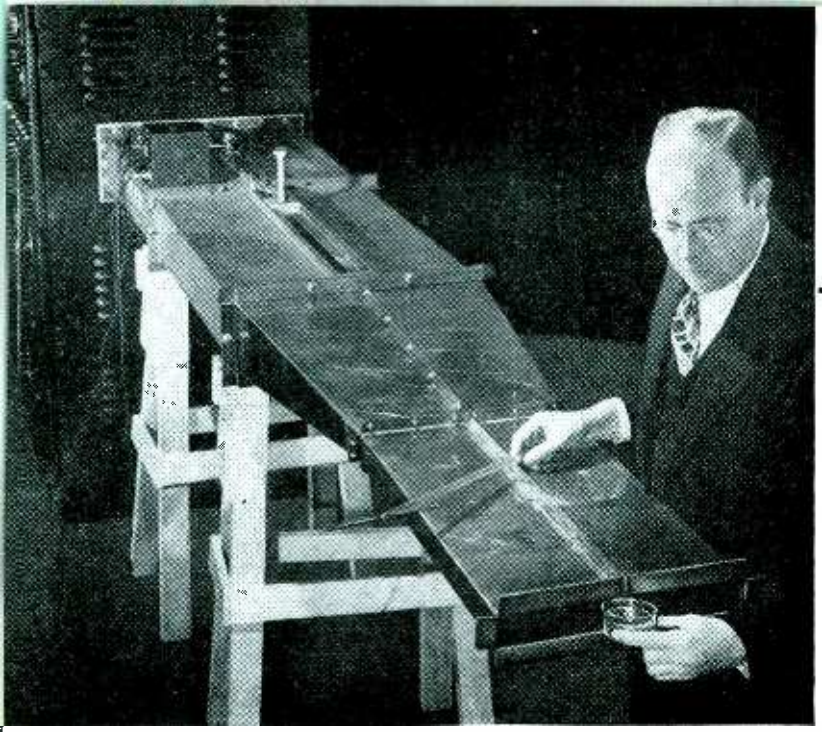
Curved Viewing Screen

The final demonstration at Princeton was something of a sensation, the first public showing of the long-rumored Philco projection black-and-white receiver, shown schematically in Fig. 2. A full program of live-talent, remote pick-up, and film programs transmitted by NBC in New York was reproduced for the Commission, press and other witnesses. This receiver produced a 15 by 20-inch picture, from a four-inch projection tube and Schmidt optical system, arranged within the cabinet to fit into a minimum of space. The picture had about 4 times the brightness of similar projection pictures previously shown and displayed a vast increase in contrast and resistance to external light. The picture was viewed comfortably with sun streaming in the windows.

The secret of this receiver is the use of a directional viewing screen, consisting of a coating of unannounced composition on a curved aluminum back. This screen confines the reflected light to a small angle, measured in the vertical plane, while permitting it to spread over a range of perhaps 100 degrees in the horizontal direction. Thus many viewers around the set, seated with their eyes at screen level receive an equally bright picture, but little light is lost in the direction of the floor and the ceiling. The screen action also prevents external light from being reflected into the eyes of the observers and thus preserves high contrast even when the ambient light is very high.—D.G.F.

References

(1) Fink, D. G., Where Color Television Stands, Electronics, p 104, May 1946.
(2) Fink, D. G., Two Systems of Color Television, Electronics, p 72, Jan. 1947.



HEATING

Experimental Westinghouse setup of microwave heating equipment. Liquid in container held near opening in waveguide is heated by r-f energy

MANY worthwhile applications of dielectric heating are impractical at the present time because of limitations in heating speed imposed by the necessity for use of radio-frequency power at conventional frequencies. Frequencies in the microwave region offer possible future solution to these types of applications if means can be found for generating sufficient power on a continuous rather than pulse basis. The purpose of this paper is to look into the future of microwaves and expose insofar as possible at this time the techniques that appear to be rational for industrial heating applications.

The only microwave tubes in large-scale production at present are resonant-cavity magnetrons for pulsed operation. Though they give peak power outputs of a megawatt or more, the average power is seldom over 1 kw, which is just on the verge of being useful for heating purposes. Furthermore, pulsed operation is seldom useful for heating, as the work piece is subject to large voltages during the operating time and must be suitably arranged to prevent breakdown.

The two tubes which show the greatest promise for future work in dielectric heating are the split-anode magnetron and the resnatron. The split-anode magnetron will develop 10 kw continuously with an efficiency of 50 percent at wavelengths of 40 to 90 cm; though there is no production of this tube at present, it could be made if the need arose.

The resnatron type of tube is the only source available in the 50-kw range. It is a beam-type tetrode which can be used either as an amplifier or oscillator at wavelengths of 10 to 100 cm, with continuous operation at an efficiency of 25 to 60 percent. It was put into small-scale production by Westinghouse, some twenty tubes having been made.

Assuming a suitable source of r-f power, the problems of making this power available for dielectric heating differ considerably from those commonly encountered with conventional frequencies, it is no longer possible to use the ordinary open-wire transmission line to convey the power from the source to the work, due to the excessive loss by radiation from such a line at microwave frequencies.

Coaxial type transmission lines are satisfactory for wavelengths as low as 10 centimeters or less under certain conditions, but at wavelengths around 10 cm and sometimes up to 60 cm or above it becomes of material advantage to use waveguides for the transmission of power.

The problems of impedance matching in waveguides are similar to those for coaxial lines. Variable-length stubs may be used, and there are many ways of terminating a waveguide so that no reflection will occur from the termination.

If the load to be matched is constant, a fixed diaphragm may be soldered into the guide at the correct place to effect a match. If the load is constantly changing, then one must have a continuously adjustable matcher, such as a two-stub tuner.

Textile Applications

In many industries we have dielectric heating problems involving the drying, curing, or setting of resins or glues in continuous processes. Take the textile industry as an example. They dry cloth after dyeing, both in bulk and on a continuous basis. Printed fabric requires a rapid drying cycle for the dyes and inks used. In the paper industry we also encounter drying of the material on a continuous sheet basis at high speed.

At conventional frequencies where power in sufficient quantity may be available to accomplish the drying of paper and textiles we are still limited by the inability to get that power into the work. The amount of power transferred into the work, once frequency is set, varies with the square of the voltage across the electrodes. Actually, power is proportional to the product of frequency, loss factor, and the square of the voltage.

For thin materials such as paper and cloth it is impossible to apply sufficient voltage across the electrodes at conventional frequencies, as flashover between the electrodes takes place long before any appreciable amount of power is coupled into the dielectric work material. The answer obviously is to use a much higher frequency.

Figure 1A illustrates how a cavity resonator might easily be used to put power into rapidly moving thin sheet material. We have a dielectric field of uniform character

WITH MICROWAVES

Suggested methods of utilizing waveguides for applying microwave energy to moving or stationary wires and threads, sheets, or irregularly-shaped objects to achieve uniform dielectric heating, and survey of tubes offering possibilities for continuous operation

By J. MARCUM and T. P. KINN

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Industrial Electronic Engineering, Westinghouse Electric Corporation, Baltimore, Md.

only in one dimension, in the plane of the E field which is a maximum at the center of the cavity or guide. By passing the material through slots at the top and bottom of the cavity we subject it to the strong dielectric field, but because of the standing wave effect along the length of the cavity the material will be heated unevenly if passed straight through the cavity. By making the entry and exit points a half-wavelength apart we obtain a condition which insures uniform heating as the material passes through the cavity.

Heating Sheets of Material

It is easy to picture this method of coupling microwave power as being used to perform many commercial heating jobs, including the bonding and drying of wallboard materials, floor covering materials such as linoleum, and plastic-bonded cork materials. Continuous curing of sheet rubber, plastics, and synthetic materials and production of plywood on a continuous basis are still other likely applications.

It may be possible and in some cases desirable to heat sheet material as shown in Fig. 1B. Here the microwave or radar antenna is put to work as a means of coupling energy into a material to be heated. An outstanding property of microwaves is this ability to concentrate them into a narrow pencil-like beam by means of a reasonable antenna structure. A so-called bedspring antenna designed to have uniform distribution of field can be used to heat large sheet material. The shape of such an antenna is flexible to a degree and therefore lends itself to the efficient heating of various widths and shapes of material.

Drying Applications

If we turn from sheet material to such items as wire and thread we again find innumerable problems where microwaves may be applied. Textiles such as rayon and nylon must be cured, dried, and the twist set. Rubber thread material, both synthetic and pure Latex, must be cured. Many insulating coatings on wire, either rubber, synthetic, or enamel, must be dried or cured. All of these operations must be accom-

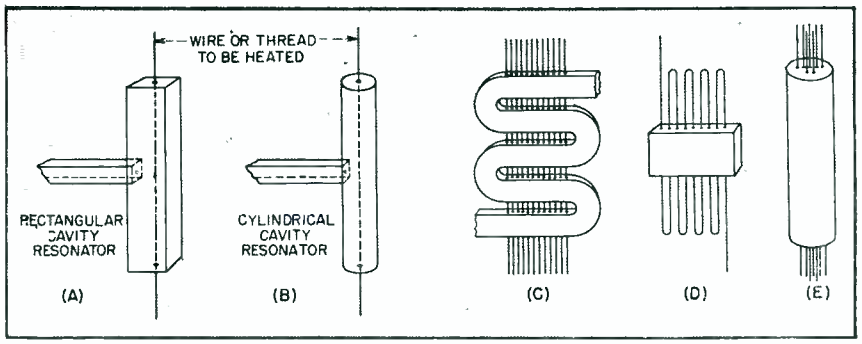


FIG. 2—Five methods to transferring microwave energy from a waveguide to a wire or thread for dielectric heating

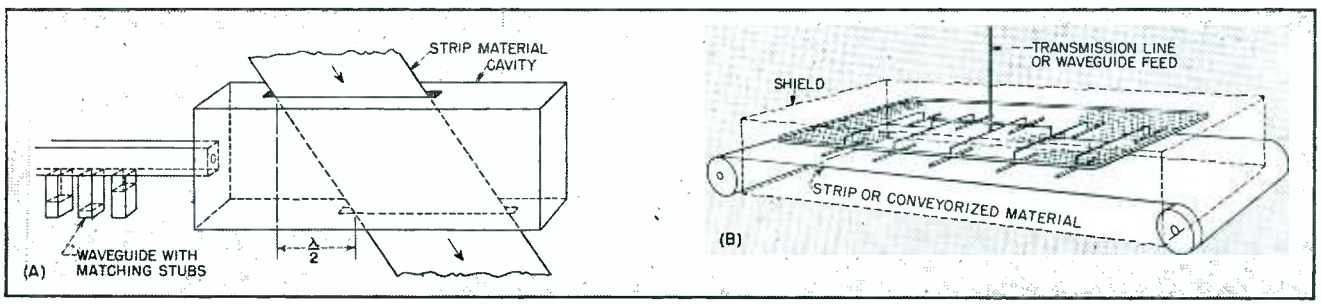


FIG. 1—Running continuous strip material through a resonant cavity at an angle as at *A* gives uniform dielectric heating. At *B* is shown one possible method of using a radar bedspring antenna for dielectric heating of moving material

plished by heat applied at high speed. Again, with conventional frequencies it has been impossible to couple energy into such materials at a rate suitable for production requirements.

Such production problems may some day be solved by microwave energy applied as shown in Fig. 2A and 2B. Here we have a long cavity through the center of which we can pass the wire or thread that is to be heated. The possibilities of such an arrangement are easily visualized. Energy transfer of such a system may be rather inefficient, in which case the arrangement shown in Fig. 2C, 2D, or 2E may become more practical. These same means of increasing coupling efficiency could be applied to sheet material.

In the lumber industry we find many problems of gluing waiting for solution by dielectric heating.

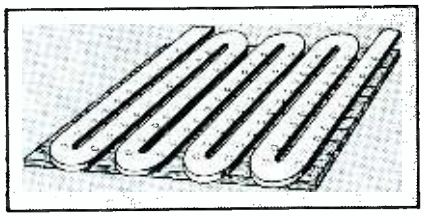


FIG. 3—Arrangement of waveguide with radiating holes for spot-tacking of glue line simultaneously at many points in edge-glued lumber

Spot gluing and edge gluing could be accomplished readily by the concentrated fields made possible through the use of openings in waveguide structures. Holes in waveguide structures would apply concentrated fields to the glue line as illustrated in Fig. 3. The continuous bonding of plywood by a method similar to either Fig. 1A or Fig. 1B would make possible a process which to date has not been tackled because of the major difficulties encountered by conventional press designs and curing methods.

Preheating Plastics

The plastics industry is now a big user of r-f energy for preheating material prior to molding. Conventional frequencies adequately supply the heating rates normally used for hand-fed press operation. High-speed automatic operation could now use r-f energy to advantage, however, if sufficiently fast heating rates could be obtained. The answer again will probably be microwave energy, possibly applied as shown in Fig. 4A. Jet molding on an automatic basis could easily become one of the faster means of molding thermosetting material.

The problem of preheating molding material is one of uniform heating. Because of the uneven field distribution in a guide or cavity, special means are necessary to provide a uniform field for uniform heating. Figures 4B, 4C, 4D, and 4E illustrate possible ways of obtaining this uniform field. Figure 4B shows two electrode plates with strap tuning inductance so placed in a guide that the inductance straps couple to the magnetic or H field. Figure 4C shows the electrode as a part of a quarter-wavelength antenna located within a cavity. Similarly, Fig. 4D suggests adjusting the thickness of the cavity in the E field dimension to suit the thickness of material, the material being confined to only the central part of the guide. The removal of energy from a guide to apply it to external electrodes can be accomplished by coupling at two points a half wavelength apart and selecting proper odd quarter-wavelength leads as shown in Fig. 4E.

Microwave energy piped to numerous press positions from one central generator may be the future answer to many a molder's present problems. A central generator supplying many operating positions, as in Fig. 4F, has not proved too satisfactory at conventional frequencies because of the many switching, matching, and voltage problems encountered. The ease with which any degree of energy desired can be removed from a waveguide makes such problems as voltage and switching simple. There is still the problem of suitable match of the guide to the generator, but here again the problem is actually simplified by the relatively simple means we have of obtaining adjustable capacitance and inductance at microwave frequencies as compared with the limitations of lumped impedances at conventional frequencies.

In the field of plastic and synthetic materials there is the rapidly growing demand for bonding or sewing of sheet material such

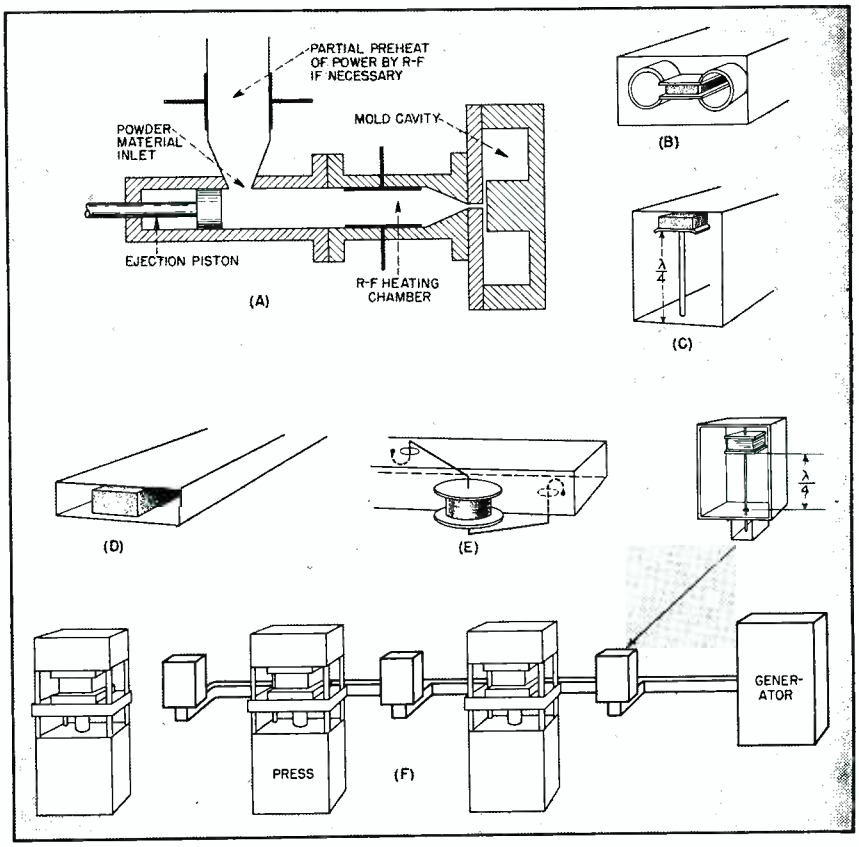


FIG. 4—Suggested methods of utilizing microwave energy in molding of plastics

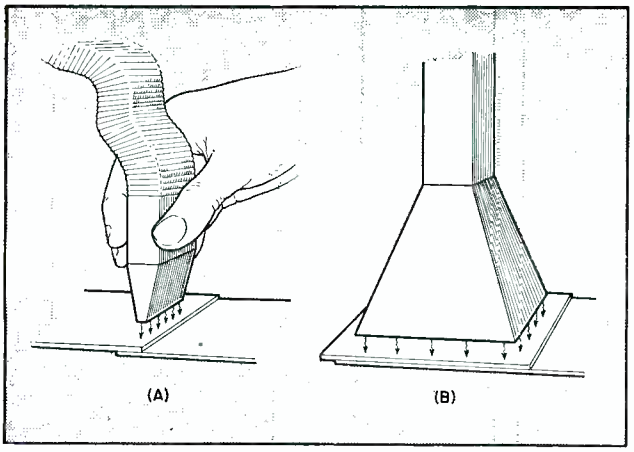
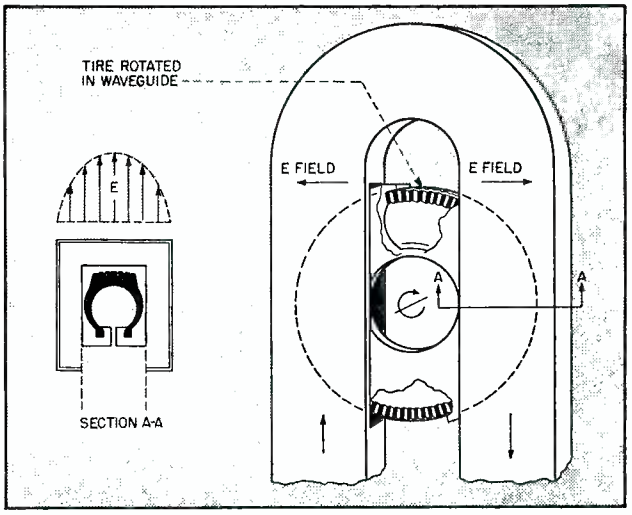


FIG. 5—A method of concentrating microwave energy at a narrow joint by means of a flexible waveguide is illustrated at A, and use of a divergent taper at the waveguide aperture for spreading the heating energy is shown at B

FIG. 6—Method of curing automobile tire by means of microwave energy



as the vinylidene chloride materials. Here again conventional frequencies are relatively slow and microwave energy properly applied may be the answer. By concentrating extremely high frequencies it may be possible to bond such sheet materials at an unbelievable rate with rather simple handling equipment. By making use of presently available flexible waveguide material, such a bonding operation could be made semiportable. Figure 5 illustrates two such possibilities of the future where concentration of power is desired or when larger surfaces must be bonded.

Curing Rubber

The rubber industry is also a large user of r-f power at conventional frequencies. Many production problems in this industry, however, await solution by the use of higher frequencies. Being a very poor thermal conductor, rubber lends itself naturally to dielectric heating. Where speed and quality are of prime importance, r-f energy supplies the answer. Probably one of the most desired places for quality in a rubber product is the tire we put on our own automobile. Radio-frequency curing of rubber in that tire could give that extra something we are all looking for in a tire. Microwave energy may again be the final answer, and Fig. 6 illustrates one possible method for accomplishing such a production problem. The field distribution within a cavity is put to advantage to assist in a uniform heating and therefore uniform curing job.

Food Industry Applications

The largest industry of them all, the food industry, is just becoming conscious of the potential advantages offered by r-f heating. The sterilization, blanching, and cooking of foodstuffs are all possible applications for r-f energy. Recent development work indicates that very large advances in quality may be possible in the future by using r-f energy for blanching and sterilizing. These same developments indicate the need for higher frequencies in the microwave region to produce the desired results at the volume and speed normally used in processing foods.

The future is sure to bring pressure on the electronic industry for equipment to process all types of foodstuffs. This pressure will become apparent as the food technologists progress in their present studies of r-f blanching and sterilization.

Many other applications will present themselves in the food industry. For example, much speculation on the cooking of various foods has stimulated the imagination and even brought forth the desire to rapidly defrost and cook a plate full of frozen meat, potatoes, and vegetables. Unequal heating of the various foodstuffs when subjected to an r-f field makes this problem impractical at conventional frequencies. By using the unequal field distribution found in a cavity resonator it may just be possible that a suitable combination of frequency, cavity size, food stuffs, and proper orientation of the food in the field of the cavity would give a means of accomplishing the desired result.

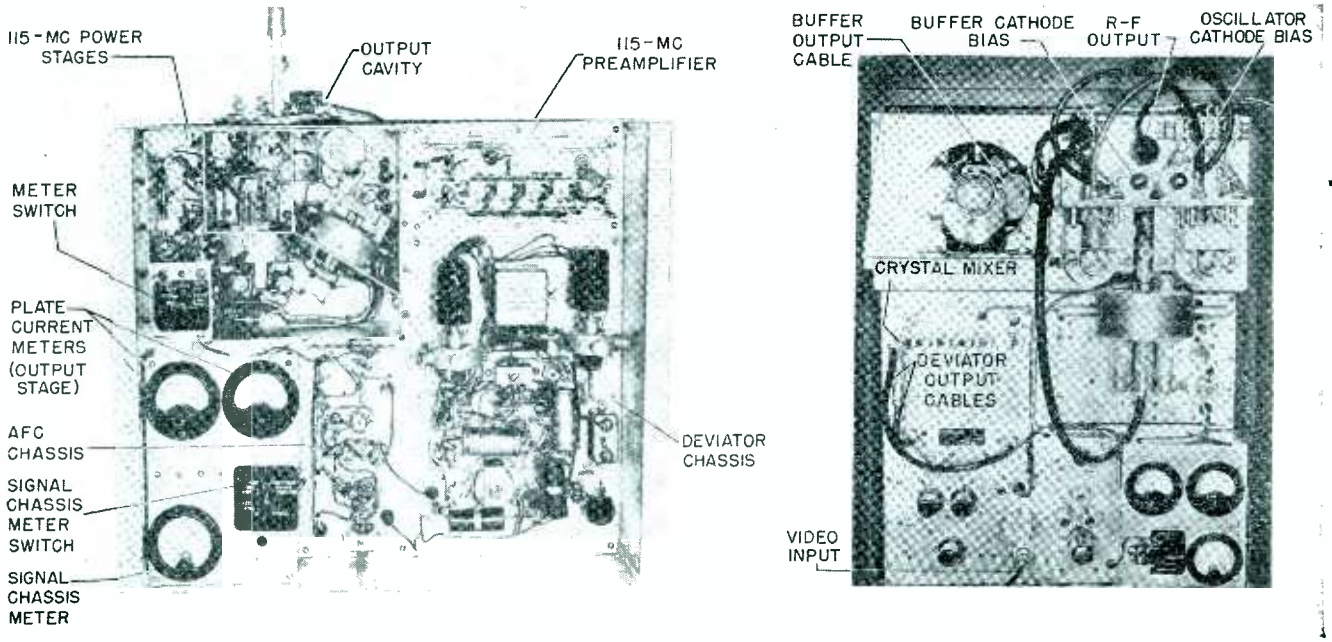
Conclusions

Throughout this paper it has been the attempt to show the present techniques of generating and handling microwave energy and speculate on how these known techniques might be applied to industrial heating problems. Some of the suggested methods of use may appear somewhat fantastic, but it is believed that the principles involved are fundamentally sound. Therefore, the ideas presented should serve to stimulate thought and development.

It must be clearly recognized that this paper is in the nature of an exploratory trip into the future and is not intended to indicate that present techniques utilizing presently available frequencies will in any sense have to be completely replaced.

It is more necessary that the heating development engineer study the use of microwave energy in industry and thereby create a demand, a big demand for high power at microwave frequencies. If this demand is sound the tube development engineer will have incentive to create what is needed, and microwave techniques in industry will become a reality.

UHF TELEVISION



Front (left) and back views of a typical relay transmitter chassis

By WILSON BOOTHROYD

Project Engineer, Research Division
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OUR ENGINEERS have recently completed and tested a radio relay system suitable for the transmission of black-and-white television signals. The basic aim of the project was to provide equipment for intercity multiple-link radio relaying, and to develop similar equipment suitable for studio-to-transmitter or remote pickup relaying. The present equipment operates in the 1,350-mc band and consists of two basic combinations of components, outlined in the block diagrams of Fig. 1 and 2.

Figure 1 is a block diagram of the studio-to-transmitter link. A composite television signal (video) of one volt peak-to-peak value, with the synchronizing signal negative, is required at the input. This input signal is applied to a deviator unit, which amplifies the video signal and uses it to deviate oppositely a pair of reflex klystron microwave oscillators. The output signals from these oscillators are mixed in a crystal to produce a difference frequency.

The difference frequency constitutes an f-m signal in the 115-mc region. The peak input signal, corresponding to the voltage difference between the tip of the synchronizing signal and the peak white of the video signal, will cause a swing of 13 mc in the difference frequency. The difference frequency corresponding to the synchronizing pulse peak is established at 107 mc. The minimum difference frequency of the microwave oscillators is controlled by an afc circuit, so that the sync pulse is transmitted at a constant frequency, regardless of picture content.

The difference-frequency signal is amplified in a wideband i-f amplifier having a pass band from 105 to 125 mc. The output signal from this i-f amplifier and an r-f carrier are applied to a pair of output tubes which serve as a heterodyne converter, from which is derived an r-f output signal whose frequency is the sum of the frequencies of the two input signals, i.e., a signal in the 1,350-mc region having an output spectrum 20-mc wide. The r-f output is radiated from a 48-inch parabolic reflector antenna system. For convenience of installation and portability, flexible cable is used to connect the antennas to both the transmitter and receiver.

The receiver is a superheterodyne using a crystal mixer, a velocity-modulated local oscillator tube, an i-f amplifier having a pass band greater than from 65 to 85 mc, a discriminator and video amplifier, and an afc circuit for controlling the local oscillator.

Figure 2 is the repeater station diagram. Here, in comparison with the receiver of the studio-to-transmitter-link, the discriminator of Fig. 1 has been replaced by an i-f converter and a crystal-controlled amplifier. The r-f carrier oscillator for the transmitter is also used as a local oscillator for the receiver.

RELAY SYSTEM

Wideband frequency-modulation equipment operating on 1,350 mc handles black-and-white video signals. Equipment is equally useful for intercity multiple link or studio-to-transmitter work. Heterodyne modulation and remodulation are employed

Several characteristic features of the equipment will be apparent from the foregoing discussion. Most important is the elimination of all video amplifiers except the simple ones at the transmitting and receiving terminals. Next is the provision for wideband deviation and amplification. A third feature is the use of heterodyne modulation and remodulation, which provides for faithful frequency conversion without demodulation to video frequencies or to an amplitude-modulated signal. Other important circuits which will be discussed herein include the following:

(1) Design of i-f amplifiers for good phase response.

(2) Use of sync-tip afc circuits with a frequency-modulated carrier.

(3) Use of constant-impedance coupling networks between chassis units.

(4) Novel circuitry for i-f amplifier design.

(5) Novel design of r-f heterodyne mixer stage.

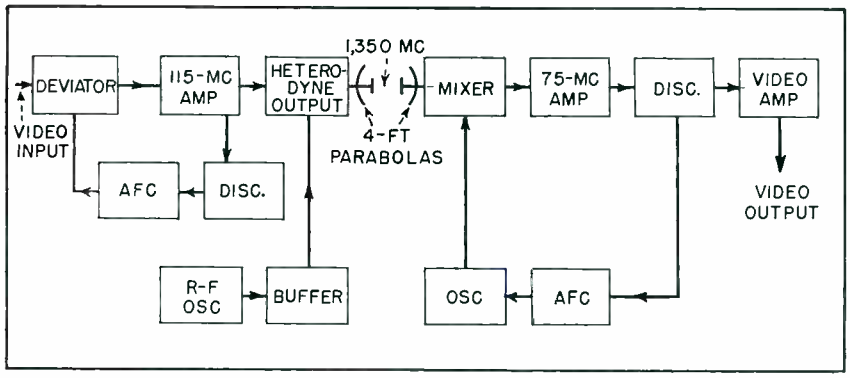


FIG. 1—Block diagram of studio-to-transmitter link equipment, showing video transmitter, at the left, receiver at the right, and the radio path between them

Transmitter Circuits

The various transmitter components are described in the order of their use in a studio-to-transmitter link. The video amplifier, which is conventional, includes an input cable impedance-matching resistor, a gain control (for adjusting deviation), and a push-pull video amplifier having a gain of 10. With 1 volt peak-to-peak input, the amplifier output tubes will deliver 7.5 volts in each plate circuit. These signals, of opposite polarity, are applied to the repellers of a pair of

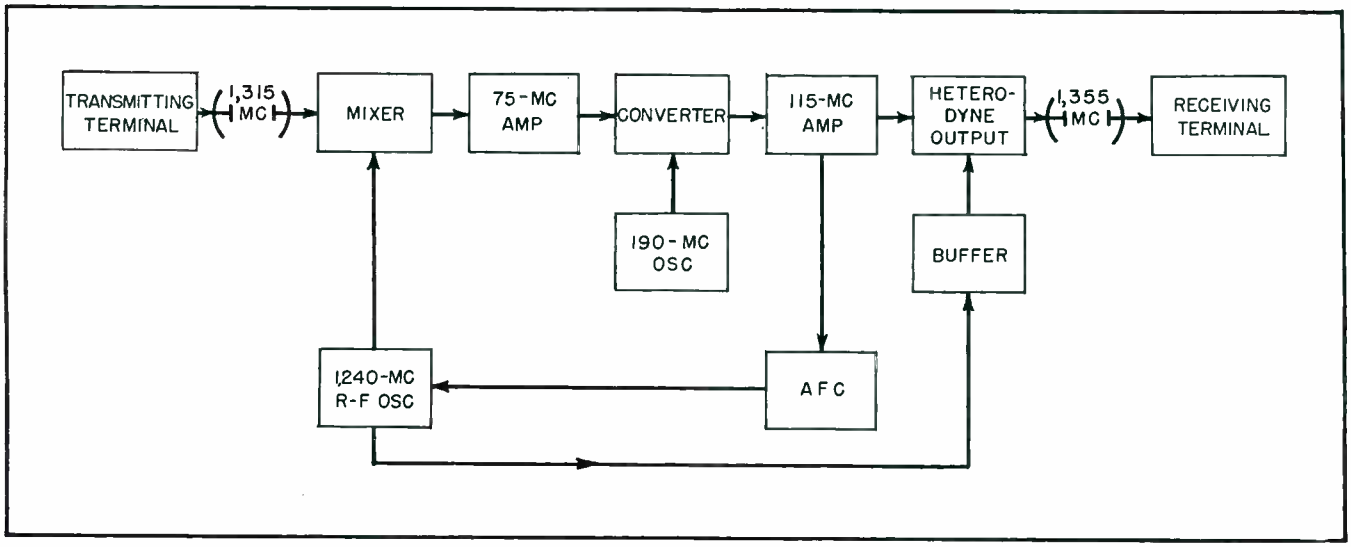
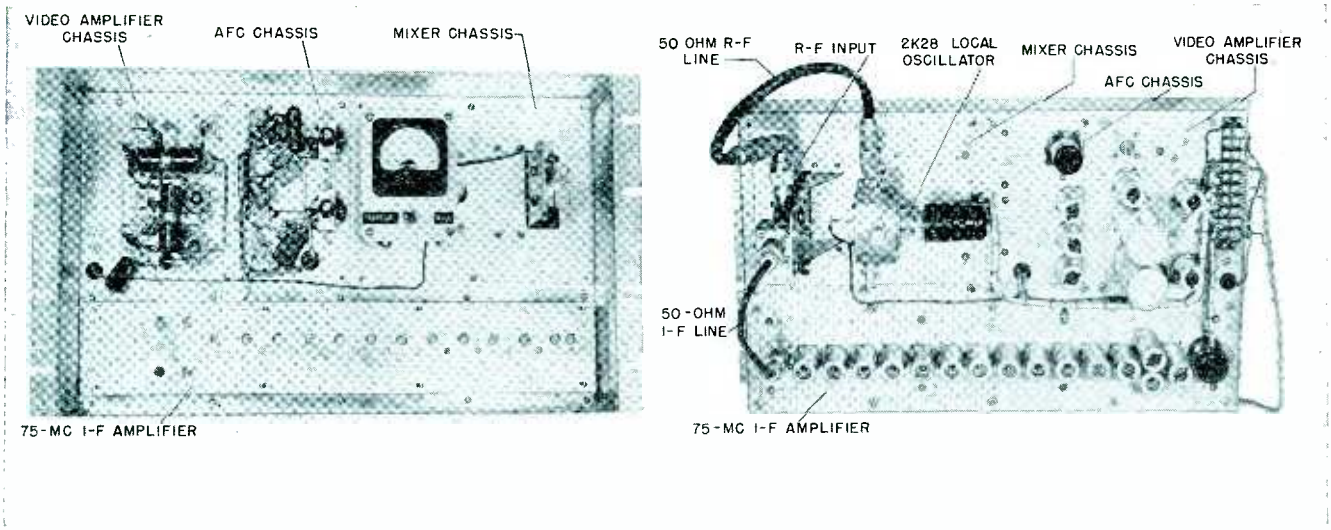


FIG. 2—Diagram of 1,315-mc television relay system. Transmitting terminal block at the left and receiving terminal block at the right are similar to the units in the studio-transmitter equipment diagrammed in Fig. 1



Front (left) and back views of a typical relay receiver chassis

2K28 oscillator tubes to deviate these tubes oppositely and thus increase their frequency difference compared to their frequency difference during the peak of the sync pulse.

Conventional a-c coupling from the video amplifier to the oscillator repellers is unsatisfactory, because it would permit the drifting of the frequency which corresponds to the peak of the sync pulse, with changes in picture signal content. Hence leveling diodes are employed across the coupling resistors so that the repeller voltage (and hence the oscillator frequency) during the sync pulse is determined by d-c bias. By this means the sync pulse is always transmitted at the same i-f frequency. This makes possible the type of automatic frequency control described below, as well as other advantages.

In order to obtain linear deviation of the oscillator frequency over an adequate range, without requiring excessive voltage swing, the oscillators are loaded by short transmission lines which are coupled to the oscillators and serve as dissipative elements to broaden the oscillator frequency characteristic. Figure 3 shows the typical curve of one of the oscillator stages under various load conditions, as well as the construction of the dissipative lines.

The microwave oscillator output signals from the deviator are mixed in an untuned mixer assembly mounted on the i-f preamplifier. The first four stages are conventional single-tuned stages whose frequencies and Q values are as prescribed by the overall amplifier pole diagram to be described. To change from a single-sided amplifier to a push-pull stage, susceptance coupling, using a capacitive susceptance in one arm and an inductive susceptance in the other, is used. This simple coupling arrangement has been found to give good performance.

Because the i-f preamplifier and power amplifier were constructed on separate chassis units, the preamplifier output circuits were so designed that variations in distributed capacitance across the power amplifier input terminals may be easily tuned out. Figure 4 shows the preamplifier output and power amplifier input circuits. The power amplifier consists of two stages of push-pull amplifiers terminating in a single-ended connection for driving the grids of the tubes in the output cavity resonator. To obtain maximum mutual conductance, these i-f amplifier tubes are operated from a 200-volt supply at maximum current. The transition from push-pull to single-ended output is again accomplished by susceptance coupling.

The i-f amplifier (including both preamplifier and power stages) consists of a number of single and double-tuned circuits whose resonant frequencies and Q values are arranged in accordance with the polar diagram of Fig. 5. As shown, the tuned circuits are symmetrically disposed about the axes, and produce the indicated amplifier response. This amplifier was designed for best phase response with pairs of poles assigned to appropriate stages. Each amplifier in the system was designed for optimum phase response and good amplitude response, consistent with efficient use of available tubes. Additional poles required by the r-f and antenna circuits are tuned to center frequency and made adequately broad. To facilitate alignment of the 115-mc power amplifier, all stages are designed so as to permit lowering of

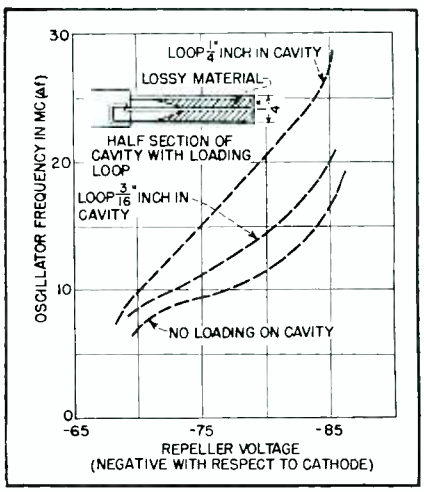


FIG. 3—Typical reflex kylstron oscillator tuning response with various degrees of loading

their screen voltages. Then grid currents may be successively metered while a sweep-frequency signal is applied to the amplifier for alignment.

The afc and a monitor are included in the i-f chassis. The discriminator on this chassis is unusual in that it is tuned for an unsymmetrical response, as shown in Fig. 6A, having no output at 107 mc and a linear characteristic for frequencies from 105 mc to 119 mc. This response curve is desirable for two purposes. First, for afc purposes, the discriminator output is d-c coupled to a 1N34 crystal which is poled as shown in Fig. 6B to pass only signals of positive potential. If the i-f signal is within the proper frequency region of the spectrum, the crystal will pick off only the peaks of the sync pulses. These sync pulse peaks are then amplified, detected, and applied as d-c bias to a 6SJ7 d-c amplifier. This amplifier is operated between such potentials that its plate voltage is at the proper potential for the repeller of one of oscillator tubes of the deviator.

A variable resistor in the amplifier cathode is used to obtain the initial adjustment. The circuit operates in such a manner that, should the frequency difference of the two deviator oscillators at the time of the sync pulse be other than normal, more or less sync pulse will be picked off from the discriminator circuit and used to provide a correcting voltage for application to the grid circuit of the d-c amplifier to modify the frequency of one of the oscillators by repeller tuning. Both the amplifiers in the afc circuit are operated at high gain, so that drift will be negligible, and hence the intermediate frequency will be held constant within the limit of accuracy of the discriminator tuning.

The second function of the unusual discriminator curve is to provide a means of monitoring the deviation. When the deviation is normal, the video signal viewed at the monitor output point will show slight saturation of the peak white signal when viewed on a standard oscilloscope. This is caused by the frequency corresponding to the negative peak of the discriminator curve. If deviation is subnormal there will be no saturation, or if overnormal the saturation of the peak white signals will be severe. Since this circuit is only a monitor circuit and is not a part of the signal amplifier, there will be no distortion of the output signal even with saturation in the monitor channel.

R-F Power Amplifier

The power amplifier terminates in the circuit of Fig. 7, which shows the heart of the transmitter, the r-f heterodyne output stage. The final stage of the i-f amplifier is an 829B tube, with the output coupled by susceptance into the single-sided circuit which drives the output stage grids.

The output stage consists of a cavity resonator housing a pair of 2C39 tubes. The main body of the cavity is a cylinder with its axis perpendicular to the grid plane. The grid plane, insulated from the cavity shell, is supported in the equator of the cavity and contacts the output tube grids, thus forming separate plate and cathode cavities within the main shell. The cathode cavity includes transmission lines whereby the filament connections are made, each line being tunable by means of capacitance adjustments. The cathode cavity is excited by a carrier-frequency signal from the oscillator and buffer stages in the second order $TE_{01,2}$ mode, in such a way that an equipotential plane extends between the two tubes.

The grid plane is effectively grounded at the carrier frequency by a pair of open-circuited quarter-wave lines which are tuned by means of polystyrene slugs. These lines also form the principal me-

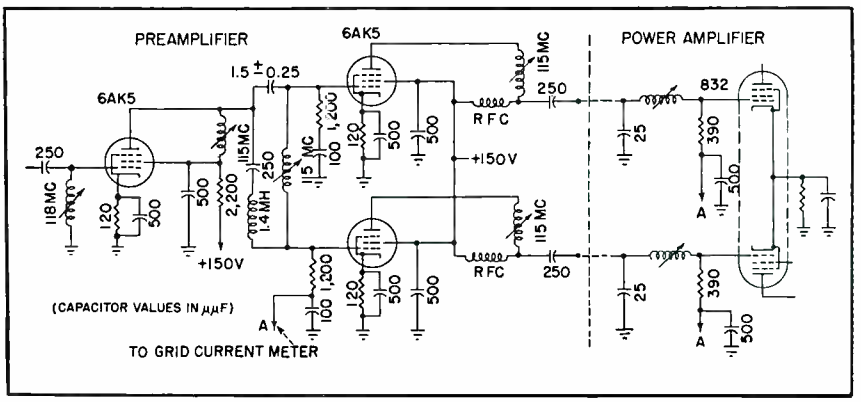


FIG. 4—Preamplifier output, and power amplifier input connections

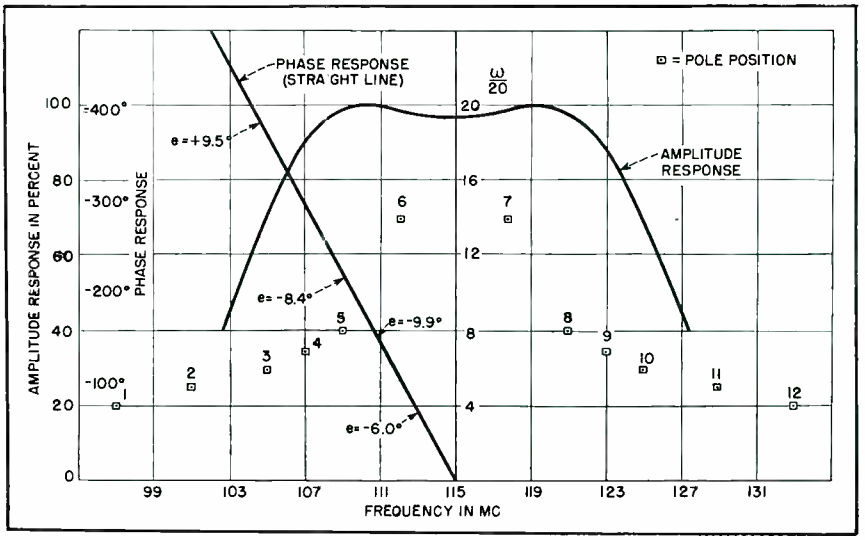


FIG. 5—Transmitter i-f amplifier response curve

chanical support for the grid plane. The grid plane is excited at the i-f frequency. Contact from the i-f final amplifier to the grid plane is provided by a rod which lies in the equipotential plane within the cavity. The capacitance of the grid plane is resonated with the inductor *L*, which is actually within the cavity, the d-c lead being brought out through a feed-through bypass capacitor. Thus the cathodes of the output tubes are driven in push-pull by a balanced r-f carrier signal, while the grids are driven in parallel by the frequency-modulated i-f signal. High-level signals are applied to both cathode and grid circuits, and the tubes are biased by grid current to approximately three times normal cutoff.

The plate cavity is tuned by slug tuners to either the sum or the difference frequency of the two input signals. The r-f output, comprising a frequency-modulated carrier having a deviation equal in megacycles to that of the i-f signal, is obtained through a coupling loop. The output cavity is loaded to a bandwidth in excess of 20 megacycles. Normal operating conditions for this stage are approximately as follows: B voltage, 700 volts; plate current 0.060 amp per tube; grid bias, 30 volts (due equally to carrier and i-f drive); carrier frequency approximately 1,240 mc; i-f drive frequency, 105 to 125 mc; output frequency, 1,345 to 1,365 mc; power output, in excess of 25 watts; carrier-frequency output (without additional filters), about 35 db below output signal.

Receiver Circuit

The receiver circuits (Fig. 1) are all conventional or similar to those of the transmitter, except that the i-f amplifier consists of 12 stagger-tuned stages. Its polar diagram is shown in Fig. 8. Additional poles are required for input and output coupling networks. Single-tuned stages were used throughout be-

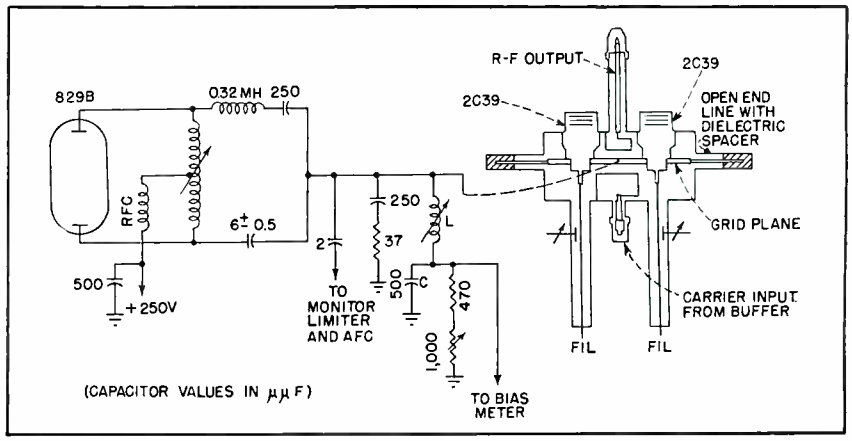


FIG. 7—Heterodyne r-f output stage of the television relay equipment, including part of the preceding i-f amplifier

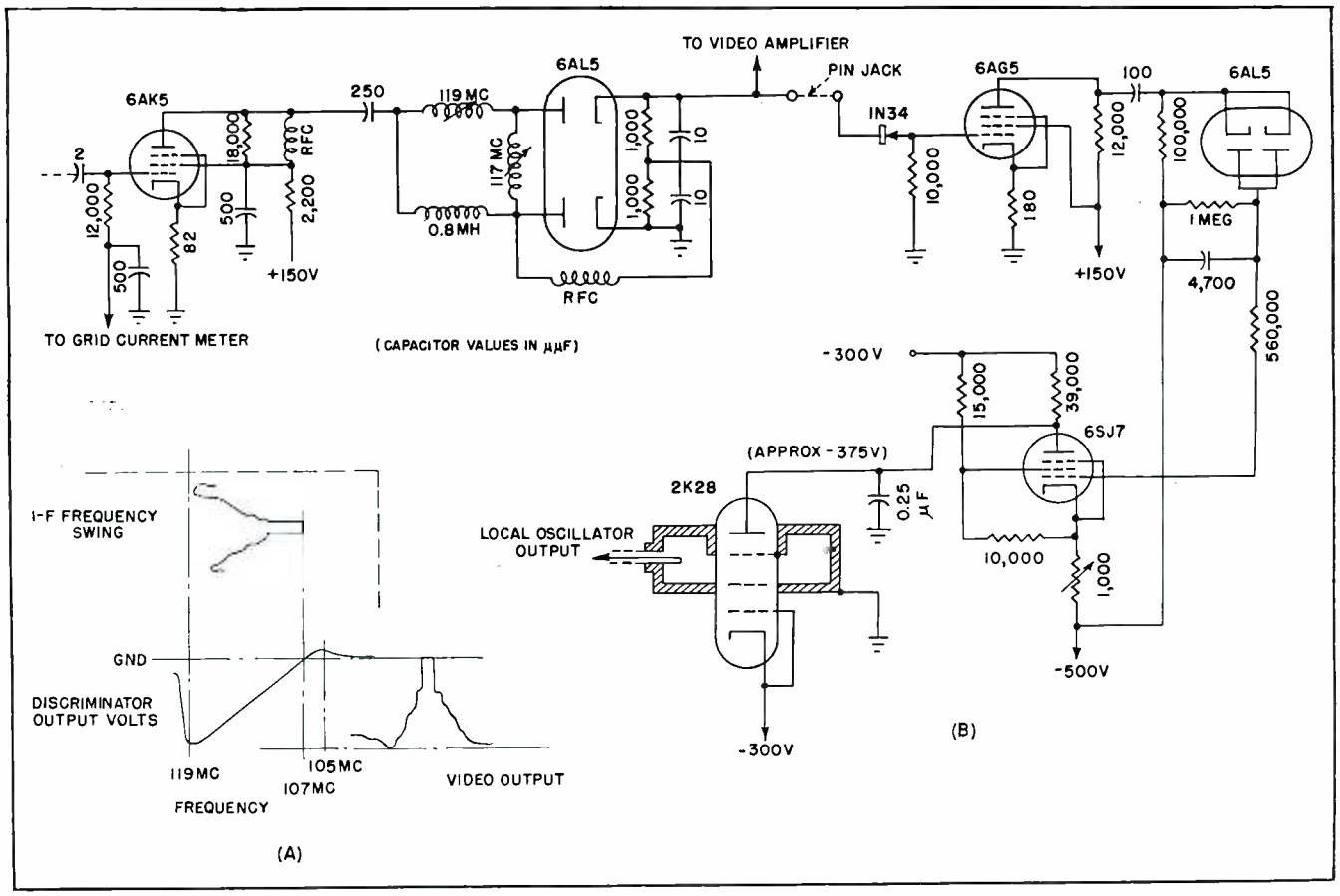


FIG. 6—Discriminator circuit employed in the system

cause of the simplicity of the layout and the ease of alignment and servicing. This amplifier has a mean gain per stage of about 2.7 and is so simple in construction that its coils can be preadjusted on a Q-meter before installation.

As tubes may be replaced without retuning, the circuits are effectively fixed-tuned. The amplifier operates effectively on an r-f input of approximately 95 db below 1 watt, although its normal operating range is at a much higher level. The receiving output is 1 volt peak-to-peak across 70 ohms (corresponding to the input level). Thus the output signal corresponds in all respects to the input signal.

The i-f frequency bands are selected primarily for their adaptability to the double superheterodyne amplifier of the repeater station. An input signal (from a previous transmitter) is heterodyned against an r-f oscillator signal to obtain a 75-mc i-f signal. This is amplified in an amplifier identical to that of the receiver and fed to an intermediate converter, where it is again heterodyned against a crystal-controlled 190-mc signal to produce a 115-mc signal. Again a 115-mc amplifier identical to that of the transmitter is used to drive another output stage. By maintaining a difference between the r-f input and output frequencies equal to the difference between the i-f frequencies, and by transposing the local oscillator frequency from below the incoming signal to above the incoming signal on alternate repeaters, a minimum number of amplifier designs are required. In repeater stations, either the afc is locked on the incoming carrier, or else stabilized oscillators are used.

SYSTEM PERFORMANCE

Transmitter Power (20 watts)	+13.0 db	
Transmitter Cable Loss (30 Ft of RG-17/U cable)	− 1.5 db	
Space Loss (31 miles, one 4-ft and one 8-ft parabolic antenna with 65 percent antenna efficiency)	−76.5 db	
Receiver Cable Loss (120 Ft of RG-17/U cable)	− 6.5 db	
Signal Level		−71.5 db
Crystal Conversion Loss (this figure is 6 db below minimum due to the bandwidth and impedances of crystal circuits)		−10 db
Receiver Noise Level	−125 db	
Crystal Noise Factor	+ 6 db	
	−119 db	−81.5 db
RF S/N Ratio		37.5 db
Improvement Due to Wideband F-M		+12 db
Effective S/N Ratio (RMS)		+49.5 db
For a television signal:		
Ratio of Peak Signal Voltage to RMS Noise Voltage		+58.5 db
Further Improvements:		
(Use of two 8-ft antennas instead of one 8-ft and one 4-ft antenna)		+ 6.0 db
(Elimination of RG-17/U cables)		+ 8.0 db
Max S/N Ratio		72.5 db

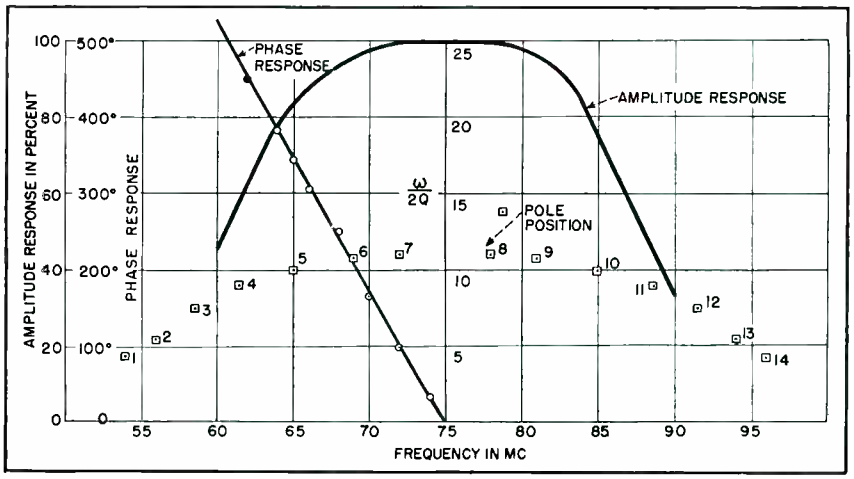


FIG. 8—Receiver i-f amplifier response curve

Operating Characteristics

The system described has no operating controls other than an initial deviation adjusting control. In fact, no additional controls have been found necessary because of the inclusion in the equipment of amplifiers of adequate bandwidth. With a d-c maximum carrier swing of 13 mc, only the first-order sidebands of the f-m signal are transmitted when they occur at the limits of carrier swing. At the high deviation ratio employed, this condition is satisfactory. The amplitude response is controlled throughout the system, while special attention has been paid to the phase response of the amplifiers. For single link pickups a signal-to-noise ratio of 50 db is obtainable at a range of 30 miles provided that no more than a reasonable length of flexible antenna cable is used. System performance data is given in an accompanying table.

The performance of the system in the presence of multipath signals is also good. Under test conditions, with signal levels below normal levels, unique patterns resembling grained wood patterns may be observed, in which the change of picture shading due to the echo will be related to the frequency shift of the carrier during the time interval equal to the difference in the propagation times over the two signal paths. The change of shading is most pronounced following a sharp signal change in the picture pattern. Under normal operating conditions, but in the presence of an echo signal of approximately 5 percent of the strength of the principal signal, essentially complete suppression of the echo is achieved and performance is superior to that of an amplitude-modulated system under equivalent conditions.

PRODUCTION TESTING

Power with which to operate instruments at any one of 21 calibration speeds is obtained from a tuning-fork oscillator, electronic amplifiers, synchronous motors and unique electromagnetic generators. Remote control of test frequencies is available to each operator

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THE PURPOSE of aircraft tachometers is to indicate the rotational speed of the engines. The remoteness of the engines from the instrument panel generally makes mechanical means of transmission impractical and calls for the application of electrical telemetering techniques.

The telemetering system usually consists of a synchronous, three-phase generator which is mounted on and driven directly by the aircraft engine, and a synchronous three-phase motor located in the indicator instrument on the instrument board and energized by the tachometer generator.[1, 2] The instrument motor rotates an assembly of permanent magnets which produce an electromagnetic torque in an aluminum alloy disc. The disc is displaced by the electromagnetic torque against the restraining torque of a spring with linear elongation characteristic. Therefore, by coupling a pointer to the disc, a deflection can be obtained that is proportional to the speed of the aircraft engine.

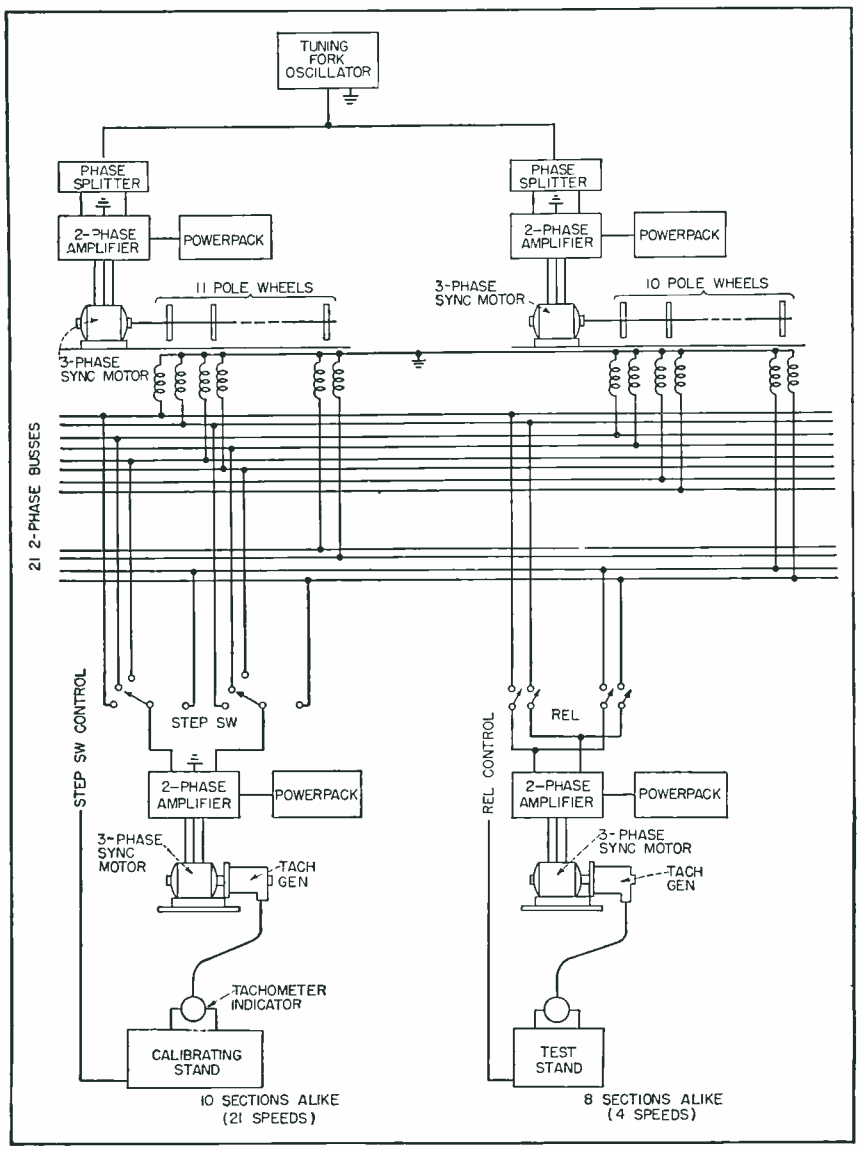


FIG. 1—Block diagram of the testing system

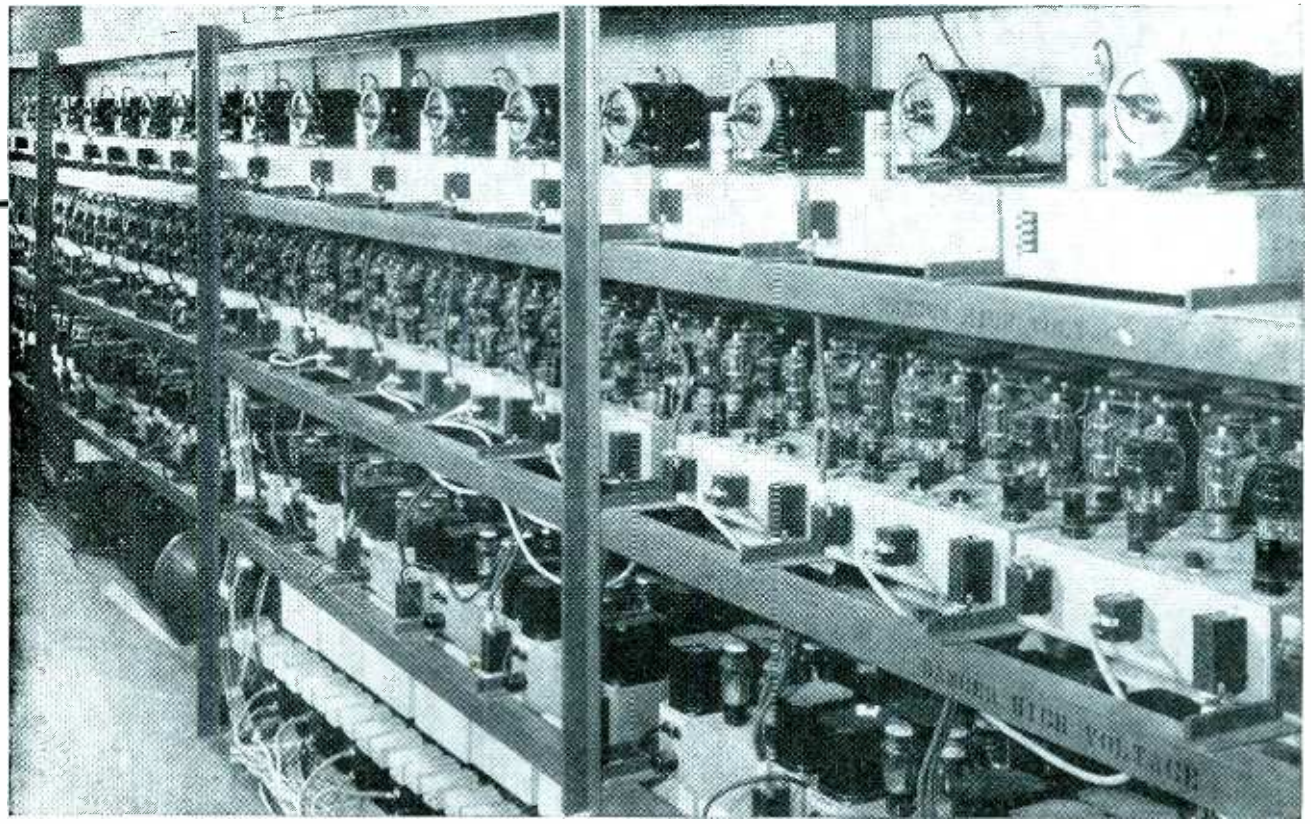
The indicator instruments are assembled from interchangeable subassemblies. Each subassembly must be tested before it is placed on the main assembly line. Finally, the fully assembled instrument is tested. Tests include exposure to vibration, various angular positions in space, temperature as low as −55 C and as high as 70 C. These tests must be conducted at various predetermined speeds and at narrow tolerances.

After the instrument has passed through all the preliminary tests, it is calibrated at a speed of 3,000 rpm, corresponding to two-thirds full scale, by partially demagnetizing the rotating permanent magnets. The calibration is then checked for increasing and decreasing speeds. While some tests are required to be made at only four predetermined speeds, other tests require as many as twenty-one predetermined speeds.

The requirements for a tachometer testing system handling large

* The testing equipment described was developed, built, and operated by the Sunbeam Corp., Chicago, with which the author was formerly affiliated.

OF TACHOMETERS



Equipment for the production testing of aircraft tachometers. Pole wheels are on the floor, in the background, with frequency-selector relays and stepping switches in the foreground. Powerpacks are on the first shelf, two-phase amplifiers on the second and synchronous motors driving tachometer generators on the third

quantities of instruments at high accuracies may be stated as follows:

(1) Selection of the predetermined speeds must be a simple operation.

(2) Test speeds must be of an accuracy exceeding the accuracy of the instrument under test.

(3) It must be possible to operate simultaneously a multitude of testing stands.

(4) A test going on at one test stand must not interfere with tests being conducted simultaneously at other test stands.

(5) Test equipment must stand up under almost continuous use.

Basic Solution

In Fig. 1 a tuning fork oscillator of an accuracy of 0.001 percent and 50 cycles per second is used as a standard frequency reference.[3] The single-phase output of the tuning fork oscillator is fed into two phase splitters consisting of resistance-capacitance networks which split the oscillator voltage into two components electrically approximately 90 degrees apart. The two voltages are applied to the inputs of two two-phase amplifiers. The two output transformers of the two-phase amplifiers are in Scott connection, resulting in three-phase power output.[4] This three-phase power is used for energizing two synchronous motors driving a total of 21 two-phase generators (called pole wheels) which produce voltages at 21 different frequencies, corresponding to the 21 different speeds at which the indicator instrument is to be operated under test.

The voltages generated by the 21 pole wheels are routed to a bus system from which they can be picked up by rotary switches or relays and fed into two-phase amplifiers. These two-phase amplifiers are identical with those used for energizing the synchronous motors which drive the pole wheels. Their three-phase output is used to energize synchronous motors driving standard tachometer generators. Because of the application of synchronous motors and generators all the way through, the accuracy at which the instrument motor will run equals the accuracy of the tuning fork oscillator. The output of the tachometer generator is wired to the test or calibrating stands of the indicator instruments. The test stands are equipped with means for the remote control of the associated amplifier and for the selection of any speed necessary for testing.

Two-Phase Amplifiers

Both phases are independently amplified throughout the system, but the output sides of the output transformers in each two-phase amplifier are connected in Scott transformation in order to obtain a three-phase output.

The first stage of each amplifier

used for the amplification of the small voltages obtained from the pole wheels (or from the phase splitters) operates on an input signal of between 0.1 and 1 volt. These rather small voltages require high-gain amplification which is obtained from a 6SJ7 tube in pentode connection as shown in Fig. 2. The frequency range is 8⅓ to 75 cycles per second. Because of the low frequency, unusually large capacitance values have to be chosen for the bypass capacitors shunting the cathode bias resistor and the screen resistor, as well as for the coupling capacitor to the following stage.

The second stage uses a 6L6G tube, connected as a class-A1 amplifier to provide driving power for the final stage. The final stage consists of a push-pull amplifier in class-AB_2 connection, using 807 tubes. It was necessary to connect radio-frequency chokes in the plate and screen grid leads in order to suppress parasitic oscillation.

The output transformers were especially designed in order to permit operation at very low frequencies and also to provide the correct winding ratio for Scott transformation. With variable speeds of the synchronous motor (energized from the amplifier), the load resistance of the motor reflected between the plates of the 807's also varies. At the higher speeds of the synchronous motor, where relatively large amounts of power are required for pulling into synchronism, rematching of the output impedance becomes necessary. For this purpose additional taps at the output transformer are provided and these are automatically switched by the speed selector.

The synchronous motor driven by the amplifier is rated ⅛-horsepower, 220 volts, three-phase, 1,500 rpm at 50 cycles. Power-factor correction capacitors adjusted for full compensation at full load were used to unburden the amplifier from carrying inductive reactive power.

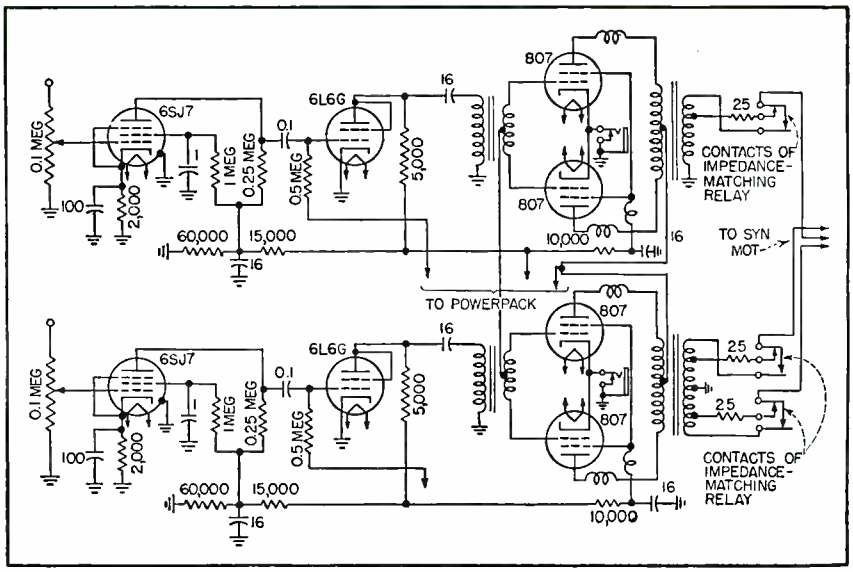


FIG. 2—Typical two-phase amplifier

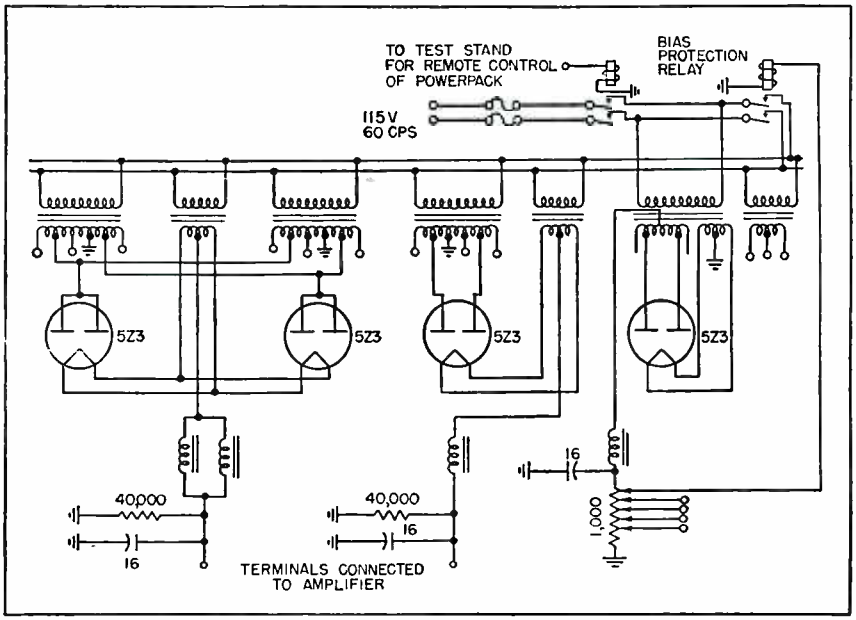


FIG. 3—Powerpack for a two-phase amplifier used in the tachometer production testing setup

Powerpack

Each amplifier has a powerpack, as shown in Fig. 3. Two 5Z3 tubes are used to provide the plate power for the two 807 push-pull amplifiers. Another rectifier produces the plate power for the first and second stages and the various screen currents. A third rectifier is used for obtaining the bias voltages for the second and third stages. The powerpack is remotely controlled from the test stand by means of a relay whose contacts control the 115-volt power supply. In order to protect the amplifier against overload in case of loss of bias, a protection relay is energized from the bias voltage. The contacts of this relay are in series with the 115-volt supply. In case of bias voltage failure, this relay becomes de-energized, opens its contacts, and thus disconnects the rectifiers from the 115-volt, 60-cycle power supply.

Figure 4 shows, from right to left, the powerpack, the amplifier, and the synchronous motor-generator section. The relay between the two output transformers, visible on the amplifier chassis, is the automatic impedance rematching relay. The two knobs at the front end of the amplifier chassis control the potentiometers for the input to the first amplifier stages. A tuned flywheel serves to subdue torsional oscillations of the synchronous motor.

Pole Wheels

The two synchronous motors shown in the upper section of the block diagram (Fig. 1), have four poles and hence rotate at 1,500 rpm

when energized by 50-cycle power from the tuning fork oscillator. Gears reduce the motor speeds to 100 rpm on one machine shaft and to 200 rpm on the other machine shaft.

A number of discs are mounted on the two shafts, as shown in Fig. 5. Various numbers of teeth are cut into the discs. Each of these discs or pole-wheels is straddled by one pair of pickup coils. Each pickup coil has two windings. One winding is energized by d-c and serves to magnetize the pole-wheel, whereas the other is used to pick up the a-c voltage induced in it by the variable magnetic flux, caused by the teeth and slots in the pole wheels.

If a pole wheel has, for instance, 36 teeth and is rotating at 100 rpm. the frequency picked up by the coils will be 36 x 100 = 3,600 cycles per minute or 60 cycles per second. This is the frequency for a tachometer generator and instrument motor running at 1,800 rpm. Since the tachometer generator is coupled to the cam shaft of the aircraft engine, the engine runs twice as fast, namely, 3,600 rpm. Consequently, the indicator will also indicate 3,600 rpm as the speed.

It follows that the number of teeth per pole wheel of the 100-rpm machine has to be 1/100 of the speed to be indicated by the instrument. On the 200-rpm machine the number of teeth per pole wheel has to be 1/200 of the speed to be indicated by the instrument.

The application of two pickup coils per pole wheel serves to obtain two voltages of the same frequency, but of a phase displacement of approximately 90 electrical degrees. Thus 21 pairs of voltages are generated, each pair having a different frequency corresponding to the 21 different speeds to be obtained for the instrument motor.

In order to minimize magnetic stray fields and at the same time to provide mechanical protection, guards made from soft iron are placed over the pole wheels.

Test Stands

In order to test tachometers in production 18 test stands are required. Eight test stands are operated at four predetermined speeds, whereas the remaining ten require 21 predetermined speeds. Besides obtaining 21 speeds, it is necessary that these speeds can be obtained in increasing and decreasing sequence.

In order to select the frequencies allocated to the various speeds, relays and stepping switches were chosen which are remotely controlled from the test stands. For the four-speed test stands, relays were used for frequency selectors, whereas in the case of the 21 speed calibrating stands, rotary switches were applied.

Each four-speed test stand has a selector switch to energize any of the four selector relays which are assigned to the specific test stand. Contacts of these selector relays establish electrical connections between one of the 21 different frequencies from the bus system and the input of the two-phase amplifier which is allocated to the test stand under consideration. The powerpack belonging to this amplifier is turned on by remote control from the test stand. By operating the selector switch for the selection of a given speed, the corresponding selector relay energizes the two-phase amplifier with the correct frequency. This amplifier energizes a three-phase synchronous motor which belongs to the test stand under consideration, and makes it run at the desired rotational speed. A tachometer generator coupled to the foregoing synchronous motor provides the energy to be used for operating the instrument motor in the instrument under test.

In order to provide 21 speeds in increasing and decreasing sequence, one rotary stepping switch was assigned to every one of the ten calibrating stands. This switch is of a standard telephone type, having 50 positions and four levels. Two levels of the rotary switch connect the standard-frequency busses to the input of a two-phase amplifier of which one amplifier (with powerpack) is assigned to each calibrating stand. The frequencies are connected to the rotary switch in such a way that the brushes will connect the frequencies in sequence, increasing from 500 rpm to 4,400 rpm and then declining from 4,400 rpm down to 500 rpm. The third level of the rotary switch energizes indicating lamps located at the calibrating stand, identifying the

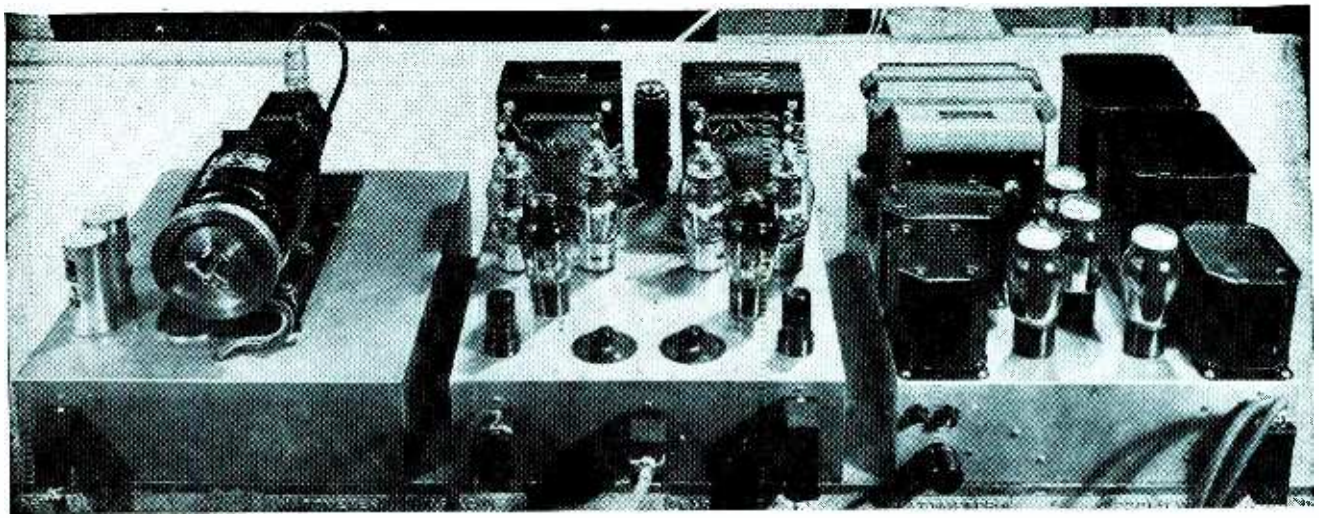


FIG. 4—From left to right: synchronous motor tachometer generator chassis, two-phase amplifier, and powerpack

speed selected by the rotary switch. The fourth level is reserved for the control of the selector switch.

If a test should be made in which every speed is needed for increasing as well as decreasing values, the operator pushes a step-button on the panel of the calibration stand shown in Fig. 6. If the rotary switch is in its home position, no voltages are fed into the input of the amplifier and the synchronous motor is standing still. As soon as the operator actuates the pushbutton, the rotary switch will step into a position where the amplifier input is connected to one of the 21 frequencies, resulting in the lowest speed (500 rpm.). If the operator wants, at this time, to go to the next speed (600 rpm), all he has to do is to again push the same pushbutton. The rotary switch will now make one more step, connecting the amplifier to a frequency corresponding to 600 rpm. Every time the operator pushes the button the next higher speed will be obtained, until the top speed of 4,400 rpm is reached. After that the speed will be reduced, step by step, every time the operator pushes the button.

In the majority of tests, however, certain speeds can be skipped. In order to maintain the same simple operation and yet obtain automatic skipping, a two-position selector switch was provided on the calibrating stand. If this selector switch is switched into *local* position, every one of the 21 speeds is obtained. If, however, this selector switch is turned into *express* position, voltages are supplied to certain contacts on the control level of the rotary switch. Any time the brush of the control level finds a contact which is energized by the selector switch it will energize its electromagnet, resulting in a further step of the rotary switch. Thus, if the operator wants to obtain the next speed, all he does is to push the *step* pushbutton once, as usual.

If it is desired to test an instrument at only one speed, for instance 3,000 rpm, it is not necessary to use the *step* pushbutton to step the rotary switch by multiple operation of this pushbutton until the speed of 3,000 rpm is reached. In order to avoid such loss of time another pushbutton, *up to 4,400 rpm*, is provided which when pressed, makes the rotary switch step up automatically. As soon as the desired speed is obtained, readily visible from the indicating lamps, the pushbutton is released and the rotary switch remains in the desired position.

In order to return the rotary switch to zero from any position, it is not necessary to push the *step* pushbutton until the rotary switch is brought back step by step to the zero position. A special pushbutton marked *back to zero* is provided which energizes all contacts of the control level except the home contact. The rotary switch then runs into its home position within one or two seconds, depending on the contact point at which the rotary switch was standing before this pushbutton was operated.

In the calibrating stand pictured a dual tachometer indicator is under test. The changeover switch on the left side of the panel permits the energization of either or both instruments. The two a-c electromagnets surrounding the instruments serve to partially demagnetize the permanent magnets for the purpose of establishing one point of the calibration. By operating the changeover switch the electromagnet belonging to the indicator motor under calibration becomes energized. The current in this electromagnet is controlled by means of a variable transformer. The front panel of the calibrating stand shows 21 indicating lamps corresponding to the 21 available speeds. The pushbuttons for the control of the rotary switch and the *local-express* selector are shown in the lower section of the panel.

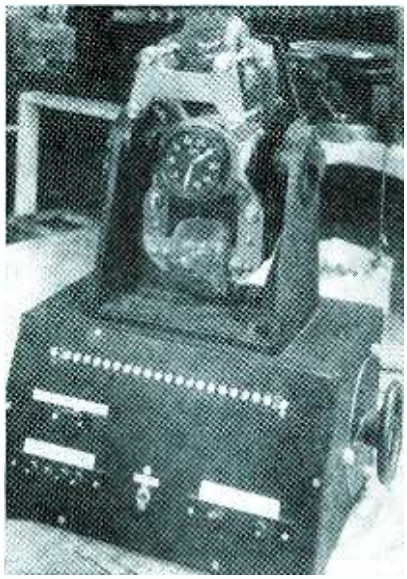


FIG. 6—Typical tachometer calibrating stand at which an operator remotely controls test frequencies and adjusts instruments by rotating the demagnetizing control wheel at the right

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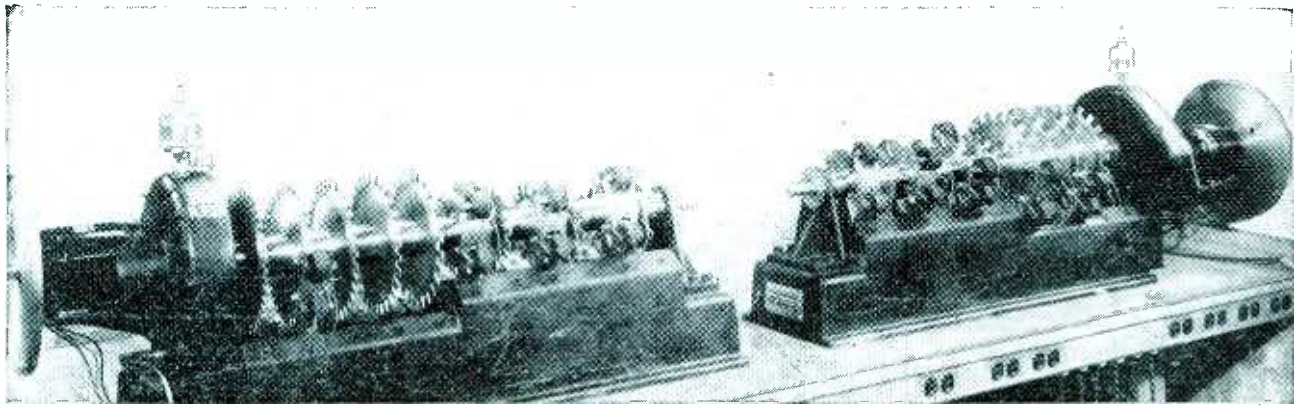


FIG. 5—These two pole wheel arrangements electromagnetically generate 21 tuning-fork-controlled test frequencies

RADIO DISPATCHING for Taxicabs

Companies using two-way radiotelephone equipment in newly opened 157-megacycle region find it pays for itself in a short time. A system using commercially available f-m transmitters and receivers is described

TWO-WAY radio between dispatcher and cabs in a taxi fleet furnishes an important new market for communications equipment, effects important economies in fleet operation, and provides better, cheaper service for the riding public.

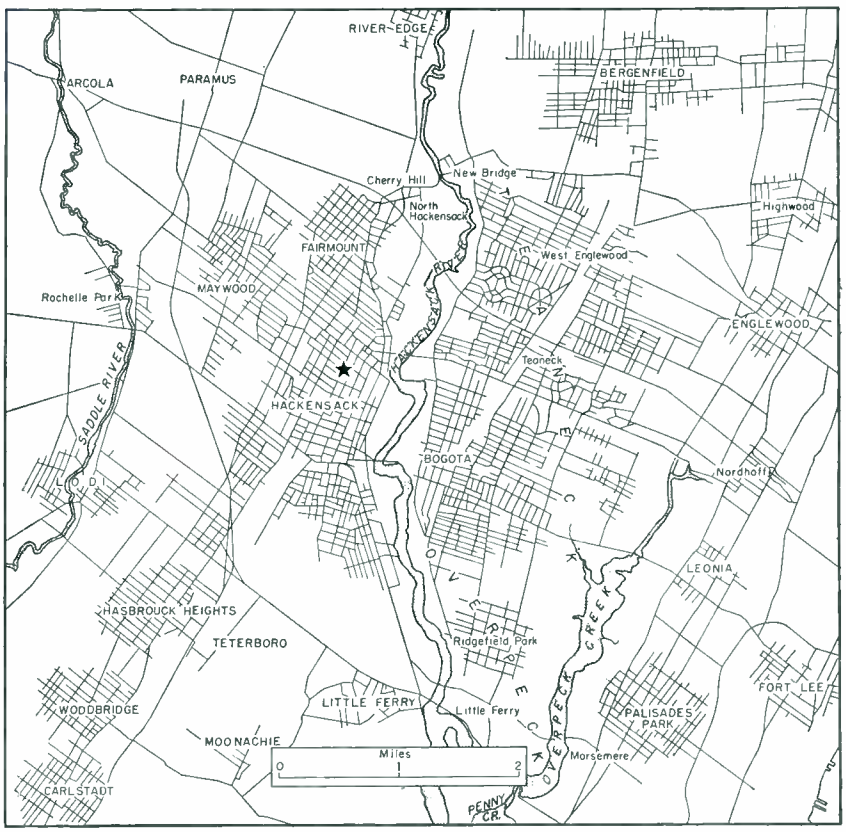
A study of several recent installations now operating under experimental licenses indicates a need for overall engineering of systems operating in any given area, an awareness on the part of FCC of the rapidly growing problem of frequency assignments, and, particularly in the initial stages, a strong spirit of good will and active cooperation among users of the new technique.

Potential users must consider the specific sort of taxi service they render and tailor their demands upon equipment manufacturers accordingly.

Representative System

One particular set of operational problems is faced by the Hackensack Taxi Service, covering the area in and around Hackensack, Bogota and Teaneck, New Jersey. Meticulous records have always been kept, so that it is easy to assess gains or losses with any innovation.

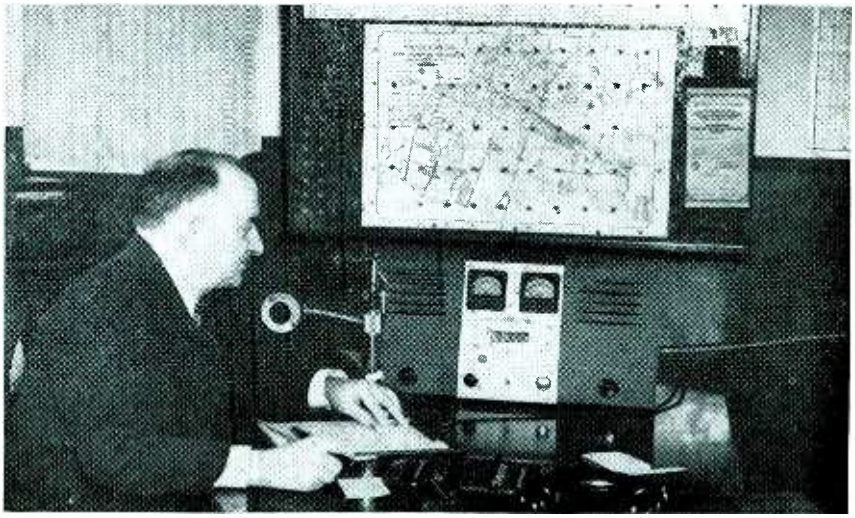
Since installation of the two-way radio system, fares have averaged 6 percent more for the same fleet, with the number of completed trips



Map showing area of taxi operations covered by 15-watt transmitters. Location of fixed station transmitting and receiving antenna about 90 feet above sea level is indicated by star. Some areas served are behind elevations exceeding that of this antenna

per hour correspondingly increased. On the basis of these figures, it is anticipated that the whole radio installation will pay for itself in ten months. "Over the meter" charges on out-of-town calls have been dropped since radio dispatching was installed. This means that the customer who formerly paid a meter charge from the taxi terminal to his home, as well as the regular home-to-destination charge and twenty-five cents in addition, now pays only for the actual mileage from home to destination. Radio dispatching eliminates the unproductive return mileage formerly run up by the cab on such calls.

The type of community served dictates the sort of dispatching service needed. Hackensack and its suburbs are typical of many small cities everywhere that do a "telephone" rather than a "pickup" taxi business. Because the majority of users initiate requests for service by telephone, as early as 1924 a telephone call box dispatching system was installed that increased earnings 20 percent and also improved service. The telephones were available to the public as well as to reporting drivers. A portion of the telephone system has been retained as a service to customers, but in no way competes with the radio dispatching system. In fact, the radio system has increased the utility of the telephone. All instruments are connected in parallel on one line so that when a customer fails to hang up the system goes dead. Now the dispatcher can send the nearest car to the phone last used with instructions to hang up the receiver!



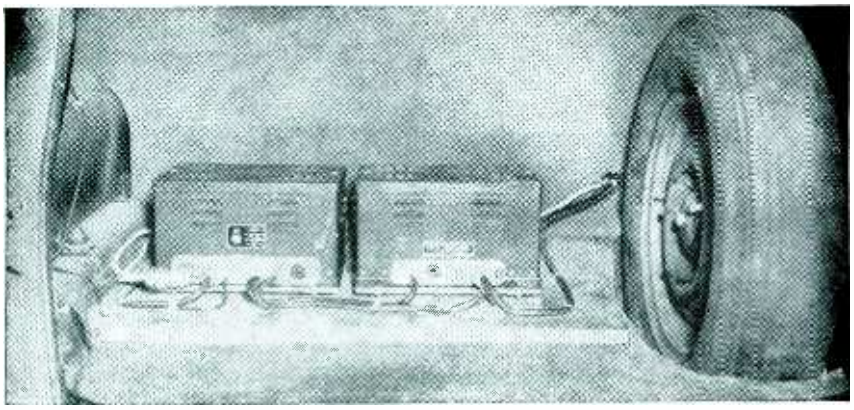
Dispatchers' desk showing dual telephone positions for incoming calls, radio microphone, and remote control unit that is operated by foot switch

It is the feeling of the company that the type of dispatching operation best suited to the situation is now in use. The number of cabs (11 at present) does not require a selective calling system of the sort that may be desirable in a larger fleet, and in fact, would slow down operations under the present system without adding to its serviceability. While no sort of lockout system is now in use, again because of the relative smallness of the fleet, it may be considered desirable to install a simple system as business expands.

Because all the cabs share pickup and telephone business equally, it has been desirable to equip each cab with two-way radio. Present experiments in larger cities may possibly show that a law of diminishing returns begins to operate before a whole fleet is radio equipped.

At the present time, 11 separate companies centered in as many communities of northern New Jersey are operating two-way radio systems with all dispatchers' transmitters operating on the experimental frequency of 152.27 megacycles and all cars on another experimental frequency of 157.53 mc, assigned to taxicab service over the whole country.

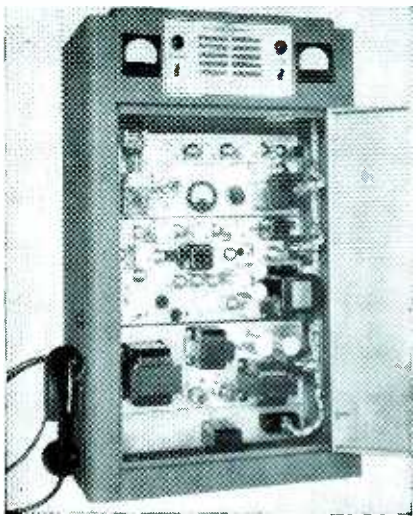
Each installation was a separate job, with antennas generally erected in locations dictated by conditions of expediency. For this reason signals from several dispatchers can be heard in any cab. Operations are sometimes difficult and would have been next to impossible without the formation of an association of the various owners, who have standardized calling procedures and assigned numbers with which the individual number of each cab in a given fleet is prefixed. For instance, Hackensack cabs use the dispatching numbers 9-1 through 9-11. Call letters assigned by FCC to the dispatcher, W2XKG, and the cars, W2XKH, are employed only as often as legal requirements demand.



Mobile transmitter (left) and receiver (right), mounted in rear deck of taxi

Equipment Installation

Physically, the present Hackensack radio plant has been adapted to existing facilities. The dispatchers' office is located in the center of the city near rail and bus terminals.



Fixed station transmitter-receiver located near foot of antenna and a half mile from dispatchers office. From top to bottom, chassis contain transmitter, receiver, and power supply

Here the incoming subscribers' telephone lines, radio control unit and microphone are located. The antenna used for transmitting and receiving is atop a 60-foot mast mounted on a one-story building used for repairs, maintenance and garaging, about half a mile from the dispatchers' office. The compact transmitter-receiver unit, itself locked, is fastened to the wall of a locked room in the garage and is connected to the control equipment by two pairs of wires furnished by the telephone company. One line is used for audio signals, incoming and outgoing, while the other serves to operate the send-receive switching mechanism built into the locked unit.

A complete log of all transmissions is kept by the dispatcher on duty, who is required to hold a restricted radiotelephone operator permit. The individual taxi drivers are not required to be licensed for radio operation inasmuch as their equipment is tamper-proof. One experienced technician, on call 24 hours a day, is the only person allowed to adjust the transmitting equipment and he holds a Radiotelephone License, First Class, as required by the FCC.

Fixed Station Details

The fixed station equipment is remotely controlled by the dispatcher. It comprises a phase-shift f-m transmitter and a receiver. Provision is made to switch the transmission line from the antenna to either unit as the wire line is connected to receiver or transmitter. The bandwidth of the antenna has been designed to provide adequate gain for both fixed and mobile frequencies. The circuit elements making up this equipment are shown as a block diagram in Fig. 1.

The phase-shift transmitting system shown in Fig. 1A provides a frequency-modulated signal with sufficient deviation to reduce noise and allow reasonable audio quality. A deviation of 20 kc each side of the carrier frequency (as contrasted with the broadcast standard of 75 kc) is adequate to provide an overall audio response that is essentially flat from 350 to 5,000 cycles. At the same time, stringent legal and practical problems of frequency stability are solved by using this circuit.

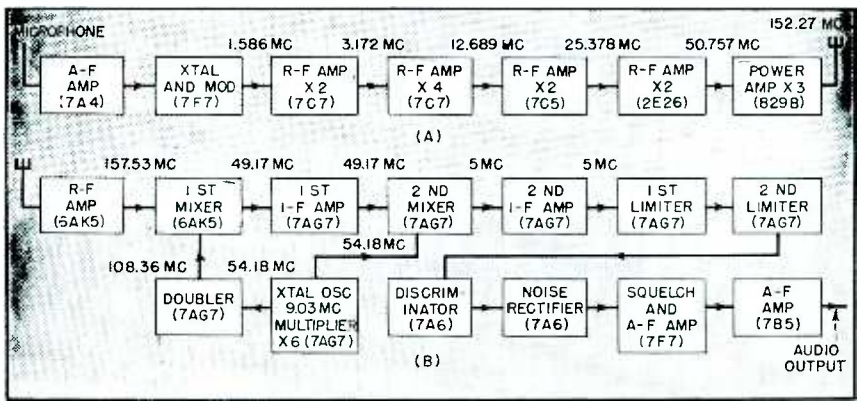


FIG. 1—Block diagram of Hackensack system circuit elements used in both fixed and mobile transmitters (A) and receivers (B). A single crystal furnishes conversion frequencies for the double-detection superheterodyne receiver

The number of frequency multiplications (96) is readily accomplished with 5 tubes. Nominal power output is 15 watts, but performance of the system can later be enhanced by the use of a higher-gain antenna or a more favorable antenna height or location.

The receiver is crystal controlled in order to insure optimum signals from unattended equipment. The block diagram of Fig. 1B shows the layout of circuit elements. A double-conversion superheterodyne makes use of a single crystal operating at 9.03 megacycles for both local oscillator frequencies. The double i-f system gives good bandpass characteristics and a favorable image ratio. A squelch circuit can be switched in or out to quiet the audio output of the receiver during the period when no signal is being received.

Since the transmitter-receiver operates on 115 volts and power consumption varies between 125 and 320 watts, no special wiring is necessary.

Mobile Stations

Circuitwise, the mobile equipment is identical with that employed in the fixed station, but is differently packaged. A loudspeaker is normally operative in the taxi, but the receiver of a telephone handset can be used for conversations once communication is established. A switch on the handset operates a relay to shift the antenna connection from receiver to transmitter when the cab operator wishes to talk back. The antenna itself is a quarter-wave whip mounted through the roof of the cab and works against the metal roof as a ground. Power is taken from the car storage battery and the total standby power drain is about 10 amperes at 6 volts. An additional 23 amperes is required during periods of transmission from the cab.

Acknowledgment

Assistance by Harry G. Remsen, proprietor of the Hackensack Taxi Service, and officials of the Link Radio Corp., in the preparation of this article is gratefully acknowledged.—A.A.McK.

TELEMETERING From V-2 Rockets

Time-modulated pulse system in nose of rocket samples successively up to 23 instruments and transmits readings to ground station over 1,000-mc radio link using 2C43 disk-seal tube as oscillator. Airborne circuits are given here; Part II will cover ground circuits

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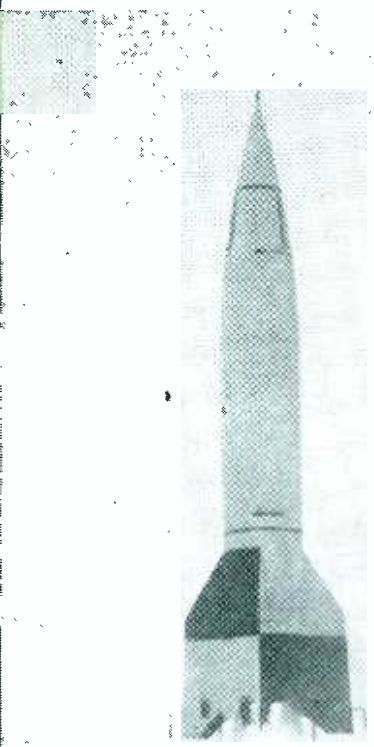


V-2 rocket taking off at White Sands, New Mexico, with radio telemetering equipment in nose. The AAF program calls for firing a total of 50 of these guided missiles

Part I

ONE of the most important problems which must be solved in connection with the use of a rocket as a vehicle for upper-atmosphere research is that of making available to the observer information obtained at the rocket during flight. Radio telemetering equipment designed by the Rocket Sonde Research Section of the Naval Research Laboratory has been employed for this purpose during all of the V-2 firings at White Sands, New Mexico.

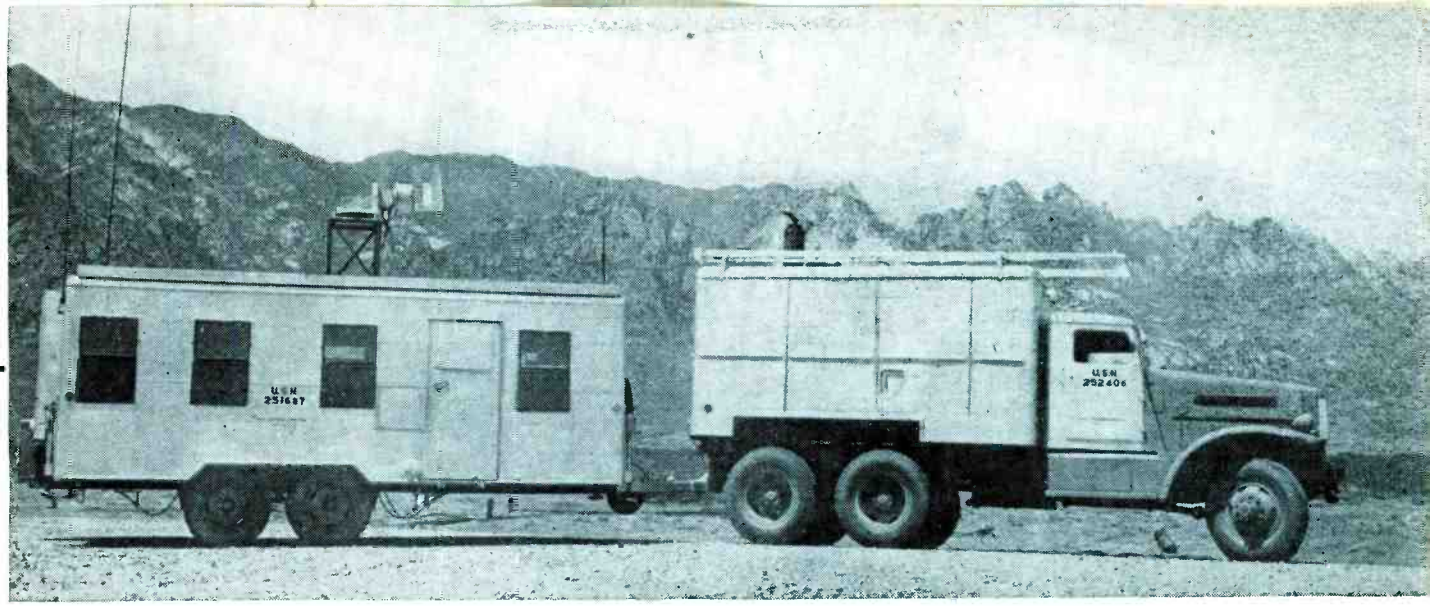
Typical of the basic research data telemetered by the system are temperatures and pressures in the upper atmosphere, various characteristics of the primary cosmic radiation, and properties of the ionosphere. For studies of rocket performance, data are telemetered on such quantities as speed, rocket acceleration and altitude, skin temperatures at various critical points, and motion of the control fins.

The system was designed to telemeter, by means of independent time channels, as many as twenty-three separate quantities by successively sampling a corresponding number of data voltages obtained from instrumentation installed in the rocket. The sampled voltages are converted to a form suitable for radio transmission, radioed to a ground station, reconverted to their original form, and recorded.

Time-Modulated Pulse System

To obtain reliable telemetering over ranges in excess of 100 miles with limited allowances for size and weight of the rocket-borne equipment, a time-modulated pulse system was chosen. The pulse system delivers a higher peak power with a lower average power consumption and occupies less space than a comparable continuous-carrier system. The system used in the V-2 operates at about 1,000 megacycles, a frequency which is high enough to penetrate the ionosphere and which at the same time is clear of other frequencies used in the flights.

The data voltages are converted into time intervals, defined by voltage pulses, corresponding in length to the magnitude of the data voltages. The data voltages are sam-



Mobile telemetering ground station. The trailer carries a 1,000-mc receiver, a decoder, recording equipment, monitoring and test equipment, communication receivers and transmitters, and timing mechanisms, while truck contains 25-kw power generator

pled in a specific order and are used to generate a series of pulses, the time intervals between which measure the sampled data voltages. The intervals maintain the same time sequence as the sampled voltages, the pulse marking the end of one interval serving as the initial pulse of the succeeding interval.

A complete sampling of all data voltages is used to form such a group of time intervals periodically. A master keyer initiates the sampling process at a uniform rate. The distinction between different groups is made possible by allowing for a sufficiently long time between the initial pulses of each group. In this manner, the interval between the last pulse of one group and the first of the next is made to be very much longer than any of the measurement intervals.

Airborne Unit

In Fig. 1 is a block diagram of the airborne unit which converts data voltages into appropriate form and transmits a corresponding radio-frequency signal. A master keyer, which is a freely running multivibrator of constant period, generates the first pulse of each group. This pulse is fed to a channel collector, a circuit common to the outputs of each time channel, and at the same time is used to trigger time channel multivibrator 1.

The multivibrator for each channel is of the self-returning type, the recovery time of which is determined by the corresponding data voltage. The first, upon recovery, delivers a pulse both to the channel collector and to channel 2 multivibrator, which in turn triggers that of the next channel and delivers an output pulse to the collector. The process is repeated in appropriate sequence until all time channels have operated, after which the circuit is quiescent until the master keyer again initiates the sequence. The output pulses delivered to the channel collector by the various multivibrators are fed to a power modulator which in turn pulses the vhf power oscillator, feeding the antenna.

Ground Station

In Fig. 2 is a block diagram of the ground station, which receives, decodes, and records the data. The antenna is trained to follow the airborne radiator by both optical and signal-maximizing techniques. The detected output of the receiver, suitably amplified, is fed into a decoder unit, the purpose of which is to recover the original voltage forms from the time-modulated signals. The original data is then separated into the various channels, displayed on meters, and recorded by various methods.

The use of several different methods of recording provides safeguards against the possibility that the whole record be lost due to the failure of any one method. The principal record is made on a moving strip of photographic paper by means of Hathaway magnetic string oscillographs. Auxiliary records are obtained by photographing the meter panel with a 35-mm movie camera. An oscillographic record is made of the output of the video amplifier with a continuous film camera. The same signal is

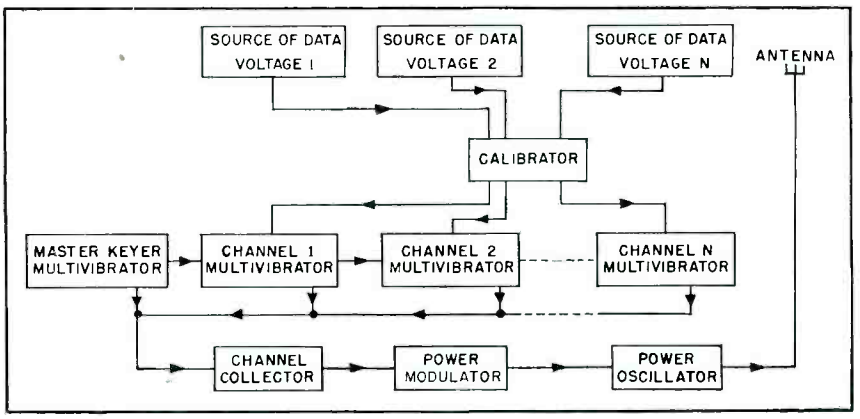
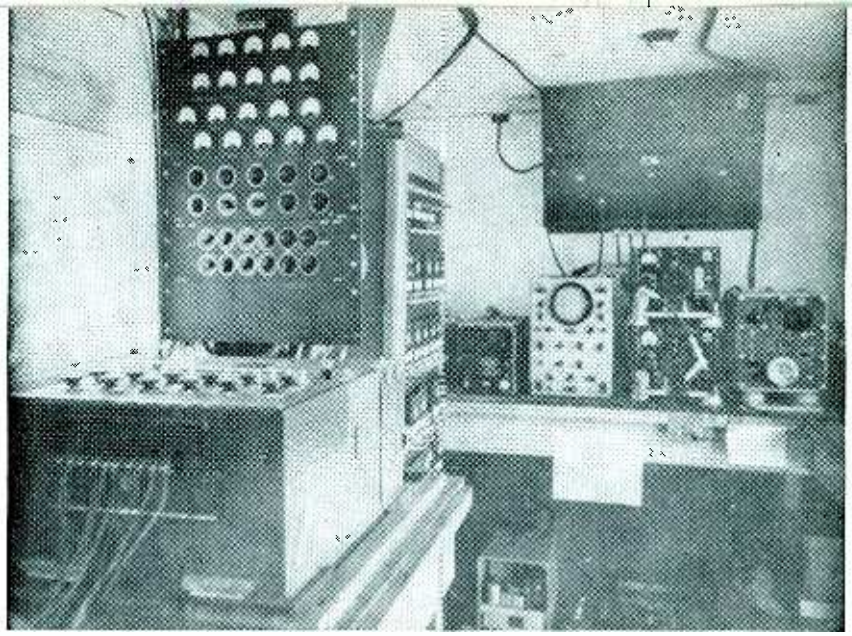


FIG. 1—Block diagram of airborne telemetering unit used in V-2 rockets

recorded on a magnetic wire recorder from which the data can be recovered later in the event of decoder failure. Timing signals are impressed on all of the recording media from a time signal receiver.

The pulse discriminator in the decoder may be adjusted to reject pulses of other than a specified duration. The discriminator output is fed to both the synchronizing pulse generator and to the input of each channel separator via the pulse inverter. The synchronizing generator output consists of one pulse at the start of every group of received pulses, which goes to channel 1 separator, triggering a multivibrator. This multivibrator is returned to its original state by the second pulse of the pulse group now arriving from the inverter. On returning to its original state, separator 1 delivers a pulse which triggers separator 2. The return of separator 2 is effected by the third pulse of the incoming series relayed by the pulse inverter. This action continues, each channel separator triggering the following channel while being itself returned by the signal.

During the conduction period for any channel separator, the corresponding metering circuit is fed a constant voltage, the same for all channels, for a length of time equal to the interval representing the corresponding data voltage. A capacitor is charged thereby to a potential which depends upon the duration of the voltage applied. By suitable circuits, this potential is measured with a vacuum-tube voltmeter, the magnitude being a linear function of original data voltage.



Interior of trailer serving as mobile ground station. At left foreground is a standard 12-channel Hathaway magnetic string oscillograph. Meters above it read individual channel output voltages, and are photographed by a movie camera (not shown) during each test. Upright instrument behind meters and facing right is the decoder. Instruments on table at rear are, left to right, video amplifier, monitoring scope, antenna servo control unit, and timer unit

Calibrator units are placed in the transmitting station to determine any shift in the absolute response of the system. The calibrator periodically breaks the connection from the data voltage source to the pulse time modulator channel, and connects in its stead first a ground or zero voltage and then a stable reference potential of 3.5 volts. Two such calibrating units are built into each transmitter.

A large number of slowly varying quantities such as temperature and pressure may be measured through a single telemetering channel by mechanical commutation. When used, such mechanical commutators are provided as part of the instrumentation of the experiment concerned. For one V-2 rocket, temperature and pressure measurements utilized 16 commutated subchannels compressed into two telemetering channels.

Data taken by telemetering is correlated with radar tracking plots, optical data, and photographic records of the missile's trajectory by means of a master timing signal, so that telemetered information may be plotted as a function of the altitude of the rocket for the entire flight.

The timing signals originate at a special installation provided by a group from the Army's Aberdeen Proving Ground. A timing pulse is provided every half second above a 100-cycle background, beginning at the time of the rocket takeoff, with every twentieth pulse after takeoff omitted.

At the telemetering ground station, the time signals are fed to one of the Hathaway oscillograph recording channels to make a permanent time reference along with the telemetered data. The time signal also triggers time marking de-

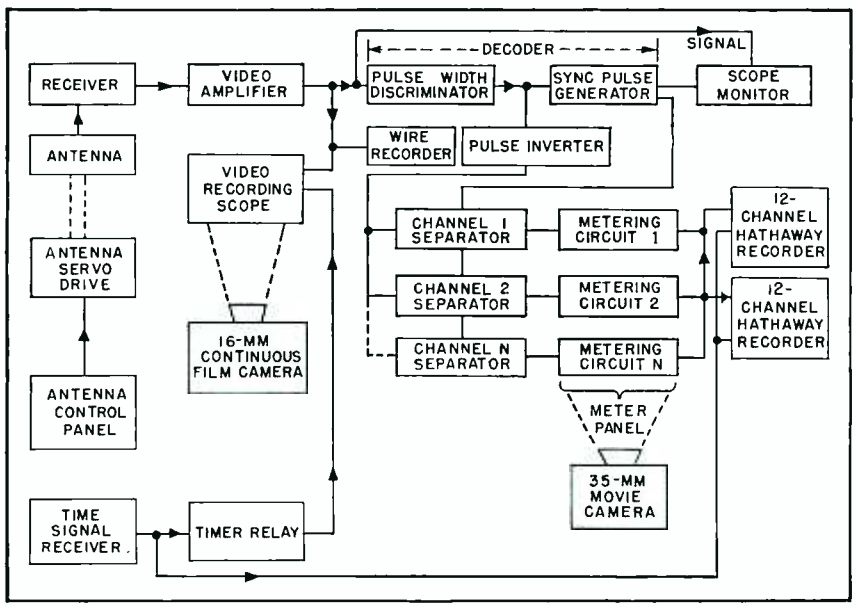


FIG. 2—Block diagram of equipment located in trailer serving as ground station for V-2 telemetering system

vices used with the movie camera, wire recorder, and continuous film camera.

The ground station antenna, located at the center of the trailer roof, can be directed either by an observer on the roof or by an operator inside the trailer. For the most part all operations work automatically during a telemetering run except for directing the antenna which is done both optically and by listening to the signal and maximizing the output. More than one ground station is used to lessen the chance of a break in the telemetering service. In all of the firings to date, there have been two mobile stations in operation.

Circuit of Airborne Telemetering Unit

The pulse time modulator in the airborne unit is designed to generate a time interval over the range of from 50 microseconds for zero voltage input to 200 microseconds for + 5 volts input signal. These times are measured from the leading edges of the two pulses defining a time interval.

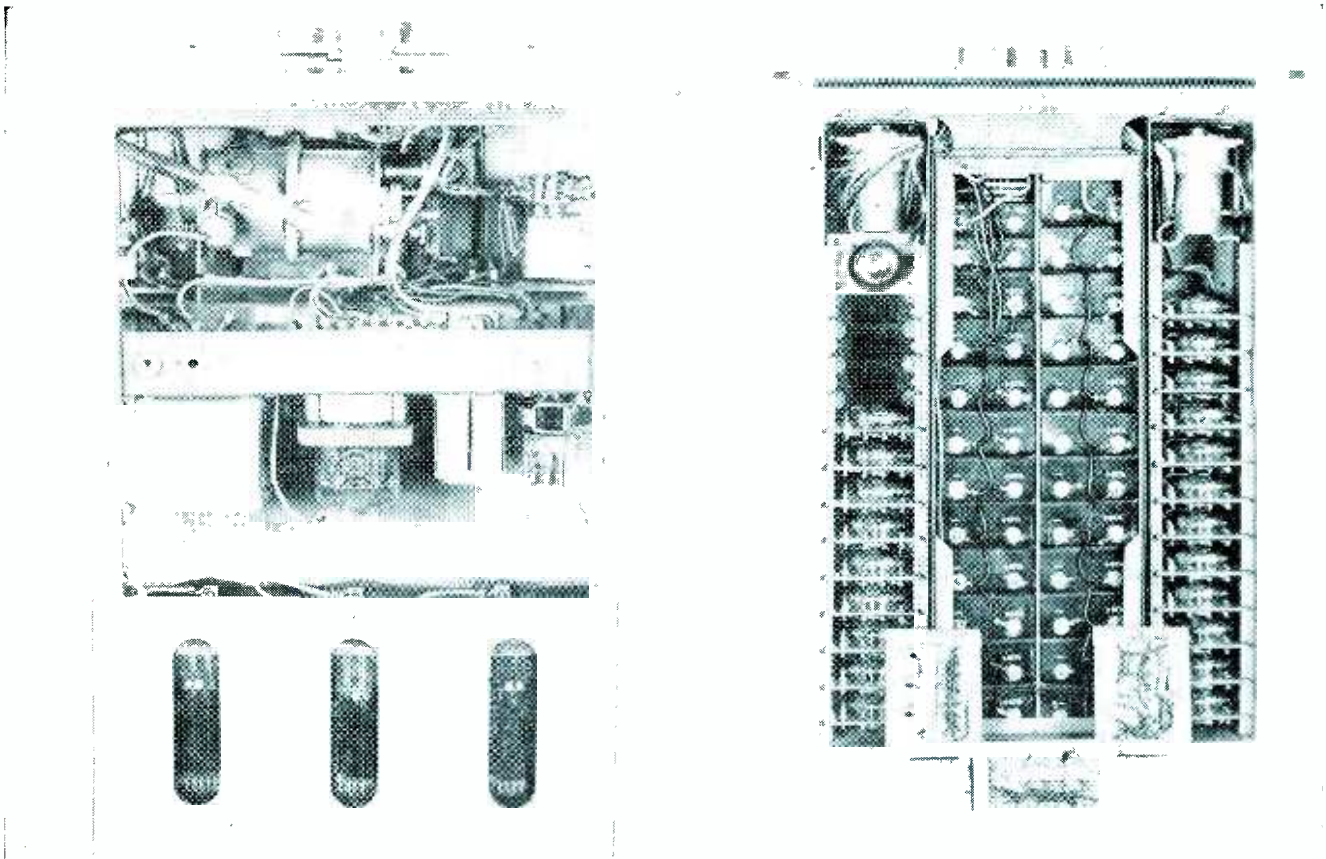
To maintain satisfactory differentiation between groups, it is necessary that there be a spacing of at least 600 microseconds between the last pulse of one group and the first pulse of the next. Furthermore, the full 200-microsecond period, corresponding to a + 5-volt input, might conceivably be required for all channels in one sampling cycle. Thus, the time required for the formation of a single group of telemetering pulses may be as long as 5,200 microseconds for a 23-channel system. In such a case, the maximum allowable repetition rate is 192 cycles a second. With such an arrangement, data voltages fed into the telemetering channels are sampled 192 times a second.

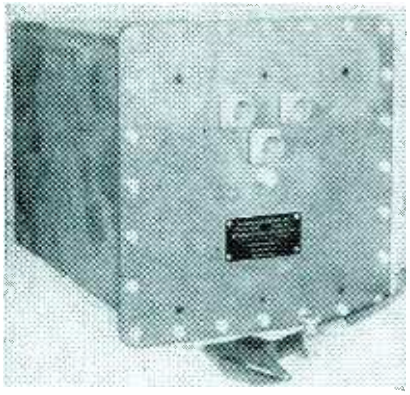
The circuit diagram of the airborne unit appears in Fig. 3, and corresponding wave forms at ten different points in the circuit are shown in Fig. 4. All electronic circuit functions are initiated by a master keyer, which is simply a freely running multivibrator. The period of the multivibrator of the master keyer is the pulse group repetition period, and is set by adjusting R_1. The output from the master keyer (point A) consists of square waves which are coupled through short time constant circuits to channel 1 and the channel collector.

The positive surge from the keyer does not affect either channel 1 or the channel collector. The surge does not affect V_4 because the grid is already at full conduction potential. It does not pass to the channel collector because it is blocked by diode crystal X_1. At time t_1 the negative surge from the keyer, acting on the blocked multivibrator of channel 1, triggers it from its normal state to a temporary state (from a state in which V_4 is conducting to a state in which V_3 is conducting). As a result of the negative surge impressed on the grid of V_4 the potential of the common cathodes drops until V_3 begins to conduct. Conduction of V_3 produces a negative surge at its anode, which is coupled to the grid of V_4 to drive that grid still further negative. Channel 1 now remains in its temporary state until the charge impressed upon this grid leaks off through resistors R_2 and R_3.

During the temporary state of channel 1, the grid potential of V_4 rises at an exponential rate determined by C_1, R_2, and R_3. At time t_2, after the grid of V_4 has returned

Two views of airborne unit out of housing. At left is the oscillator cavity (upper section) with 2C43 disk-seal tube operating at 1,000 mc, and 3E29 modulator tube mounted upside down below it. At right are two groups of pulse time modulator circuits and the high-voltage supply battery. Three of the plug-in ptm units are removed from their sockets to illustrate the use of subminiature tubes. Motors in upper corners drive the calibrator units that apply known voltages at regular intervals in place of instrumentation voltages





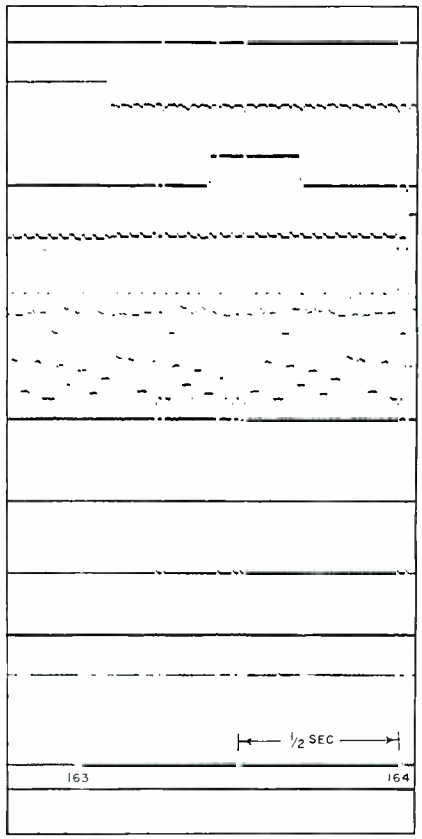
Complete telemetering airborne unit in 14 x 14 x 20-inch pressure-sealed case weighs only 150 lb, including 1,000-mc dipole

sufficiently positive, conduction in V_4 again begins; the cathode potential rises, a positive surge is generated at the anode of V_3 which is coupled to the grid of V_4, the circuit returns to its steady-state condition, and a negative surge is generated at point D. This surge, coupled through short time constant circuits to channel 2, initiates in channel 2 an action similar to that which took place in channel 1. Such action continues from one channel to the next, the return of a channel to its stable state triggering the succeeding channel to its temporary state, and simultaneously delivering a pulse to the channel collector circuit. When the last channel is reached the action stops and does not repeat until a pulse from the master keyer once more triggers channel 1.

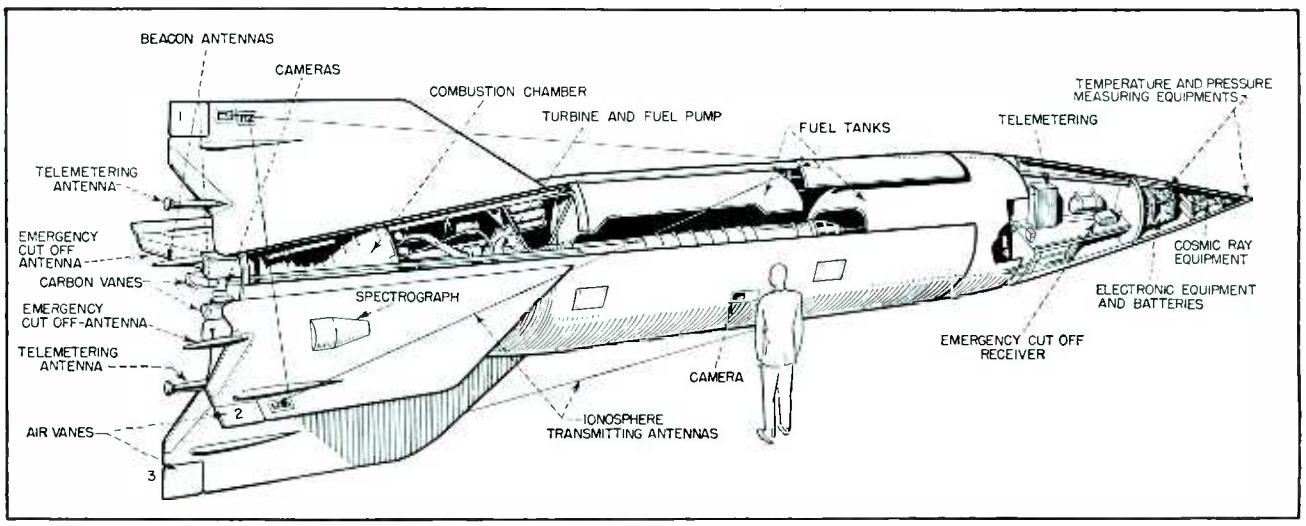
The length of time during which each channel remains in its temporary state is determined by the voltage input to that channel. Each channel is calibrated so that with 0 volts applied to the input, the temporary state is of 50 microseconds duration, and with 5 volts applied to the channel the temporary state is of 200 microseconds duration. The calibration procedure, as illustrated in connection with channel 1, consists of first setting the input voltage to zero and adjusting R_2 until the temporary-state duration is 50 microseconds. Then with a positive voltage of 5 volts applied to the input, R_4 is adjusted until the temporary-state duration is 200 microseconds. Fixed resistances matching the values of R_2 and R_4 are then mounted in place of the temporary variable resistances. The applied voltage is effective both upon the triggering and the return of each channel.

A positive voltage on the grid of V_3 produces a much heavier conduction in that tube when the channel is triggered. Hence, a larger negative signal is impressed on the grid of V_4 and therefore takes a longer time to leak off through resistors R_2 and R_3. Furthermore, the level to which the voltage must leak before conduction in V_4 begins is raised. As a consequence the voltage which is effective in determining the temporary-state duration is the input voltage which is applied during the temporary state. With this system of pulse-time modulation the duration of the temporary state of each channel can be made a linear function of the input voltage.

Upon the return of each channel to its normal state a negative pulse is transmitted through a small crystal diode to the common line G



Section of typical telemetering record. Numbers on time reference trace (second from bottom) indicate elapsed time in seconds since takeoff. Time reference pulses are a half second apart



Sketch of V-2 rocket equipped for study of ionosphere, showing location of telemetering unit in nose and telemetering antennas behind tail fins. In the first successful flight made for this purpose, all instruments recorded continuously until the huge missile landed 13 miles away after reaching an altitude of 63.5 miles

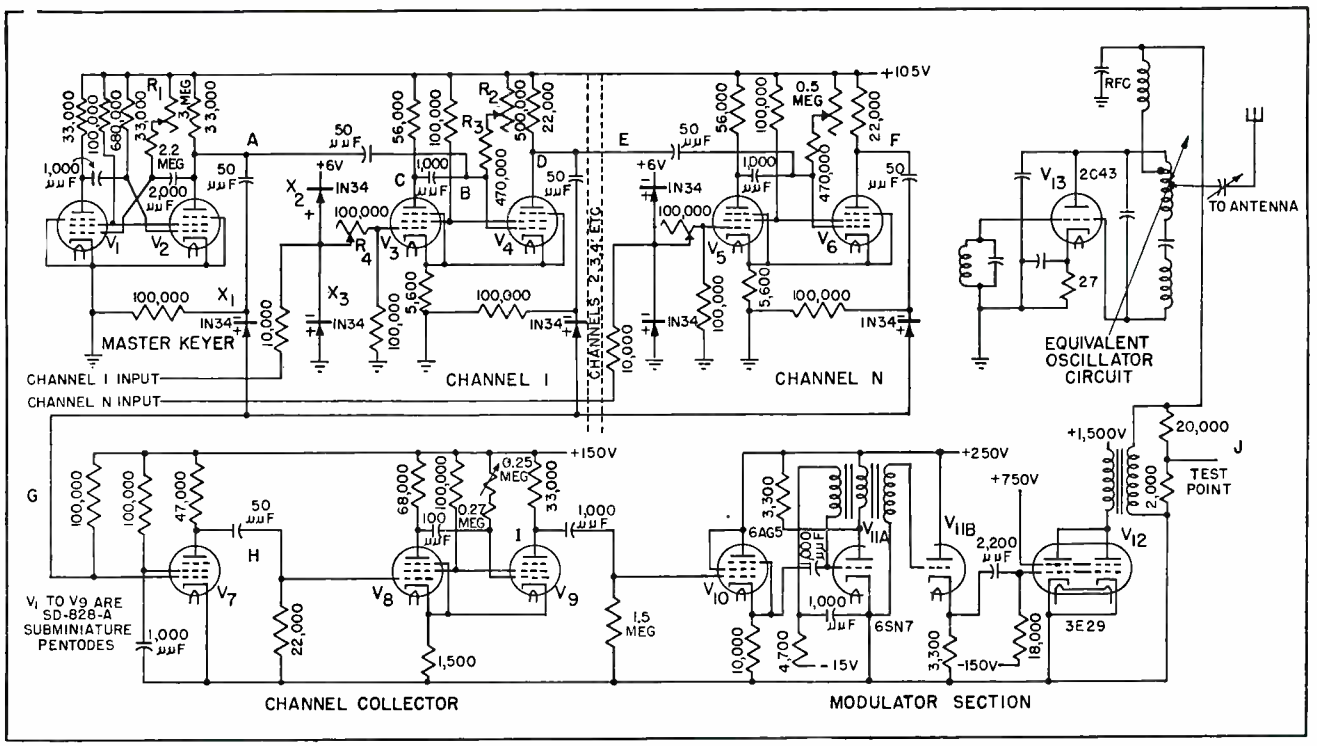


FIG. 3—Circuit of airborne telemetering unit. First and last channels are shown, others being identical

of the channel collector. The purpose of the crystal diodes is to prevent interference between channels and to allow a pulse of sufficient amplitude to reach the amplifier of the channel collector. Furthermore, only the negative pulse on the return of each channel to its normal state is transmitted through the diode to common line *G*. Thus, for 23 channels, 24 pulses in each group are transmitted to the grid of amplifier tube V_7, where they are amplified and inverted in phase to trigger the blocked multivibrator of the channel collector.

Operation of Channel Collector

The channel collector is similar in action to the channels themselves, except that its temporary state is made very short. The pulse generated by the return of each channel triggers the channel collector to produce an output pulse at *I* which is of constant duration and amplitude, regardless of the variation in the signal received from each channel. The periods between collector trigger pulses therefore occur simultaneously with the periods at which the respective channel multivibrators are in their temporary states. The information has thus been converted to a pulse spacing.

Positive pulses from point *I* of the channel collector first pass through cathode follower V_{10} and trigger the blocking oscillator V_{11A}, which in turn generates sharp pulses of one microsecond duration. Since the blocking oscillator is of a type commonly used in television synchronization circuits, its operation will not be described here. The one-microsecond pulse from the blocking oscillator is fed through cathode follower V_{11B} and hence at low impedance to the grid of the 3E29 modulator tube, both halves of which are connected in parallel. The grids of the modulator tube are driven to zero bias thereby causing the tube to conduct. A pulse transformer steps up the output pulse from the modulator tube and applies it to the r-f oscillator.

The antenna feeder line is capacitively coupled to the oscillator cavity. A peak pulse power output of approximately 750 watts is obtained at 1,000 mc, with a pulse width of approximately 0.8 microsecond at the half-power level.

Crystal diodes X_2 and X_3 are connected to the input of each channel to limit the input voltage to the range from 0 to + 6 volts. Too high an input voltage will cause a channel to oscillate, sending out a

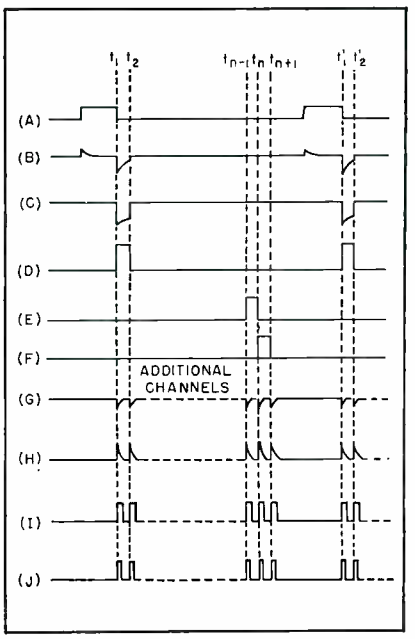


FIG. 4—Waveforms at various points in airborne telemetering circuit of Fig. 3

series of equally spaced pulses, while a negative voltage will completely stop the action of the multivibrator and prevent triggering of all subsequent channels in the system.

Part II will cover circuits used at the ground station for decoding pulses and metering circuits of various channels.

Subminiature

Characteristics of a tetrode requiring only 13 milliwatts of filament heating power and having an input resistance of millions of megohms are presented. Applications to meters for measuring ion-producing radiations illustrate ways of simplifying power supply

DURING THE LAST SEVERAL YEARS, the need for a subminiature low-current vacuum tube capable of electrometer service became increasingly apparent. Ordinary tubes were unsuitable for a number of reasons. Tubes previously designed specifically for electrometer service were too bulky and in addition required prohibitively large filament currents for portable equipment. Smaller and more conventional types, such as the type 30, were capable of serving as electrometers if specially selected and processed, but even their size and filament requirements were undesirably large.

Electrometer Tube Requirements

Considerable experimentation was carried on to determine the feasibility of using hearing-aid tubes, but results were on the whole quite disappointing. Very few of them were adequately pumped, with the result that gas current was prohibitively high for the exacting requirements of electrometers. Furthermore, their characteristic in the low-current, low-voltage region, mandatory to electrometer operation, showed such wide variations that it was almost impossible to design a circuit in which any reasonable percentage of a given number of tubes would operate; and, finally, the drift encountered in these tubes was of a magnitude that would have prevented their use even in the absence of other factors. Such drift has an almost inappreciable effect on the operation of an a-c amplifier, such as a hearing-aid or miniature radio, but in a d-c amplifier it is hardly an exaggeration to say that anything else can be tolerated providing drift is small.

Having made an exhaustive survey of existing tube types, it was finally decided to embark on the development of an entirely new tube specifically for portable electrometer service. Two requirements were to be met: (1) the tube was to be capable of electrometer operation with total control-grid current of less than 10^{-14} amperes, and (2) the filament was to require no more than 10 ma at 1.3 volts, the arbitrarily set end-point of a 1.5 volt dry cell. The advantages of a filament capable of such operation were so numerous (one-month operation from an ordinary flashlight cell, to name but one) and it was felt that the time and effort required to develop it would be justified.

Several requirements for such a filament followed immediately from the 10-ma specification. (1) It must have a high specific resistance and the minimum possible cross-section to achieve the 130 ohms resistance necessary within the length allowable. (2) Oxide coating of some sort was a necessity because adequate emission could not possibly be secured otherwise with the filament power available (normally 13 mw). (3) The composition of the wire must be such as to yield adequate emission in combination with the oxide coating.

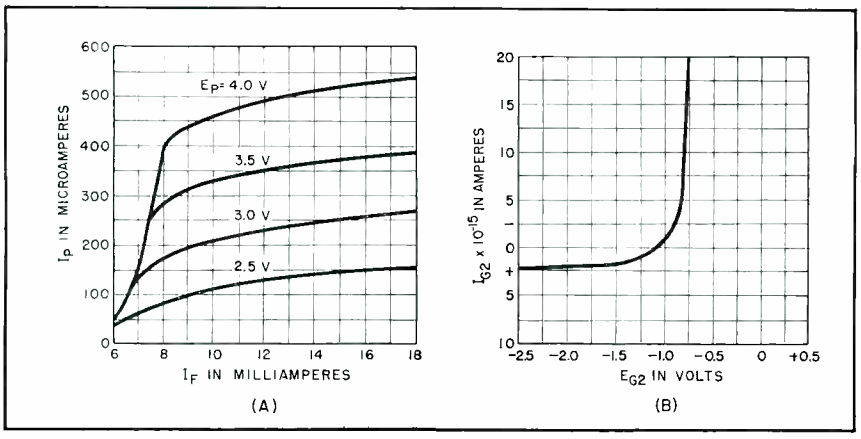


FIG. 1—(A) Diode characteristics with both grids connected to plate indicate cathode emission characteristic. (B) With 10 milliamperes filament heating current, 250 microamperes first (space charge) grid current, and 10 microamperes plate current, this second (control) grid input characteristic is obtained

Characteristics of Tube

Experiments finally produced a filament with a nickel-chrominum base wire and an oxide coating of equal parts of barium and strontium carbonate, all commercial filament mixes having proved unsatisfactory for one reason or another. The wire base is the smallest that can be commercially drawn, having a diameter of approximately 0.0004 in. An idea of the minute size of the wire can be gained by dropping a length of it; even after coating, it floats downward like a spiderweb.

Mounting such a filament in the tube requires highly skilled operators and is the most difficult step in the assembly process. Not only

Electrometer Tube

C. D. GOULD

Senior Electronic Engineer
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Cleveland, Ohio

must it be properly located with respect to the rest of the structure, but the tension of the mounting springs must be maintained within fairly close limits. Otherwise, when the wire is heated to high temperature during the activation process, the filament will either stretch or sag by an amount sufficient to render it useless.

A typical diode-emission curve is shown in Fig. 1A. The point of interest is the knee in the curve at 9 ma. To the right of this point the tube is operating fully space-charge limited. By rejecting tubes which show this knee to the left of the 9.5-ma point, satisfactory operation at 10 ma and beyond is assured, and the plate current becomes much more independent of filament current changes than would be possible if operation on the vertical portion of the curve were attempted.

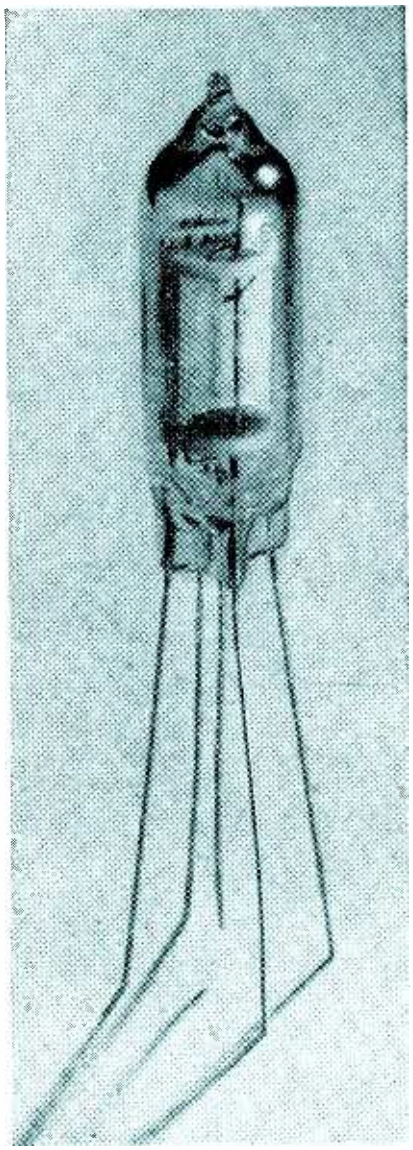
Emission capabilities of the filament are very high, being limited mainly by the burn-out point of the wire. Short-time filament overloads of 100 percent and higher have little effect on performance. By applying sufficient plate voltage to one of these tubes, diode connected, to draw 20 or 30-ma plate current, it is possible to have plate current continue undiminished even after the filament voltage is disconnected, due to the heating of the filament wire by the plate current flowing through it. Although such operation requires space currents that are too high for long life operation, the phenomenon has been used in r-f rectifiers.

In actual operation the total cathode current is never more than about 250 microamperes, nearly all of which, in the electrometer connection, is drawn by the first (space-charge) grid. For the absolute ultimate in electrometer operation this grid is a necessity; operated at a positive potential of about three volts, it repels back to the filament the positive ions released during the emission process and prevents their reaching the negatively biased control grid.

The presence of this space-charge grid makes possible a number of different connections of the tube elements. The characteristic curves for these various connections are shown in Fig. 2A to 2D; the two used for electrometer work are shown in Fig. 2A and 2B. Figure 2A is the classical electrometer connection, and Fig. 2B is the inverted triode connection, which is extremely useful in certain types of work with higher voltages than can be handled with the straight electrometer. Figure 2C is the high-mu connection and Fig. 2D the low-mu connection.

High Input Resistance

The two great difficulties in using a vacuum tube as an electrometer, over and above positive ion emission from the filament, are gas current and leakage resistance. Gas current, caused by the migration of positive ions to the negatively charged control grid, can be controlled in three ways; for the ultimate in performance all must be employed. The first is the achievement of the highest vacuum in the tube that can be obtained. The second is operation with sufficiently low potentials on the tube elements to prevent ionization of the few gas molecules that inevitably remain even when all precautions have been taken in pumping. Hand in hand with this latter precaution goes the necessity of excluding any light whatsoever from the tube when it is in operation. Photoelectric emission of electrons from the control grid results in positive grid current indistinguishable from gas current, even with quite feeble illumination.



Electrometer tube shown twice actual size

Leakage resistance, especially when the tube is operated under conditions of relatively high humidity, is a problem of extreme importance. In earlier models of the subminiature electrometer tube the problem was solved by cementing an amber bead around the

control-grid lead to isolate it from the remaining leads. With the advent of silicone water repellant substances, however, a much more satisfactory solution to the problem was obtained by coating the tube base around the control-grid lead with a silicone preparation and baking this on at high temperature. The resulting grid-circuit input resistance is of the order of 10^{16} to 10^{18} ohms, and strongly resists anything but direct contamination by dirt or fingerprints. Even when the surface has been contaminated, it can be restored very simply by washing with alcohol and distilled water, using a soft brush, and baking in an oven for a short period at about 100 C.

The VX-41, as finally developed, easily met requirements for low gas current originally imposed. A graph showing control-grid current for the electrometer connection is given in Fig. 1B. This curve is for an average tube; selected specimens will have grid current of one-tenth to even one-hundredth the amount shown in the curve. Furthermore, great improvement can be had in this respect by operating the tube at an even lower plate voltage than the six volts used here; operation with only four volts on the plate gives a very significant reduction in grid current.

Grid current in the inverted triode connection is as small as in the electrometer connection, because here again the element next to the cathode is operated at a positive potential, and serves to return positive ions to the filament.

Application to Radiation Meters

Because our primary concern is the measurement of radiation and radioactivity, the uses to which these tubes were first put were in this field. The first instrument designed using the VX-41 was a sensitive portable radiation meter, a simplified circuit of which is shown in Fig. 3. The ionization chamber in the input circuit of the first tube consists of a cylindrical metal tube with very thin walls, and with a center electrode mounted coaxially and insulated from the shell. A potential of 45 volts between these two is sufficient to collect all the ions produced in the chamber by the low-intensity radiation that this device was designed to measure. The third tube in the circuit, the VX-32, was designed specifically as a current amplifier to operate a meter. It has an amplification factor of only 1.5 and the relatively high mutual conductance of 150 μmhos, and as it is pumped and insulated in exactly the same manner as the VX-41 it can itself be used as an electrometer, with somewhat greater sensitivity than the VX-41, where more grid-current can be tolerated. Grid-current in the VX-32 is about ten times that in the VX-41.

It will be noted that one 45-volt B-battery supplies both plate and filament current for the entire amplifier, at a total drain of somewhat less than 11 ma. The use of a single battery simplified the replacement problem tremendously. In the actual instrument, the on-off switch carries a battery test position whereby it is possible to set the filament current at exactly 10 ma; when this can no longer be done the battery is replaced.

The radiation meter described above measures the rate at which radiation strikes the ionization chamber. The higher the radiation, the greater the number of ions produced, the greater the current through the high input resistor, and the greater the voltage across it. However, because the effect of high-voltage radiation such as x-rays on the human body is cumulative, a device which will indicate the total amount of radiation received in a given location is of prime importance. X-ray technicians and cyclotron operators, for example, are exposed to varying amounts of radiation in the course of a day. By the use of an instrument which indicates total quantity of radiation it is possible to monitor the location in which the operators work, and make sure the total amount of radiation received in one day does not exceed the tolerance dose. Such a device is the protexi-meter, shown in a photograph and in Fig. 4. The principle of opera-

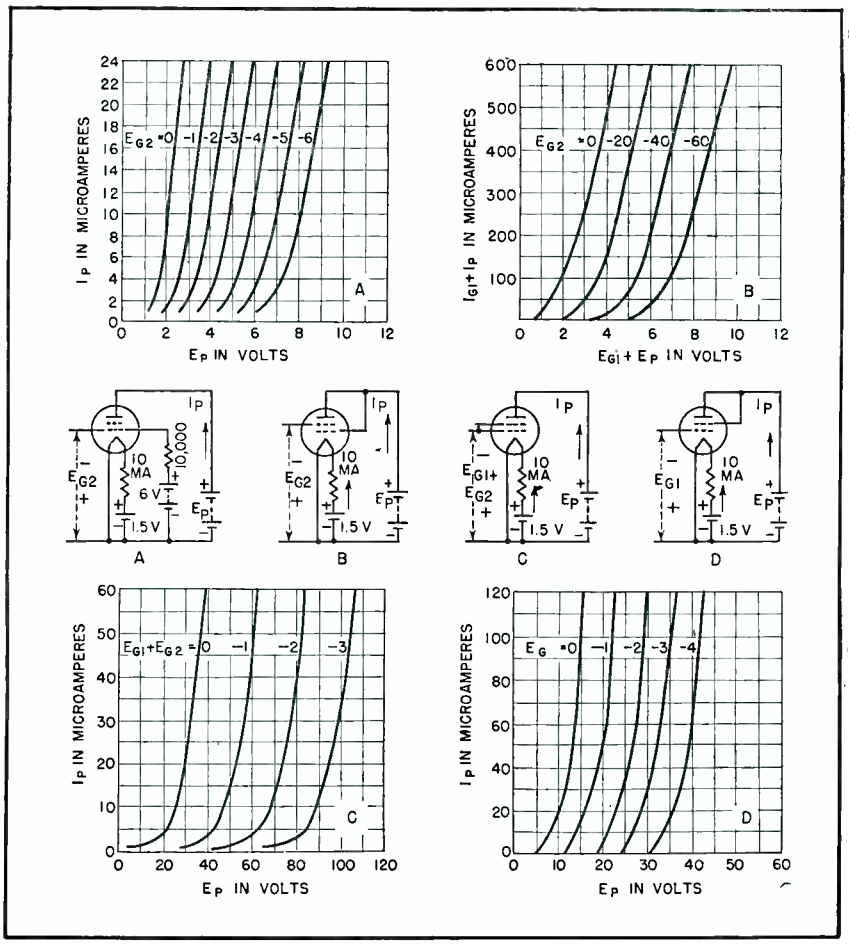


FIG. 2—Transfer characteristics obtained with tube connections shown

Accumulated effect of x-ray radiation is indicated directly in milliroentgens by this instrument; midscale indicates daily safe exposure. Figure 4 is the circuit

tion is quite simple, but considerable refinement of manufacturing technique was required to produce the instrument successfully because of the tremendously high resistance which must be maintained.

The shell on top of the instrument is a sealed ionization chamber containing a nonionizable capacitor and an electrometer tube operated as an inverted triode. The capacitor is charged by a device which will be described later, and supplies the collecting voltage for the ionization chamber. In the absence of radiation no ions are produced, and the charge on the capacitor remains unchanged. When radiation strikes the chamber, however, the capacitor will lose its charge by an amount directly proportional to the total quantity of radiation received. Thus to measure the total amount of incident radiation it is only necessary to measure the change in voltage across the chamber and capacitor; this function is performed by the electrometer tube.

Estimate of Leakage Resistance

It is obvious that for such an instrument to perform successfully the leakage resistance across the capacitor, chamber, and electrometer tube must be almost infinite, and gas-current in the electrometer almost zero. Some idea of the magnitude of these requirements may be had by considering the performance of these instruments as produced.

The total capacitance of the chamber, capacitor, and electrometer grid is about 100 micromicrofarads. This capacitance is charged to −24 volts initially and when discharged (a condition that represents twice the maximum daily tolerance dose) this potential drops to −6 volts. In the absence of radiation the meter will move two percent of full scale per day. This drift of course includes the effect of the background of cosmic radiation which is present at all times everywhere, but by assuming this equal to zero we can arrive very simply at an upper figure for leakage and gas current.

Daily drift corresponds to two percent of 24 volts minus 6 volts, or a voltage change of 0.36 volt per day across 100 micromicrofarads. Because $Q = CE$ (where Q is charge on capacitance C at potential E), this voltage change represents a loss of charge of 36 micromicrocoulombs per day, which is equivalent to a current of 4.15×10^{-16} ampere. It is difficult to allocate this leakage between gas current and leakage current, but the fact that the drift rate is nearly constant from one end of the scale to the other indicates that most of it must be gas current. If it were all due to leakage current the amount of leakage resistance (assuming the chamber fully charged) would be given by $24/(4.15 \times 10^{-16})$, or 6×10^{16} ohms, approximately. It is safe to assume that it is at least ten times this amount, or nearly one million million megohms.

The charging circuit for the chamber is of some interest. Apart from the 24 volts necessary to charge the chamber, the entire instrument can be operated from a 6-volt supply. This supply is made 7.5 volts to allow for aging of batteries, and is furnished by five flashlight cells. To step this voltage up to 24 volts, current is momentarily passed through a small choke loaded with a resistor. The voltage pulse developed when the current starts is ignored. When the current through the choke is suddenly interrupted, the voltage which will appear across the choke can be made any value desired, up to a few hundred volts, by properly proportioning the shunt resistor. To a first approximation (neglecting the effect of the resistance of the choke) the ratio between supply voltage and developed voltage equals the ratio of the series resistor to the shunt resistor. Because the capacitance of the grid circuit chamber requires only a minute charging current it will be charged nearly to the full voltage developed across the choke.

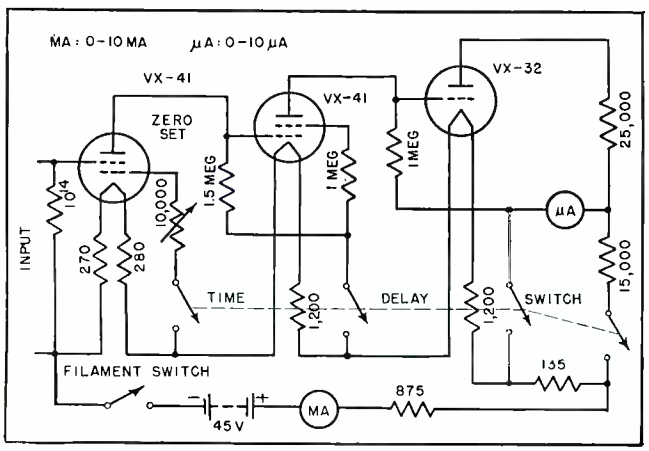


FIG. 3—Circuit of portable instrument for indicating intensity of low-level radiation

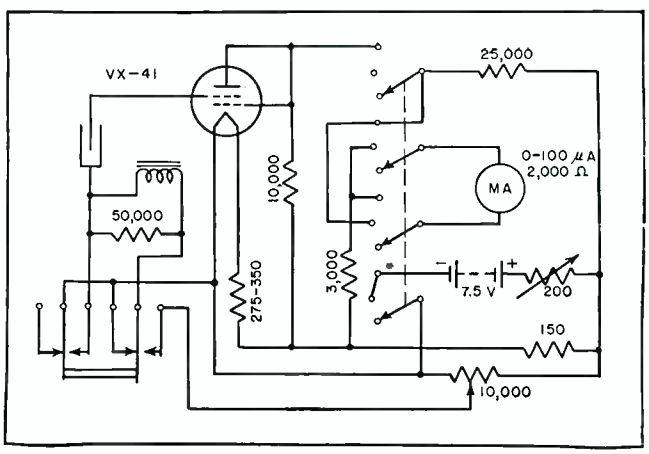


FIG. 4—Cumulative x-ray radiation is indicated by this direct reading integrating meter

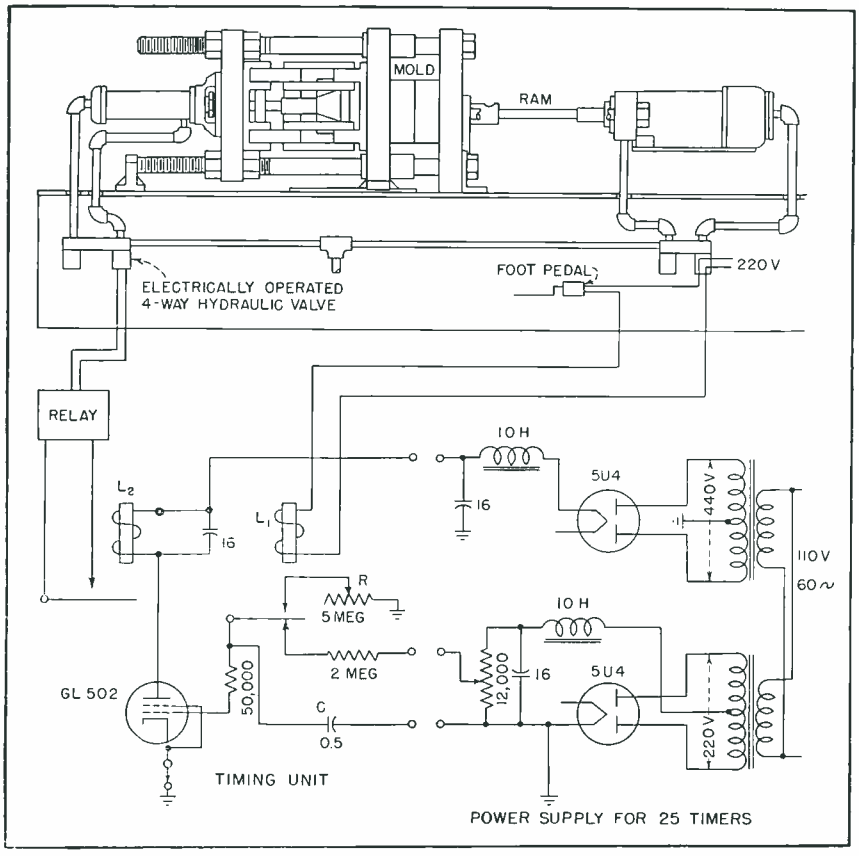
Power supply and two of the units. A spare supply is available for immediate plug-in should breakdown occur

TIMER for Diecasting Machine

Accuracy and efficiency of diecasting with aluminum and zinc is obtained by an electronic timer that determines the interval between the shot or molding action and the ejection of the casting from the mold

By GERALD DeLONG

Cannon Electric Equipment Co.
Los Angeles, California

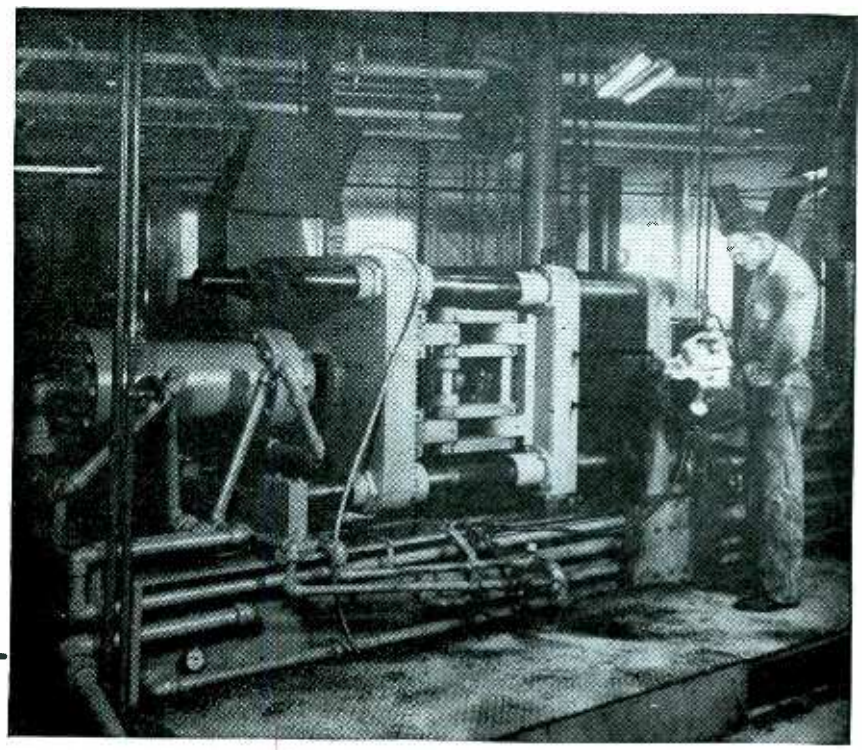


Circuit of one timing unit and the common power supply

CANNON ELECTRIC diecasts for other firms such parts as roller-skate wheels, crank-cases, pistons, cylinder heads and parts for motor scooters. The precision requirements of these diecastings involve exacting tolerances, and the normal human variations of an operator's timing of the diecasting process may result in a warped or otherwise imperfect casting.

Before the installation of the electronic timing unit to be described the time lapse for cooling or setting up of the metal in the mold was controlled arbitrarily by each operator. If the operator were on piece work a tendency frequently developed whereby the operator opened his machine as quickly as possible after each shot. On the other hand, if the operator were fatigued or his sense of timing slow he might allow excessive time to elapse before he opened the mold and ejected the casting.

Tests proved that this interval was a critical constant for a given type of mold. Any significant decrease in the arbitrary interval value (reduction of 0.1 second or more) resulted in a plastic deforma-



Diecasting machine for aluminum and zinc. Automatic control of the cooling period of the metal in the mold is obtained by a decay circuit

tion. Greater tendency for cold-flow warping during machining was also evident.

In developing the timing unit, it was found that in most thyratrons the grid does not have complete control over the plate current; it can initiate the flow of current yet has no power to stop the flow once it has begun. In the type selected, the control grid controls the flow of current between cathode and plate and can be biased to cutoff without removing the plate voltage.

Circuit Operation

A negative potential up to 200 volts may be applied to the control grid of the tube. This can be drained off to ground—in this instance through a variable resistor to ground—until the voltage ranges from 3¾ to 0.9 volts at which point, depending upon the performance of the individual tube, the tube fires. To restore the tube to normal, high negative bias voltage is applied to the grid.

In the cycle of operation, the operator closes the diecast mold, and pours molten metal from a ladle into the machine. He then steps on the foot pedal which rams the molten metal into the mold at high pressure and at the same time closes the initiating relay on the electronic timer, starting the timing cycle.

The contacts of the initiating relay L_1 normally apply the bias to the control grid of the tube and the tube is quiescent. Operation of the foot pedal actuates the 220-volt relay coil L_1, causing the bias to be removed from the tube, allowing capacitor C to discharge slowly through variable resistor R. This resistor allows the timing cycle to be changed from 0 to 18 seconds as required by the shop foreman.

When the negative potential at the grid decreases to the proper value, the tube fires. The firing of the tube causes plate current flow to operate relay L_2. This relay in turn operates a second and heavier solenoid that actuates a solenoid hydraulic valve to open the diecasting machine.

When the machine begins to open, the operator takes his foot off the pedal, pulling the ram back. This also removes the current from the coil of the initiating relay, allowing the contact arm to snap back and apply the bias voltage to the control grid of the tube, causing the tube to cease firing and complete the cycle.

Individual Timers

Since the diecasting machines turn out a variety of products, each machine requires its own timing control unit, and 25 timing units are installed in the plant. These are assembled in one central rack and fed from a common power supply. The removal of one unit does not interfere with the operation of the other units.

The central control rack is furnished with a door that is kept locked and the key is in the possession of the foreman of the section. When a new mold is set up in one of the machines, the foreman determines the mold curing time, and sets the variable resistor R in the corresponding timing unit for the number of seconds that it is desired the die shall remain closed.

The operator of the diecasting machine closes the die manually, pours the charge of metal and kicks the foot switch. From that point, the electronic gear takes over, times the cycles, opens the mold and returns the ram to its original position. The cast piece is removed and the cycle starts over again.

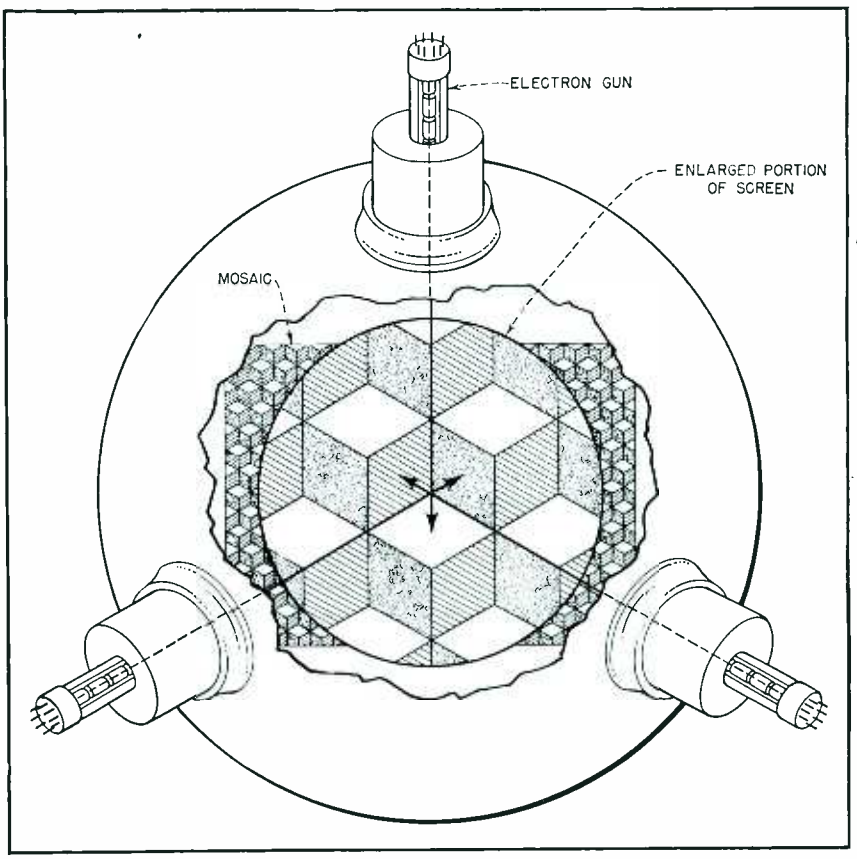
The central control rack contains 25 timing units. These are only accessible to the foreman of the section for adjustment

Experimental C-R Tubes

RESEARCH INTO PHOSPHORS and methods of reproducing television images indicates that television receivers can be made to give bright, detailed images in either monochrome or polychrome.

Many experiments now in progress would not ordinarily be discussed until they were nearer commercial application. However, in view of present engineering and economic discussions on the possibility of translating color television into a public broadcasting service, it seems advisable to describe briefly several cathode-ray tubes that will be available in a few years. Thus engineers faced with the necessity of making immediate executive decisions about future developments will have available the facts, not only of presently available means, but also of future potentialities on which to base their decisions.

The following description of tubes and equipment is based on a recent tour of the Allen B. DuMont Laboratories.



Cutaway drawing of back of Trichromoscope shows how three guns paint three-colored picture on embossed mosaic on face of tube (seen here from behind). In experimental model, mosaic (not shown to scale) covers only portion of tube's face. Section of mosaic in center is shown much enlarged

Screen Brightness

To increase the screen brightness from cathode-ray tubes, the beam current and potential can be increased. Beam current is limited by the size of the focused spot. In large tubes, high beam currents can be used because the absolute size of the spot that will just cover a television picture element is large. Thus a bright picture can be produced from a large directly viewed tube.

When beam potential is increased, so also are difficulties and danger from the high voltages, and there may be production of x-rays by high-velocity electrons. Moreover, effectiveness of the high beam potential in projecting electrons at high velocities onto the phosphor of the screen is partially counteracted by the space charge that accumulates at the screen. To realize the full possibilities of a high beam potential, it is therefore desirable to remove as fast as possible the electrons that reach the screen.

This removal can be done by providing a metallic backing to the phosphor screen. The metallic backing has to be thin enough not to slow down the beam electrons, but thick enough to provide a conductive surface over which electrons can move. Also, if it is optically flat, the backing can be used to reflect forward the light given off into the tube, by the phosphor, which would otherwise be wasted. Both actions of the metallic backing increase the efficiency of the tube. The backing is aluminum vaporized onto a flat intermediate surface produced by an organic coating deposited on the phosphor. The organic coating is then evaporated, leaving a mirror surface supported on the tips of the crystalline phosphor.

A 12-inch cathode-ray tube using a medium-persistance (P4) standard white phosphor that gave 20 foot-lamberts at 10,000 volts without the aluminum screen backing gives 300 foot-lamberts at 20,000 volts with an aluminum backing. Intense ambient lighting, 150 foot-candles of incident floodlighting, completely washed out the picture on the dim tube but did not destroy the visibility of the picture from the bright tube. Even 1,000 foot-candles, comparable to direct sunlight, did not completely wash out the brighter picture.

The life of such a bright picture tube is not materially reduced because the electrons penetrate more deeply into the phosphor (as a consequence of the prompt removal of electron charge by the metallic backing) than in the unbacked

for TELEVISION

Several new types of cathode-ray tubes for television receivers are in development; a tube having a screen brightness of 300 foot lamberts for monochrome receivers, a projection tube and a direct viewing tube both for polychrome receivers, and a tube having a very fast response phosphor for use in Photovision relaying

tube and thus cause less burning of the phosphor. The distribution of gun potentials in the tube is modified to take advantage of the greater obtainable contrast. In an unbacked screen, the negative charge would become greatest at places of greatest brightness, thus preventing further bombardment of that spot in an effort to make it brighter—a saturation effect. In the metallically backed screen, such saturation is greatly reduced so that much greater brightness contrast is available at the receiver. This type tube is going into production.

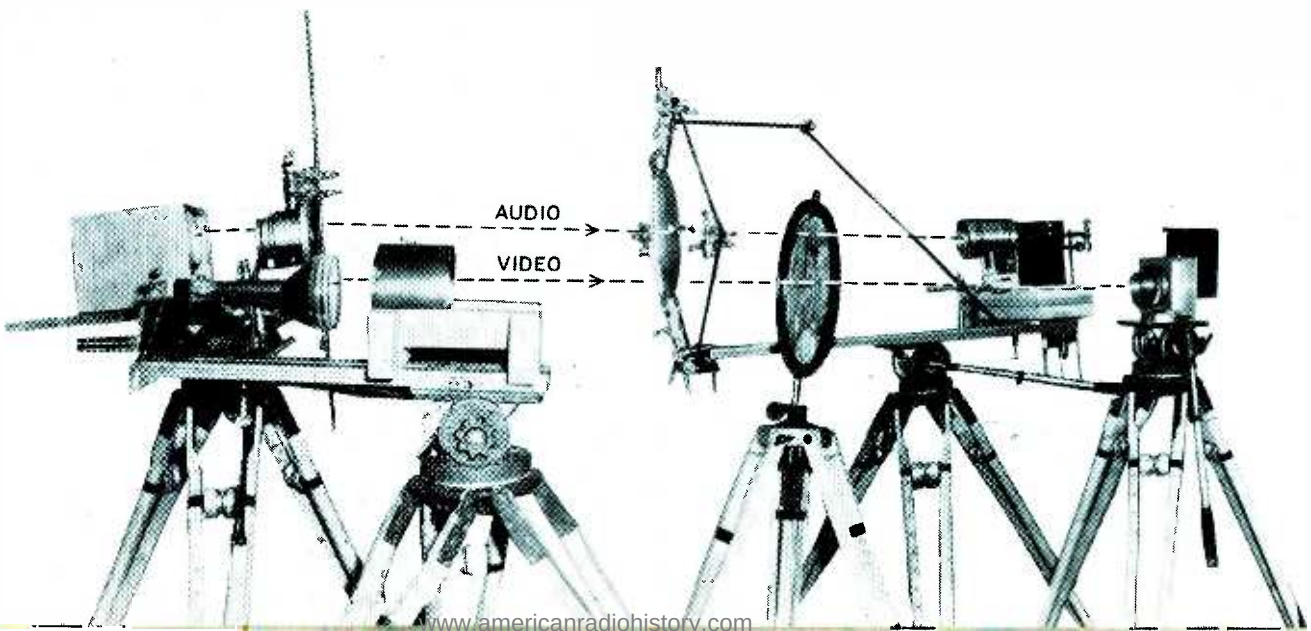
Flicker

For the received television picture to be observable without fatigue in a normally illuminated room, the picture must be reproduced at a brightness level well above the ambient light level. Therefore the trend in developing cathode-ray tubes for television receivers has been toward producing the brightest possible picture. So far, a picture so bright that flicker (which becomes more noticeable as the viewed picture becomes brighter) would become apparent with the standard repetition rate of 60 fields a second doubly interlaced to give 30 full frames a second has not been commercially producable. But with 300 foot-lamberts, some flicker is apparent under some conditions.

The duration of persistence of vision decreases relatively as the object brightness increases. Thus, for a fixed rate of picture interruption, there is a limit to the brightness that can be used in reproducing the picture before flicker becomes apparent. Also, the closer the viewer is to the picture (more correctly, the greater the angle subtended by the picture at the eye), the more noticeable is any flicker. But the greater the ambient illumination the less apparent is the flicker.

There are several types of flicker produced by television pictures. Monochrome pictures are reproduced 60 times a second. Thus there is a field repetition rate flicker in which the whole picture is seen to fluctuate in brightness, usually in an observable motion with the scanning pattern. In addition, because two different fields are being reproduced by the double interlace form of scanning, there is a fine detail or interlace flicker in which sharp edges and other small details comparable in size to a single pic-

Laboratory Photovision setup shows the elements of the system. Light serving as the transmission media for video and audio signals is generated (left) in two separate cathode-ray tubes and focused by lenses. Two spots on one tube could be used just as well. At receiver, (right) lenses collect transmitted light and focus it on electron multiplier photoubes. Large lenses are used experimentally to simplify alignment of optical system. Black boxes indicate simplicity and compactness of electronic circuits



ture element are seen to vibrate between adjacent lines, one line in each of the two interlaced fields, at the 30-cps rate of the full frame. This latter form of flicker, being the slower of the two, is the first to be noticed.

For conditions that make flicker most apparent, close viewing distance and low ambient illumination, interlace flicker is apparent in a picture reproduced on the experimental 12-inch tube at brightnesses above about 300 foot-lamberts. However, an ambient lighting of about 100 foot-candles and a viewing distance of about three feet (five times the picture height) counteract the interlace flicker at this picture brightness. In other words, for a normally lighted room and a viewing distance that would permit several people to watch the screen, no flicker is apparent. Of course the picture brightness could be reduced by the viewer to a level appropriate to the conditions under which it is viewed. As the ambient illumination increases, picture contrast decreases because, although the white becomes whiter and the black becomes less black, the ratio of the brightnesses of the white to the black decreases.

Tubes for Color Television

Polychrome pictures can be reproduced brightly as a result of development of colored phosphors. Phosphors that give saturated primary colors at high brightness, and thus eliminate the light losses of filters, have been developed. In addition, the elimination of the filters simplifies the optical system. Furthermore, the use of separate colored phosphors in a sequential color scanning system makes it possible for the individual phosphors to have a decay characteristic about as long as for a simultaneous system, thus increasing the available light from the sequentially reproduced picture and decreasing the degree of flicker. But increasing the decay time of the phosphors in an effort to increase the brightness would tend to accentuate the color breakup inherent in the sequential system.

By using a multigun cathode-ray tube and by dividing the screen into several preferably equal rectangular areas, each area being coated by a different phosphor, a single tube serves for the three tubes recently used in demonstrating simultaneous polychrome television. Of course the same tube could be used in a sequential system by electronically switching from gun to gun in accordance with the color sequence; however, the picture would not be as bright in this case as in simultaneous operation. In either case, lenses project the primary pictures onto a viewing screen. The individual color rasters can be positioned electronically to register them. No crosstalk is encountered between the several electrostatic deflection systems of the several electron guns.

In the laboratory model of such a tube, four guns and four screen areas were provided. In addition to the three primary colors, a white was added. In comparing the range of colors obtainable, it was obvious that the addition of a white channel added to the range of colored light values that could be reproduced, just as the use of a black plate in four-color printing adds a gradation not obtainable if only primary colors are used. The use of a dark (nonreflecting) screen would accomplish much the same result without the added transmitted bandwidth of a fourth channel.

For direct viewing, the Trichromoscope produces a three-colored picture. In it, three guns, each modulated by one of the three color channels, scans the screen from a different angle. The magnetic deflection yokes of all three guns are driven in series from a single deflection generator so that the three beams scan in perfect synchronism. The screen surface is a series of three-sided pyramids. The beam from one of the guns strikes but one side of each pyramid. Those sides of the pyramids that are oriented in the same direction, and are therefore scanned by the same gun, are coated with the same colored phosphor. Thus each picture element on the screen of the cathode-ray tube consists of three separate areas of colored phosphor. Using a metal backing for the screen to prevent secondary electrons from one phosphor from exciting adjacent phosphors of other colors, as well as to prevent loss of back light and to conduct away the charge from the screen, 600 foot-lamberts of directed brightness are expected from this tube. Such great brightness can be obtained because the pyramidal mottling gives roughly three times the surface area of phosphor to each picture element as contrasted with a plain-surfaced screen. Flicker would be noticeable using this brightness at present repetition rates if the tube were viewed from short distances.

Eventual economical manufacture of the Trichromoscope in commercial quantity is as much a factor in engineering its development as the design of the tube itself. The screen is shaped for test models by an ultrasonic engraving technique. A soft die with the pyramidal pattern milled on it is coated with a very fine grinding compound and placed on a plate of glass. The glass and die are then placed in an ultrasonic vibrator. So much energy is delivered to the interface between die and glass by the very high frequency of the vibrator despite its low amplitude that the grinding compound eats into the hard glass. The die must be enough softer than the work to act as an efficient carrier of the grinding compound. The cross-knurled pattern of pyramids is such that, except at the edges of the patterned area, it is the same on the die as on the work, so no complicated inversion need be made in machining the die.

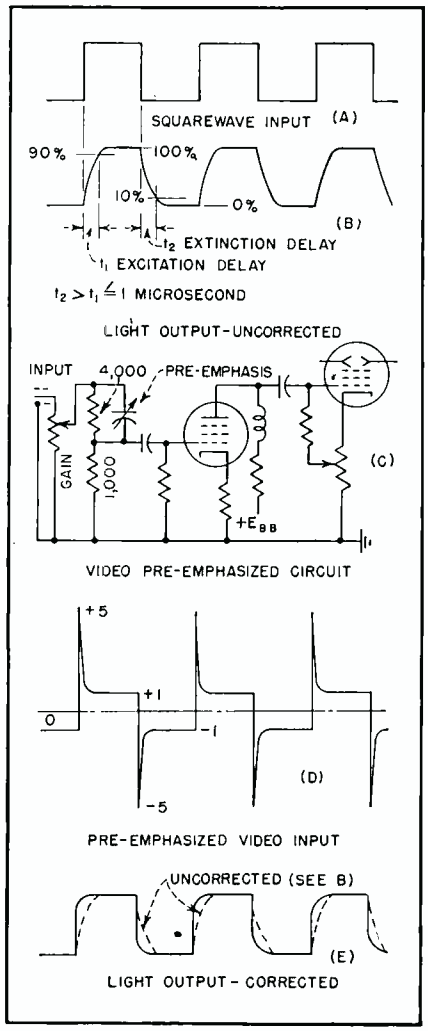
For quantity production the soft die will be used to cut a hard die, on which it would be difficult to machine the very fine pyramidal pattern. The hard die will then be used to press the glass face for the cathode-ray tube just as other intricate patterns, such as diffraction gratings, are pressed into glass. At the same time that the pyramidal pattern is being pressed into the back side of the glass, a multilens pattern can be pressed on the front side. With individual lenses over each pyramid, the light from the Trichromoscope would be directed forward, concentrating most of the light into the angle from which the tube would normally be viewed. (It is undesirable to view the television receiver screen from too oblique an angle because of the foreshortening of the figures.)

Phosphors are deposited on the faces of the cathode-ray tubes by settling from suspension. In the Trichromoscope, the tube is so oriented in the phosphor suspension that all the faces on the same sides of the pyramids are horizontal. The phosphor then settles on the upturned faces and not on the others. In this way the three different phosphors can be deposited on their appropriate sides of the pyramids.

Photovision Tubes

For relaying television signals over distances up to five miles (about the same distance between relay stations as between repeaters on television coaxial links), and where line of sight relay paths are obtainable, Photovision can be used. The technique is to modulate continuously the intensity of a beam of light just as one amplitude modulates a radio-frequency carrier with the video or audio signal, and to project the beam to a phototube at the receiving station. Basically the technique is simple. Practically it has been used for telegraph signalling by the Navy for years. Experience has shown that it is quite possible to transmit audio over light beams for distances of five miles despite severe weather including fog and snow storms. But to modulate the beam with a video signal at upwards of six megacycles per second has required some research!

The speed of response of phosphors had to be made quite fast for sequential television reproduction to be free of color overlapping. With the experience gained in developing such fast-response phosphors it seemed that a phosphor might be developed that would have fast enough response for use in Photovision. The rapidity of response of a phosphor can be increased by decreasing the crystal size and the screen thickness, and by increasing the excitation current per unit area. Fortunately high beam current density is compatible with the requirement for great brightness necessary for operation well above the system noise level. However, the high currents would burn the screen, so the phosphor is deposited on a rotating disc which is driven by an induction motor through the glass envelope of the tube.



If a squarewave (A) is used to intensity-modulate a phosphor, the light output (B) from the phosphor will show finite rise and decay times. A compensating network (C) can be introduced into the intensity-modulating amplifier; it adds a large differentiated spike to the squarewave (D), with the result that the light output (E) closely duplicates the waveshape of the original input signal

Using fast-response zinc oxide deposited very thinly in fine crystals, a sufficiently fast-response screen with adequate brightness was obtained.

The rate at which a phosphor reaches its full light output after inception of excitation is very fast; the rate at which it stops radiating light after excitation ceases is slower. However, the excitation and extinction rates are not so different that they need be considered separately for a first approximation. One might consider the phosphor as having a limited high-frequency response. High frequency compensation is therefore added to the electrical circuit to counteract the inadequacies of the phosphor.

The Photovision system is comparable with coaxial or microwave relay systems. The cathode-ray tube light modulator replaces the complex carrier modulators of the other relay systems; negligible modulation power is required. A lens system at the transmitter focuses the beam to an electron multiplier type phototube at the receiver which replaces the superheterodyne preselector, converter, intermediate amplifier, and demodulator stages. Additional video amplification is used in all relay systems to bring the signal to the desired working level.

Either a duplicate system can be used to carry the voice channel, different phosphor colors (different carrier frequencies) can be used, or the voice can be carried on a subcarrier that translates it above the video channel. Either of the first two methods could be used to carry the extra color channels of simultaneous polychrome television. A messenger signal is used as in other transmission systems to provide a reference signal for the automatic gain control at the receiver that compensates for variable losses of the transmission path. Noise in the Photovision system is very low. The transmitter and receiver are sufficiently small and light not to require an elaborate tower.

One of the complications in the development of a workable public television service is the difficulty of providing network links between stations. The expense of producing television shows is so high that, unless an audience of a size only procurable through network facilities can be reached, the cost would be unjustified. As a relay technique for forming television networks, Photovision can also be used to advantage in relaying neighborhood pickups back to the studio, and in supplying exclusive television transmissions to motion picture theaters. With a distinct possibility that the microwave spectrum will become congested, Photovision offers a means of line-of-sight relaying no more limited in range than the ultrahigh frequencies and with such greater directivity that the number of links in simultaneous operation in an area is nearly limitless.—F.R.

Ultrasonic

By BOLEY A. ANDREWS

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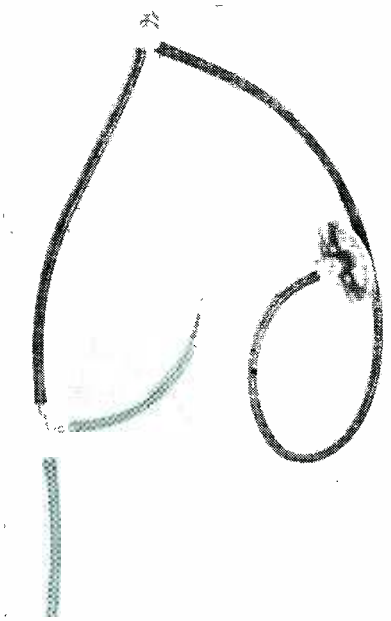
THE control system described here utilizes sounds above the audible frequency range for the purpose of actuating motor-operated garage doors from a remote position, such as from an automobile approaching the garage. The system consists essentially of an ultrasonic generator mounted on an automobile, an electronic amplifier and relay system mounted in the garage directly above the doors, and a microphone installed outside of the garage.

Ultrasonic Whistle

The ultrasonic generator used in the system consists of a vacuum-operated whistle, mounted together with a reflector directly behind the front grille of an automobile. The reflector concentrates the ultrasonic wave directly forward and protects the whistle from rain, snow, and any foreign objects which might obstruct the sound orifice.

The whistle is connected to the vacuum system of the vehicle by means of a rubber hose, and is turned off and on by an air valve clamped to the dashboard. The connection to the vacuum system is generally made at the windshield wiper mechanism by the insertion of a T pipe between the main vacuum line and the windshield wiper and vacuum whistle hose line. When an electric windshield wiper is used on a car, the vacuum connection is made at the intake manifold after in talling a suitable fitting.

The amplifier circuit combination necessary for satisfactory operation is given in Fig. 1. A voltage amplifier is followed by a triode which serves as a limiter. Limiter action takes place with input voltages of 7 mv and over. The limiter is necessary because it is desirable to introduce into the discriminator tube circuit a constant voltage regardless of signal intensity variations which can be caused by such conditions as the position of the automobile, wind velocity and direction, and any other factors which may tend to increase or decrease the ultrasonic intensity.



Ultrasonic generator shown here is only item installed on car. Pushbutton valve at top is mounted on dashboard, and ultrasonic whistle at right is installed behind radiator grille. Unattached lengths of hose here are part of original windshield wiper line on car

The amplified and limited signal is fed into a discriminator circuit which selects the desired signal frequency, rectifies it, and places a negative d-c bias on the grid of the first triode section of the following relay circuit, so that the second triode section operates the relay whose contacts control the door-opening mechanism. The discriminator also protects the control system from operation by unwanted ultrasonic sources.

Experiments and tests indicated that ultrasonic waves can be produced by such sources as jingling of keys and coins, rustling of tissue or cellophane, and the release of compressed air through a small jet. Analysis of these sounds by means of heterodyne ultrasonic detectors

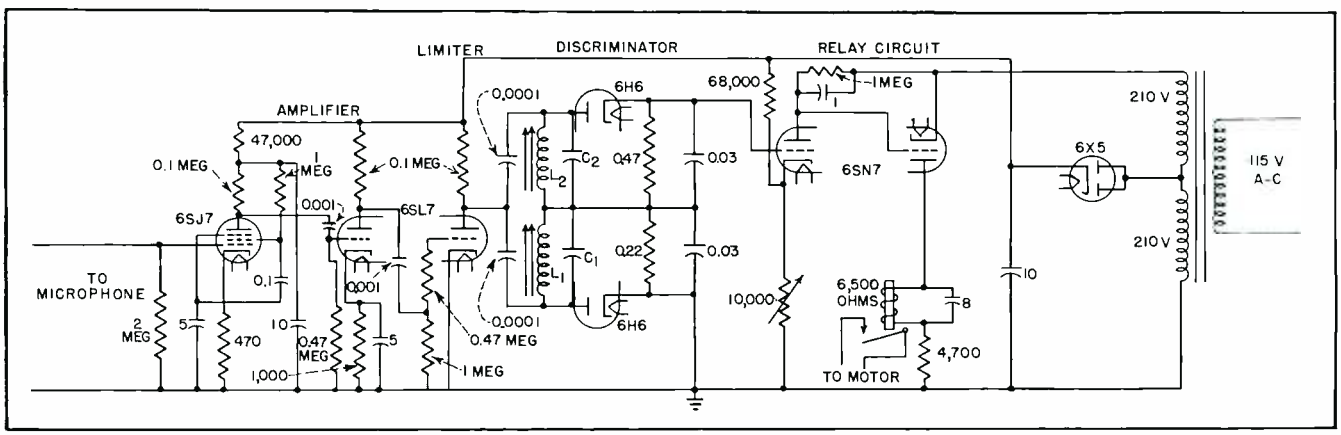


FIG. 1—Complete circuit of amplifier used in supersonic door-opening system

Garage-Door Opener

Crystal microphone above door picks up 25,000-cycle wave produced by vacuum-type whistle on automobile. Five-tube amplifier with limiter and discriminator allows desired ultrasonic signal to actuate relay in motor circuit while rejecting extraneous sounds

Typical installation of microphone on two-car garage, between doors (in circle). Driver pushes button on dashboard after turning into driveway, and doors are open by the time the car reaches them if approach is made at normal slow speed

indicated the presence of a large number of ultrasonic frequencies which were not of great strength at any one frequency, but gave small responses at a multitude of frequencies in the range of approximately 18,000 to 40,000 cycles.

A second tuned coil, generally tuned to a higher frequency than the desired signal, is inserted in the discriminator circuit. Any signals received in this circuit are rectified and delivered as positive voltages to the relay circuit. If an undesired ultrasonic signal is received at the discriminator circuit which contains a multitude of frequencies as generated by the above-mentioned ultrasonic sources, the resultant d-c output will be zero or predominantly positive, depending on the frequency distribution, and the relay will not operate. The relay tube circuit is thus operative only when a negative voltage of proper amplitude is applied to the grid.

The d-c voltage obtained from the discriminator circuit is applied to the grid of a two-stage double-triode relay control tube. Contained within this circuit is a time-delay network which closes the relay contacts after approximately three seconds of steady signal reception. This time delay is necessary to prevent door operation by transient ultrasonic waves and sudden line voltage surges.

The relay used in the control has a low armature release point, being generally 50 percent of the pull-in value. This is required because in field installations a large drop in line voltage occurs when the motor operating the doors is running on the starter winding. This drop in some cases reduces the line voltage from 120 volts to as low as 80 volts for a short instant.

Choice of Generator

Various methods of generating ultrasonic waves were investigated

before the final development of a vacuum whistle for this purpose. The first method considered was the use of quartz crystals similar to those used in underwater signaling. While this method was satisfactory for underwater use, the acoustical difference between quartz and air proved too great for efficient sound generation in air. The associated electronic oscillator equipment required in conjunction with the quartz transducer also proved too cumbersome and costly.

The second method involved a magnetostriction oscillator using a nickel rod with an attached piston. This system, as in the case of the quartz transducer, required an electron oscillator and was very inefficient when using air as the medium of transmission.

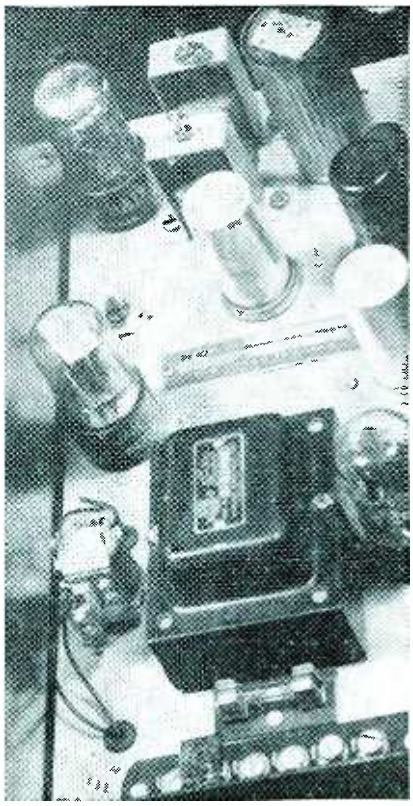
A third method used a pressure-operated air whistle constructed similar to a Galton whistle. The frequency of this whistle was determined by the size of a resonant cavity which was placed directly in front of an air orifice.

The intensity of the ultrasonic waves produced by the pressure-type ultrasonic whistle was satisfactory, but the frequency of the whistle varied greatly with air pressure. Since this whistle was pressure-sensitive, and the only source of air pressure was from a cylinder of the vehicle on the compression stroke, an air regulator would be required to smooth over the air pressure. This would have been too costly and cumbersome.

Whistle Design Data

A vacuum-type ultrasonic whistle was developed, and is now being used with good results. As shown in Fig. 2, the whistle is composed of three important parts, an air orifice, a resonant cavity, and a vacuum connection. The wavelength corresponds very nearly to the natural frequency of the cavity, which can be calculated from $\lambda/4 = L + 0.3\ d$, where L is the depth and d the diameter of the resonant cavity in millimeters, and λ is the wavelength in meters. For the best results the depth of the cavity should not exceed twice its diameter.

In operation, the air is drawn through an orifice and the resultant air jet is projected into the mouth of a cavity, which is generally drilled to a dimension which is one-quarter wavelength at the desired sound frequency. Whistles have been constructed experimentally from a frequency as low as 5,000 cycles to as high as 45,000 cycles. Frequencies above 20,000 cycles are being used for this particular door control application.



Amplifier unit used inside garage

Several interesting facts were noted while this whistle was under development. Tests indicated that no appreciable change in frequency was encountered when using a given whistle on various vehicles which had vacuum readings varying from 15 to 19 inches. The whistle was still operative even when the windshield wiper was operated simultaneously with the ultrasonic whistle.

A change in frequency is noted when the ultrasonic whistle system is subjected to ambient temperatures. This is caused by the fact that the velocity of sound in air changes with temperature. The velocity of sound in air at any temperature t in degrees C is $1{,}087.5 + 1.97t$ feet per second. The increase in velocity per degree centigrade temperature rise is approximately 2 feet per second. Because of this change in velocity it was necessary to provide a bandwidth of frequency response in order to obtain satisfactory operation despite atmospheric temperature changes.

The microphone used with this system consists of a duralumin diaphragm to which is cemented a type PN resonant crystal. This crystal is an improvement over the Rochelle-salt type crystal in that it will withstand high temperatures such as are encountered in full summer sunlight without losing its sensitivity. The diaphragm is suspended in such a manner that it can vibrate freely at ultrasonic frequencies, the size of the diaphragm being varied according to the actual frequency employed.

Ultrasonic control as described in this article can also be used for other control purposes. The present application seems to be most apropos, however, since the vacuum generator is readily applied to an automobile and the general public is keyed up for postwar electronic pushbutton apparatus.

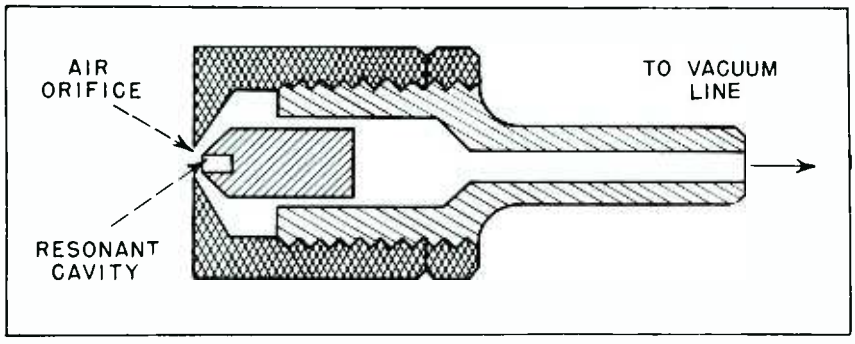
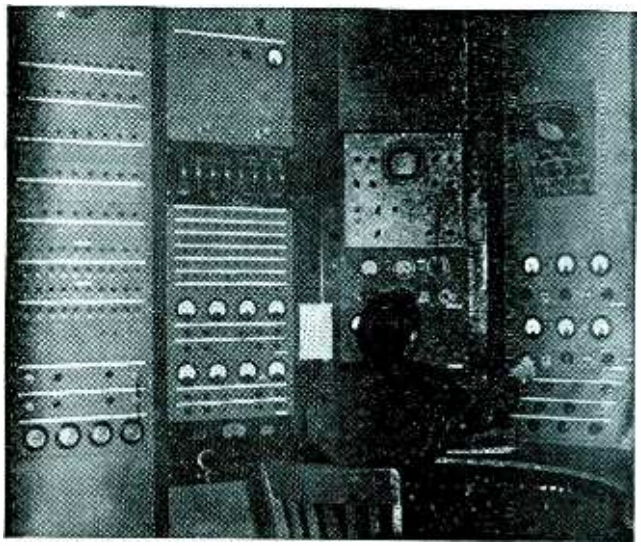


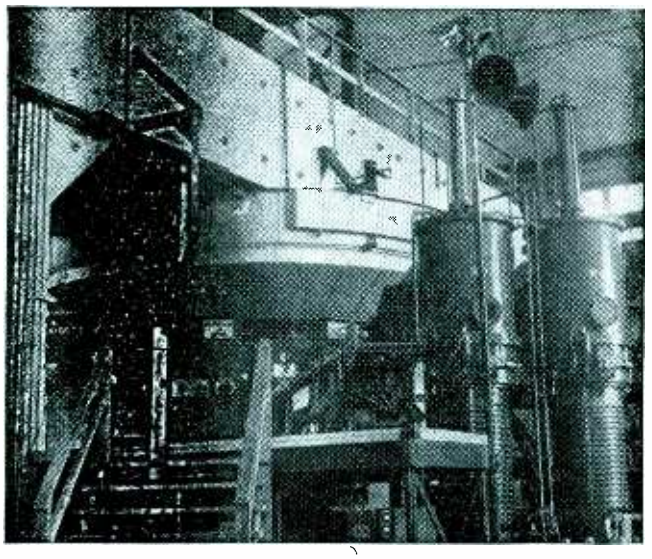
FIG. 2—Cross-section of ultrasonic generator used on automobile. Air gap between orifice and resonant cavity is adjusted for high signal intensity and entire assembly is then locked and soldered

F-M CYCLOTRON

Operating at about 10 mc and to be used in atomic energy research, world's largest cyclotron accelerates electrons to energies comparable to those of cosmic rays



At main control position are vacuum gages, interlock lights, vacuum-pump flow sheet, shortwave receiver for monitoring oscillator, and oscilloscopes showing oscillator frequency and dee potential against time

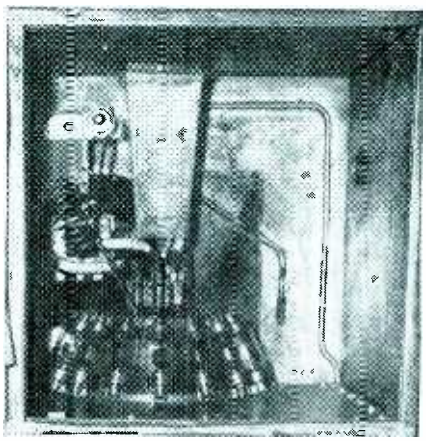


Pole faces of cyclotron are slightly more than 15 ft. in diameter. Electromagnet has 3,700 tons of steel in core, 300 tons of copper in winding, consumes 500 to 600 kw excitation. Gap is 20 in. wide

GIANT CYCLOTRON at University of California uses a frequency-modulation principle to accelerate electrons to 200 million electron volts. Protons (hydrogen nuclei) can be accelerated to 350 mev, alpha particles (helium nuclei) to 400 mev, deuterons (heavy hydrogen nuclei) to 200 mev.

Electrically charged particles that are to be accelerated are projected into the 1,600 cu ft accelerating chamber, which is between the pole faces of the magnet, and is maintained at a vacuum of a millionth of a millimeter of mercury by five stages of diffusion pumping followed by a mechanical pumping stage.

Charged particles, in circling the chamber, pass the gap between the half drums (dees). A peak potential of 50,000 volts across this gap accelerates the particles as they pass from the left dee to the right one. After half a revolution, the particles return from the right dee to the left one, being again accelerated because the potential between the dees has reversd polarity. As the electrons move faster they travel in larger spirals and, because of their relativistic increase in mass (they circle the chamber about 10,000 times a millisecond), at lower angular velocities. They thus transit the gap late in the cycle and are not accelerated. To compensate for this phase defect, the frequency at which the potential across the dees is reversed is lowered.

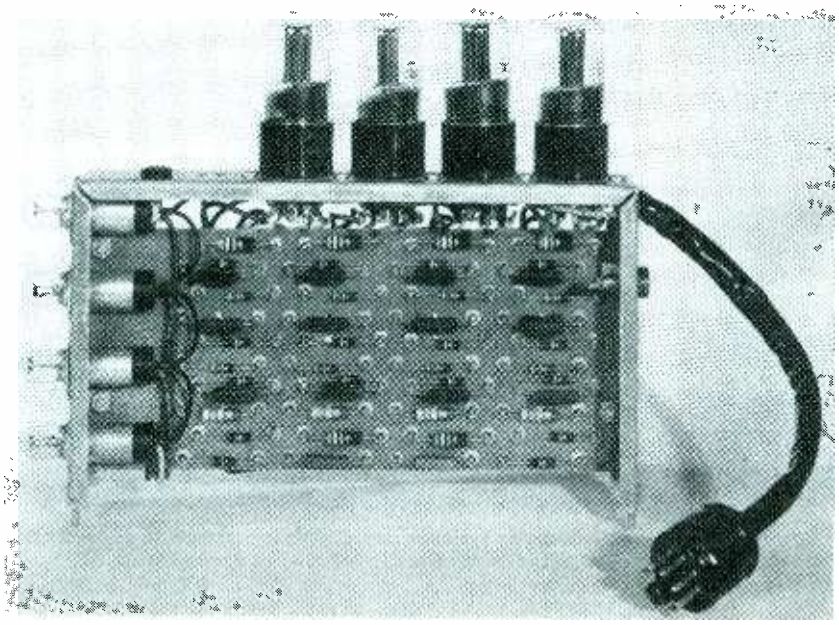


Grounded-grid oscillator using water-cooled 9C21, the leads of which can be seen projecting above ring of vacuum capacitors that ground the grid, dissipates 50 kw at plate. Rectifier in grid circuit, not shown, stops damaging grid emission

In this cyclotron the oscillator used to charge the dees is frequency modulated at 120 cps between 12.5 and 8.17 mc by a vacuum capacitor with 24 teeth on its rotor passing at 300 rpm between forked projections at the end of the parallel-wire resonant line. The change in capacitance loading on the line changes its resonant frequency. Charged particles are accelerated during the half of the modulation cycle for which the oscillator frequency is decreasing.—F.R.

Predetermined Counters

Banks of ten-position switches permit setting electronic counter decades to actuate a relay after any desired total count. Industrial uses include batching, counting, timing, controlling zipper-making machines, and automatic packaging of pills



Complete four-tube counter decade, which delivers one output pulse for every ten input pulses

WITH the ever-increasing use of high-speed industrial processes and operations there has developed a great need for control, counting, sorting, and packaging equipment to keep pace with highly efficient manufacturing standards. To meet this need there are now available high-speed predetermined counters which can be used for automatic control of machinery.

Mechanically operated counters have their limitations in the maximum speed at which they can count (usually less than 10 per second) and the fact that they are usually actuated by the operation of a machine rather than by a processed item. Therefore the counter continues to register even if the machine runs out of stock or fails to operate correctly.

The predetermined counter to be described can readily be used to count, sort, or group for packaging any small or large items at rates up to 15,000 per minute in predetermined quantities from 1 to 10,000 or more pieces. Some of the products which could be so counted are pills, buttons, screws, washers, caps, sheet steel, machined parts, and even liquids.

By way of illustration, consider the application in counting and grouping of pills for packaging. Figure 1 indicates how a predetermined counter is used to count a definite number of pills and accurately channel the quantities into two lines of bottles on a moving conveyor belt. Pills to be packaged are placed in a hopper and are fed to a rotating disc and belt arrangement which is designed to emit pills in single file at rates of approximately 250 per second. As the pills pass through the light beam they cause impulses, representative of quantity, to be injected into the input of the predetermined counter.

Assuming that the desired quantity in each bottle is 100, the counter is set by means of dials to actuate a self-contained high-speed single-pole double-throw relay each time a count of 100 is reached. The output of this relay actuates a solenoid which moves a deflector plate and thereby channels the pills in quantities of 100 alternately through two duct channels. The conveyor belt carries the empty bottles in two lines to gates which are directly under the ducts. These gates are actuated alternately by the same impulses which control the deflector plate. When each bottle has been filled with the correct quantity of pills the respective gate is opened and the bottle is permitted to travel along the conveyor to the capper.

Single Predetermined Counters

The basic unit of the predetermined counter is the four-tube counter decade described in detail in June 1944 ELECTRONICS, p 110, which will register a count from 1 to 9 on neon bulbs and then reset to 0, and will provide one output pulse for every 10 input pulses which are injected. This is accomplished in a binary progression using a 1-2-4-8 series.

The single predetermined counter consists of four such decades in tandem, four wafer preset switches for setting the predetermined count, and an electronic switch which is used to actuate a double-pole single-throw output relay. The block diagram in Fig. 2 indicates how these parts are functionally connected together. By using the four decades a count of 0 to 10,000

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can be predetermined simply by setting the four dial switches (each having ten positions numbered 0 to 9) to the complement of the desired number. In other words, if an operation is required to take place at 3333 counts, the number which is set up by means of the dial would be 6667. The addition of 3333 counts to the preset number of 6667 makes 10,000, which is the maximum count of the instrument and therefore actuates the electronic switch for control of the operation. In the case of the pill counter described previously, the count of 100 was achieved by setting the dial switches to 9900.

The dial wafer-type switches serve to make connections to the proper grids of the trigger tubes, for injection of the pulses needed to give a predetermined starting count. One four-layer wafer-type switch is required for each decade, with connections as shown in Fig. 3. The preset combination of pulses can be applied automatically at the end of each count to the common terminals of all switches, or manually by means of the preset button located on the front panel.

When automatic preset is used, the output pulse from the last decade is used to trigger a pulse generator which supplies a positive pulse to the required grids for starting a new count, as determined by the setting of the preset switches. Manual preset is accomplished by closing the preset switch, which injects a positive pulse to the selected grids as in the automatic reset.

The electronic switch which controls the position of the double-pole single-throw output relay is another double-triode trigger stage with a neon indicator lamp in each plate circuit. At the end of each predetermined count these two trigger stages are alternately switched from conducting to non-

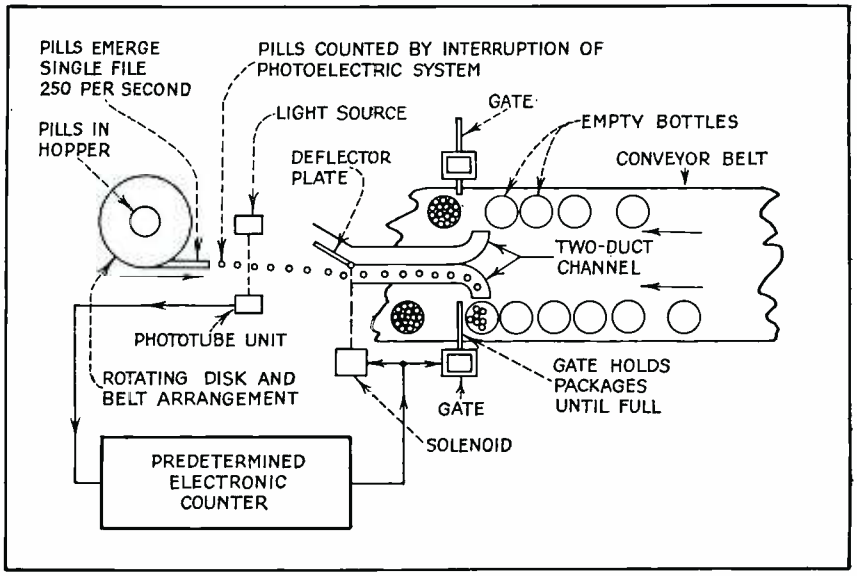

FIG. 1—Method of using single predetermined electronic counter for counting pills at rate of 15,000 per minute and placing exactly the correct number automatically in each bottle on the conveyor belt

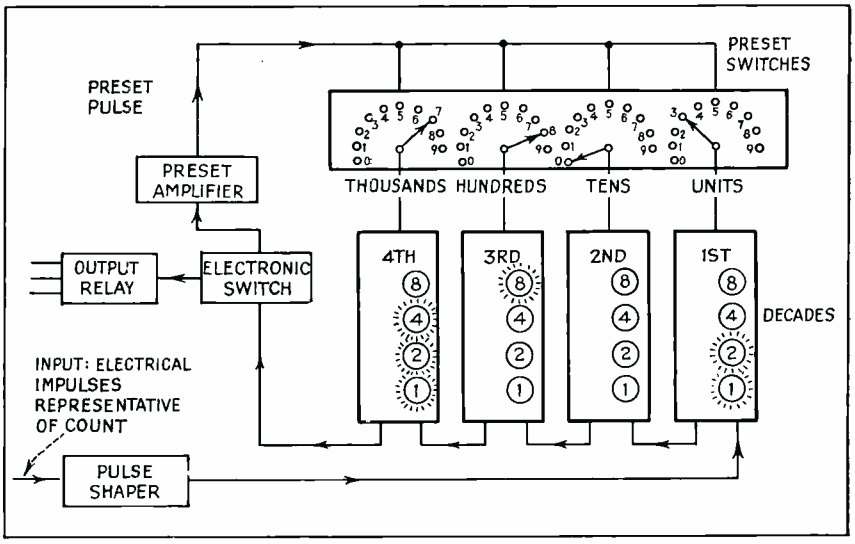

FIG. 2—Block diagram of four-decade single predetermined counter, showing switches and lamps set for starting count of 7803 as required for batching of 2197 units

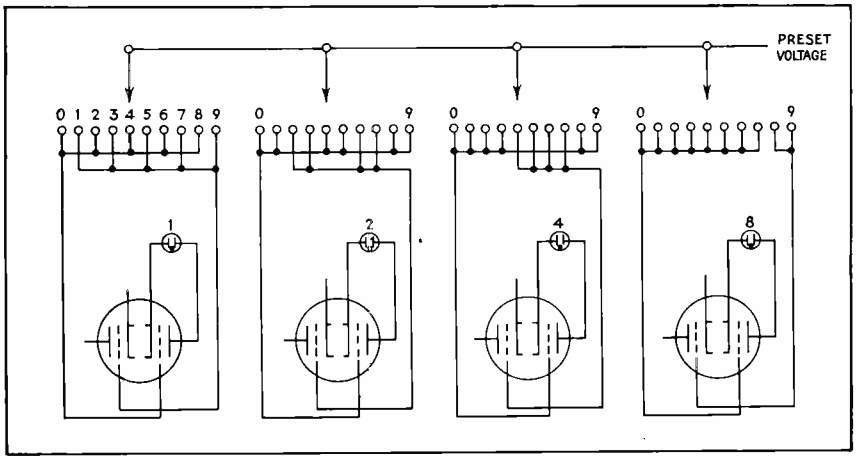

FIG. 3—Switching circuit used for selection of predetermined count on one decade

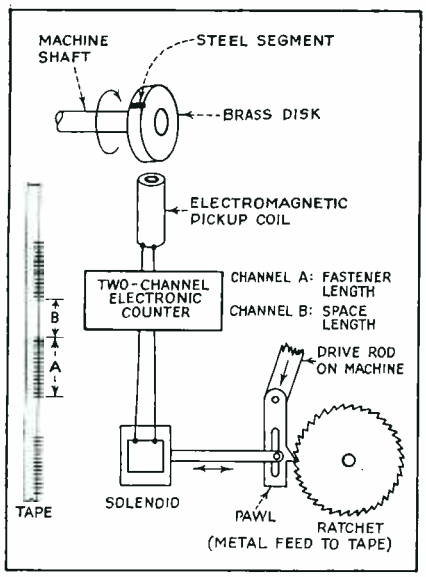

FIG. 4—Arrangement for automatic control of slide fastener machine, using one predetermined channel to control the number of elements inserted in the fastener tape and using the second predetermined channel to control the spacing between sections on the tape

conducting, thereby controlling the output relay and the neon indicating lamps.

The predetermined counter is easily applied to all types of operations and processes requiring split-second control. The input impulses may be derived from a shaft rotation, the interruption of a photoelectric light beam, reciprocating member motion, contact closures, electromagnetic field disturbance, and many other actions which are representative of counts. The fast-acting output relay can readily be adapted for solenoid control.

Dual Predetermined Counters

Dual predetermined counters may be used for controlling processes which consist of two different operations. An example of this type of application is high-speed control of zipper manufacture, illustrated in Fig. 4. The problem is to control accurately the number of metal elements and the spacing between groups of elements inserted in the continuously moving tape. These two operations are normally controlled by cams or gears, which frequently cause errors and limit the maximum speed of operation.

Since the dual predetermined counter is designed to provide alternate switching of the output relay at the completion of each of two different predetermined counts, this instrument can be readily substituted for the cam or gear control in this application. In practice the number of zipper elements desired is set up in one channel of the counter by means of the dial switches, and the spacing between the groups of zippers is set up in the other counter channel by means of a second row of dial switches. The input to the counter is derived from a shaft rotation which corresponds to the insertion of a zipper segment or to an equivalent space on the fastener tape.

With existing types of zipper machines it is necessary to change gears or cams each time a new fastener length is desired. By using a dual predetermined counter for control, this time-consuming operation is eliminated. To change fastener length with the electronic control it is necessary to change only the dial switch settings, which can be accomplished without stopping the machine.

The dual predetermined counter employs one additional preset switch channel and amplifier, as indicated in Fig. 5. It can be used to control any two-step continuous operation by actuating a control at the completion of each of two predetermined counts or time intervals. Normally this model will control at rates up to 12,000 per minute. Equipments suitable for higher rates of operation are also available.

Applications

For accurate counting at high speeds, standard counters using the decade system described will operate at rates up to a million per second in response to interruption of a photoelectric light beam, closing of contacts, or to any other type of actuator.

Predetermined counters are finding wide usage in high-speed packaging and sorting applications, as well as in high-speed manufacturing processes which require split-second actuation of controls. This type of counter is now being used in the manufacture of zippers, control of tin plate processing, packaging of many different types of small items, and hundreds of other industrial applications.

When used as an interval timer, a crystal-controlled oscillator is fed into the counter by an electronic

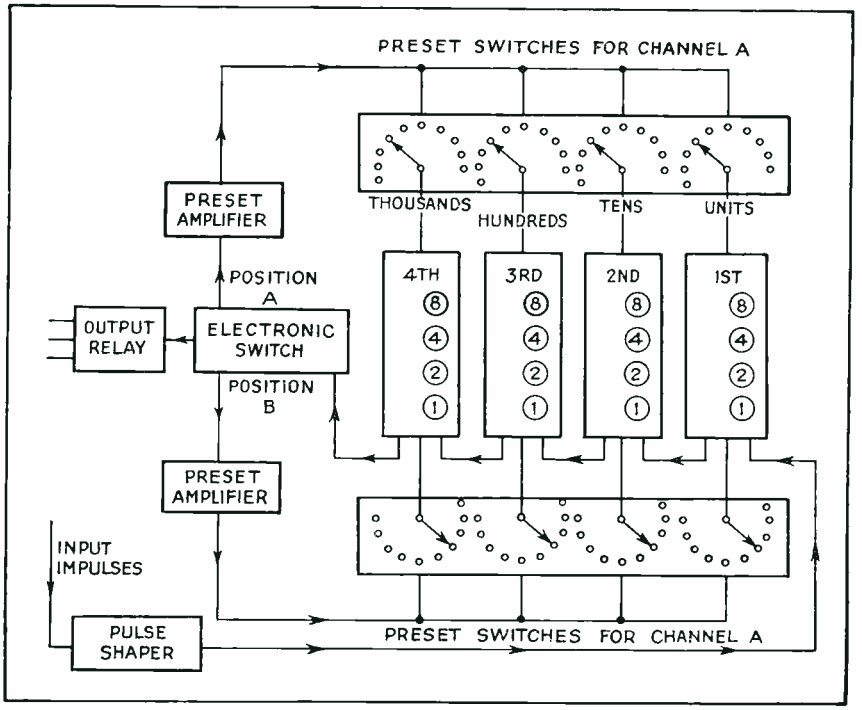

FIG. 5—Block diagram of dual predetermined counter used for high-speed control of two different operations that occur in sequence and recycle continuously

Single predetermined electronic counter, using four counter decades and one bank of presetting switches

Dual predetermined electronic counter, with two banks of presetting switches alternately controlling the decades

switch or gate which is operated by the initiating and terminating pulses from a time interval. If a 100-kc crystal is used as the standard, the accuracy of measurement will be +0 and −10 microseconds for an interval as long as desired. In units using 400-mc or 1.6-mc oscillators, the accuracy is +0 and −1 cycle of the respective crystal frequencies. These interval timers are now in use by the armed services for projectile velocity measurements.

Preset interval timers using the same principles as the predetermined counters are also being supplied for the generation of precise time intervals which are selected by means of dial switches.

Totalizing

An instrument has been developed which is capable of totalizing the individual outputs of many sources occurring at random times. This system has already been applied to a pari-mutuel betting machine at a race track for recording the amount of money bet on each horse at the ticket machines. Since this equipment must also convert the $2, $5, $10, and $50 bets into equivalent dollars for totalizing, it was necessary to develop circuits which would add and multiply electronically.

In a manufacturing process where many machines are making the same product at varying rates, it is often desirable to know the total output or the average rate per machine. The totalizator equipment can be readily used for this purpose even where the outputs occur at random rates and counts occur simultaneously.

This system can be easily applied to newspaper plants for obtaining an up-to-the-second count of the various press outputs. It can also be used to record total fluid output by totalizing the outputs of the individual flowmeters. Power plants can use such a device for recording the total output from several generators by totaling the readings of the individual wattmeters. These are but a few of the thousands of possible applications of totalizator equipment.

The basic part of most calculators is a mechanical counter decade. Substitution of electronic counters will give much greater speed and may provide a less expensive method of adding, subtracting, dividing, and multiplying, especially in business uses.

Although not specifically designed for the purpose, the predetermined type of counter described is in reality a dividing device. In this case the number of impulses injected at the input is the dividend, the complement of the number set by the dial switches is the divisor, and the number of output pulses is the quotient. The totalizing circuits mentioned are inherently multiplying and adding devices.

The electronic counter offers a method of increasing the rate of circuit selection, now generally accomplished by stepping relays as in dial-telephone operation. A series of rapid pulses may be transmitted over a line for almost instantaneous selection of a desired circuit. By the use of totalizing counter circuits mentioned previously, these pulses may even occur simultaneously.

Counter circuits may also be used in the many places where frequency dividers are required. A distinct advantage is the fact that the divider stops when the control frequency stops. The input control frequency may be varied from 100 kc down to zero and the same division rate will be accurately maintained. The counter circuit used as a frequency divider is highly desirable in television pulse generator circuits because of its stability and absolute division rate.

By use of the predetermining features described, it is possible to divide any input frequency by any factor established by means of predetermined dial switch settings.

When used as scaling circuits and counters in radiation work, decades with a resolving time of 0.00001 second are available. Counters having a resolving time of 0.000002 or higher can also be supplied. A distinct advantage in using this type of decade is decimal registration of the count, not available in other types of radiation counters.

Pulse Modulated

Method and circuits are presented for pulsing a high frequency oscillator so that all waves are of the same amplitude. Pulse rate is variable over wide limits independently of oscillator frequency. Calibration and marking of sweeps with the equipment are described

AN IMPROVED METHOD for generating a train of sine waves, in which the first cycle is identical to the following cycles, is described. The train may be initiated from an outside trigger and may therefore operate over a wide range of pulse repetition frequency. Large peak-to-peak amplitudes are available requiring but small power input.

Rapid development of equipments utilizing pulse techniques has made necessary precise methods of time measurement. The cathode-ray oscilloscope using slave sweeps has become a common tool for accurate pulse work[1, 2, 3, 4].

Various means have been suggested for calibration of time bases[5, 6, 7]. The method described in this paper provides a readily adjustable means of generating a sinusoidal wave train of uniform amplitude under control initiated by externally applied triggers.

Pulsed Resonant Circuit

The most elementary type of sine wave sweep calibrator is shown in Fig. 1A. Operation depends on the transient oscillation which results from sudden interruption of a steady current flowing through an inductance shunted by a capacitance. Should the current I_p be suddenly cut off by application of a negative gate to the triode grid, an oscillatory voltage appears across the capacitance such that

$$e_c = -I_p(L/C)^{1/2}\epsilon^{-\omega t/2Q}\sin\omega t \qquad (1)$$

where the symbols are defined and derived in the appendix.

The exponential term of Eq. 1 determines the rate of decay of the oscillation. If Q were very high, oscillations would persist, dying out gradually. However, with ordinary commercial inductors having practical values of Q, oscillations decay in a relatively short time, as shown in Fig. 1B.

The magnitude of Q required to give an amplitude Ke_0 to the nth cycle of oscillation (derived in appendix) is

$$Q = \frac{(n-1)\pi}{\ln(1/K)} \qquad (2)$$

Thus to obtain e_n equal to $0.9e_0$, that is K equals 0.9, where n is 21 cycles, Q must nearly equal 600 (This relation incidentally provides a method of measuring Q of an inductor[8].)

Limitations of the damped train as an accurate source of sweep calibration markers are numerous and some superior means have been developed.

Keyed Oscillator

It is possible to develop a sine wave train by the method shown in Fig. 1C. A Hartley type oscillator is connected so that application of a positive gate to the triode plate will result in the growth of oscillations such that

$$i = (e_s/\omega L)(\sin\omega t)\exp R_n t/2L \qquad (3)$$

Oscillations grow at a rate determined by the magnitude of negative resistance R_n introduced by the oscillator tube. This circuit may be difficult to synchronize well. The degree of synchronization depends upon factor e_s of Eq. 3. If sufficiently high frequency components are present in the rising edge of the positive gating pulse, synchronizing pulses can be obtained in the tuned circuit through the triode grid-to-plate capacitance. At best, locking with the trigger is precarious and, in addition, time de-

CHARACTERISTICS

The method described in this paper for generating a recurrent finite train of sine waves has the following characteristics:

Wave train may be initiated by an external trigger

First cycle of the sweep marker train has the same amplitude as succeeding cycles

Any number of cycles in the train may be produced by adjustment of a single control

First cycle is delayed by less than half a microsecond with respect to the trigger pulse

Frequency of waves in the train can be 20 mc and higher and still have sufficient amplitude for direct deflection of a five-inch cathode-ray tube beam or for direct intensity modulation

Plate current consumption of the generator circuit proper can be less than ten milliamperes at 150 volts

Frequency of the waves in the train may be continuously variable over a wide frequency range by simple adjustment

Oscillator

By ALLAN EASTON

Special Products Division
Emerson Radio and Phonograph Corp.
New York, N. Y.

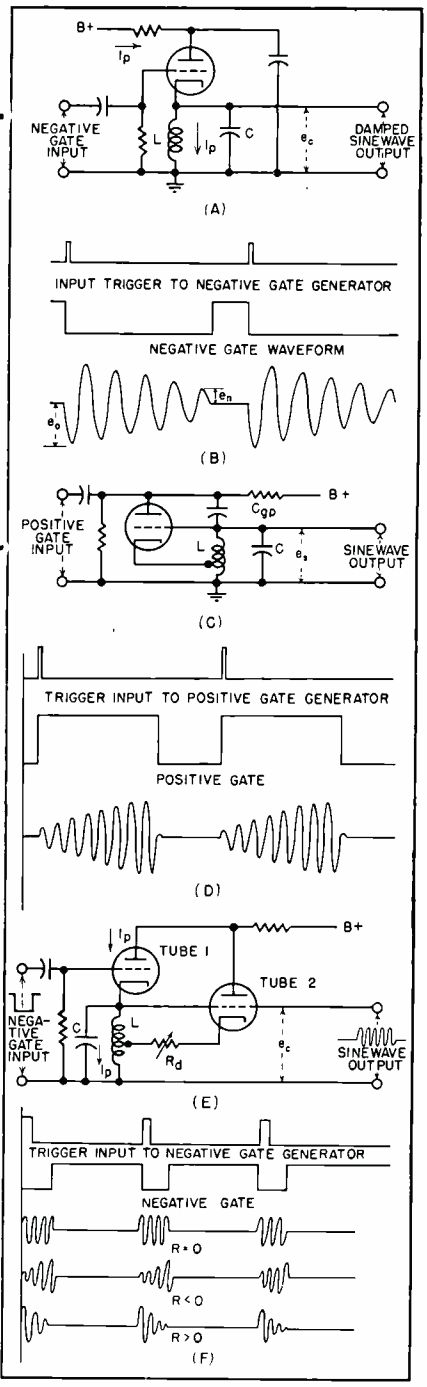

FIG. 1—By combining a pulsed resonant circuit (A) giving a damped wave train (B) with a keyed oscillator (C) giving a wave train that builds up (D), a pulsed oscillator (E) that can generate a wave train of constant amplitude (F) is obtained

lay involved in waiting for oscillations to reach final amplitude, as illustrated in Fig. 1D, may be prohibitive for many applications.

Combination Circuits

An ingenious combination of both circuits described above was developed by Radiation Laboratory, Massachusetts Institute of Technology.

The circuit, shown in Fig. 1E, may be analyzed qualitatively by considering the oscillator tube (tube 2) as a source of negative resistance. If the oscillator were not present, the circuit would be similar to that of Fig. 1A, the damping resistance in this case is greater than zero and therefore the wave train will decay exponentially as mentioned. As the magnitude of the negative resistance (controllable by degeneration potentiometer R_d) causes the equivalent circuit resistance to approach zero (Q approaches infinity), the envelope of the oscillations more nearly approaches a pair of parallel horizontal straight lines. Should the effective circuit resistance become negative, oscillations will build up from their initial value to some final value determined by circuit parameters. These conditions are illustrated in Fig. 1F.

The magnitude of the peak voltage of the first cycle is

$$e_{cmax} = I_p(L/C)^{1/2} \qquad (4)$$

Equation 4 predicts an oscillator voltage proportional to the d-c plate current and to the square root of the L to C ratio. Substituting typical values into the equation where $C=100\mu\mu f$, $L=250\mu h$, $I_p=0.010$ amp, and $f=1.006$ mc gives e_c equal to 15.8 volts peak or 31.6 volts peak-to-peak.

If this voltage is inadequate for a particular application, it is then necessary to increase I_p. The upper limit to the L to C ratio is determined by stability requirements and therefore cannot be increased indefinitely.

At about 10 mc this circuit becomes expensive and unwieldy. Suppose $C = 25\mu\mu f$, $L = 10\mu h$, $I_p = 0.010$ amp, and $f=10.06$ mc, then e_c is equal to 6.32 volts peak. To obtain the same value of e_c at 10 mc as was realized at one megacycle, plate current should be more than doubled and yet circuit stability would be poorer because of the higher L to C ratio. Should really large marker voltages be desired, excessive plate currents would be required.

Pulsed Oscillator

For reasons of economy and simplicity another approach to the problem, which extends the operating range to well over twenty megacycles, was tried. The principal difference circuitwise is the inclusion of a gas thyratron such as a type 2D21, 2050, 6D4, or 884 and associated circuits shown in Fig. 2.

Theory of operation is as follows. Three tubes are employed, a shock tube V1, a clamp tube V2, and an oscillator tube V3. The shock tube V1 has the characteristic of being able to pass large surges of current (in excess of five amperes) for a short interval and then remain in the ready state with the passage of a small current (in the order

of microamperes). Clamp tube V2 has the characteristic that its resistive impedance from cathode to ground (the plate is held at a-c ground by a capacitor), which is in parallel with the tuning coil of the oscillator, is very high when the tube is nonconducting (control grid biased negative), and very low (about 300 ohms or less depending on tube type) when the tube is conducting. Oscillator tube V3, with its circuit, is permitted to oscillate or prevented from oscillating by the clamp tube by virtue of the tube resistance which shunts the tuned circuit.

In operation the circuit is in the ready state when C_2 is fully charged through R_3 to the supply potential. Tube V2 is conducting and tube V3 is therefore in the nonoscillating condition.

Sequence of Circuit Functions

When it is desired to set off a train of oscillations each of the same amplitude, a sharp positive pulse is applied to the thyratron grid through R_1C_1, causing the gas to ionize and C_2 to discharge through the interelectrode space and the primary of the high frequency transformer. Simultaneously with the positive pulse on the thyratron grid, a negative gate is applied to the grid of the clamp tube through C_3R_4 causing the clamp tube to become nonconducting and permitting oscillations to build up.

Oscillations will, therefore, not have to build from low amplitude gradually, but can be equal or even larger than succeeding oscillations.

When the positive pulse which was impressed on the thyratron grid decays, the gas tube deionizes by virtue of R_3C_2 in the plate circuit, and the tube disconnects itself from the circuit except for the cathode to ground capacitance across the tuned circuit. Oscillations will continue until the negative gate on the clamp tube grid is removed, permitting the clamp tube to become conducting thereby quickly damping the oscillations.

Rate of decay is determined by the magnitude of the resistance the clamp tube shunts across the tuned circuit. Type 6J4 which has a very high value of transconductance will damp the oscillations faster than will type 6C4. (In all cases decay time may be longer than rise time.) Meanwhile C_2 will be recharging through R_3 preparatory for the next cycle of operation.

Circuit Characteristics

This circuit has been constructed and tested using component values indicated in Fig. 2. With a positive plate voltage supply of 150 volts, it was possible to obtain as much as 80 volts peak to peak at 20 mc. This large voltage was possible chiefly by virtue of the tremendous surge of current delivered by C_2 through the thyratron tube into the tuned circuit as explained above. The circuit as shown is capable of operation at pulse repetition frequencies ranging from less than one cycle per second to slightly over 5,000 cps. Total average plate current consumption of the three tubes does not exceed ten milliamperes at the highest frequency of operation.

Some necessary precautions for obtaining optimum performance are:

The positive trigger which actuates the thyratron grid should have a steep rise, preferably in the order of 1,000 volts per microsecond.

The negative gate which actuates the clamp tube must rise quickly enough so that the clamp tube current is cut off at the same time that the gas tube fires.

The transformer primary must be connected to the cathode of the shock tube by short leads. The primary must be closely coupled to the secondary; the primary turns numbering one half of the secondary turns, approximately.

R_7 is adjusted for flattest topped wave trains.

R_2 should be selected of sufficient resistance to limit peak current in the thyratron to a safe value as specified by the manufacturer. R_2 may be used to determine the initial amplitude of the generated sine wave train.

Applications

The most obvious application of the pulse modulated oscillator is for time base calibration. In the commonest case a saw-tooth sweep of somewhat indeterminate length is used to measure characteristics of a pulse display. The sine wave train is fed into vertical deflecting plates of a cathode-ray tube and horizontal deflection sensitivity is adjusted to give a full deflection. Thus with the period of the calibrating waves known, the time scale in microseconds per inch is determined. Calibrating markers are virtually indispensable where the sweep velocity is not constant.

The pulse to be measured may be observed simultaneously with the calibrating markers. Controllable delay and negative gate duration may be adjusted to cause the markers to coincide with the pulse.

Intensity grid modulation of the cathode-ray beam is a popular means of utilizing sweep markers. The sine wave train may be mixed

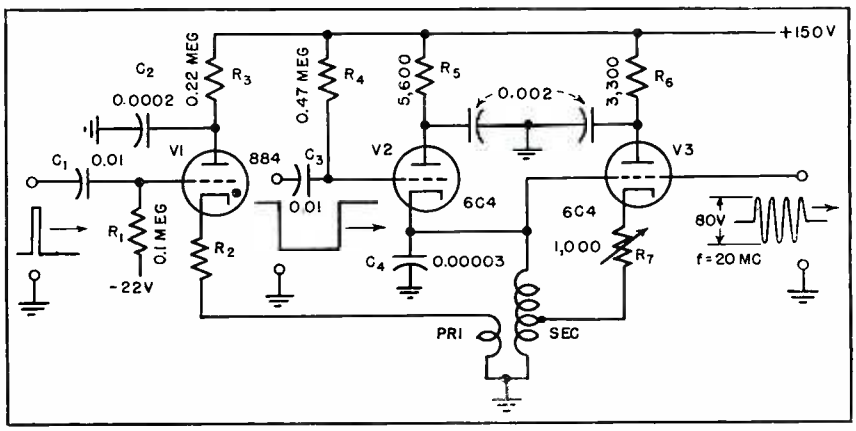

FIG. 2—Circuit of a pulsed oscillator that delivers pulses of high, uniform amplitude

with blanking pulses or may be connected to the cathode or grid of the cathode-ray tube while the blanking pulses are connected to the unused element. Alternate bright and dark spots facilitate measurement of pulses without distorting the shape of the display.

A convenient possibility is to use one pulsed oscillator for making one microsecond dots and another for making 0.1 or 0.05 microsecond dots and then mixing the two to give marker dots.

A particularly interesting extension of testing amplifiers by square wave analysis[9] is made possible with the pulse modulated oscillator. In present television receiver practice an intermediate frequency of about 21 mc has been accepted as standard. Overall bandwidths of 3 to 5 mc are used and some means for testing transient response of intermediate frequency amplifiers is needed. It is customary to use a sweep oscillator and cathode-ray oscilloscope[10] for this purpose. This method gives little information concerning transient response whereas the pulse modulated oscillator when injected into the grid circuit of the i-f amplifier enables direct observation of pulse response of all circuits after the mixer. Vertical or horizontal synchronization pulses can be used to trigger the pulsed oscillator.

Methods of Calibration

In order to utilize fully the pulse modulated oscillator, some means of accurately setting or measuring the sine wave frequency is needed.

Common is the zero beat method in which a crystal oscillator or standard signal generator is made to zero beat with the unknown frequency. Caution must be maintained to avoid synchronization of the pulsed oscillator by the standard frequency source or the reverse. It is possible for the pulsed oscillator to begin oscillating at a frequency determined by its own circuit constants and then be forced into another frequency of oscillation by the calibrating voltage. At 20 mc, small stray capacitances may cause considerable coupling. Synchronization of either pulsed

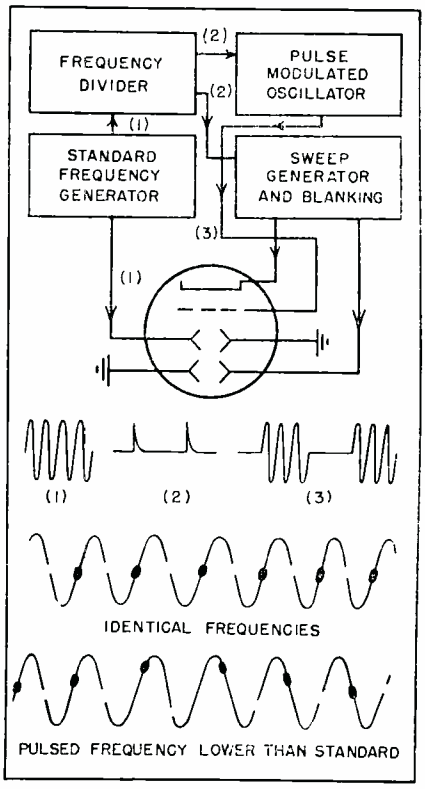

FIG. 3—Using the method shown at the top, the patterns shown below are obtained to indicate the frequency of the pulsed oscillator

oscillator or calibrating oscillator by one another or by an external stray signal must be avoided if useful results are to be obtained[11]. The zero beat method gives no information about the spacing of individual sine waves of the pulsed train but measures average frequency. If the first few oscillations had a different period from the succeeding cycles, a situation which is quite possible, the zero beat method would not reveal this fact.

The fact that the sine wave train is pulsed, that is, interrupted periodically, gives rise to a spectrum of frequencies, any one of which may give zero beat with a calibrating frequency. Only one of these beats represents the center frequency of the wave train[12].

Another method of calibration utilizes the cathode-ray tube oscilloscope to obtain a Lissajou figure[13]. When two voltages of slightly different frequencies are compared, one connected to each pair of deflecting plates of the cathode-ray tube, a stationary pattern will appear either if the two frequencies bear a harmonic relationship, or if they have a harmonic in common.

When the two frequencies are equal, a stationary geometric figure such as a circle, ellipse, or straight line can be obtained. The same precautions against unwanted synchronization must be observed in this case. The characteristic circle denoting equal frequencies can be obtained by comparing the calibrating frequency with any one of the spectral sideband components of the pulsed wave. Frequency difference between successive spectral components depends upon pulse repetition frequency. Advantage may be taken of this fact in calibrating by Lissajou figures. If the characteristic circle is obtained, change the pulse rate slightly; only the center component, that is the nominal sine wave frequency, will remain unchanged and will continue to give the circle. Any spectral sideband components will change frequency when the pulse rate is altered.

An excellent method of calibration, first demonstrated to the author by R. D. Scheldorf of Radio Corporation of America, is illustrated in Fig. 3. A crystal oscillator or other type of standard frequency generator is connected to a frequency divider which generates a synchronizing pulse to trigger the pulse modulated oscillator and slave sweep of the cathode-ray oscilloscope. The standard frequency voltage is connected to the vertical plates through the vertical amplifier, and the pulse modulated oscillator to the intensity control grid (Z axis). If the two frequencies differ but slightly, a very easily recognized result appears. The difference frequency shows up as a wave of bright spots whose period is equal to the reciprocal of the difference. Precautions must be taken as usual to prevent oscillator pulling. No trouble is experienced with sidebands. It is also possible to determine whether any shift in frequency of the pulse modulated sine waves occurs when the pulse rate or duration of the train is altered. In the case where only a few cycles of the train are desired, the above methods do not

give sufficient accuracy for the most precise requirements.

The most accurate calibrating procedure developed to date to the author's knowledge is the method described in a previous paper[14]. This paper describes a rapid, accurate determination of spacing between pulses or sine waves having production line simplicity and laboratory precision. It is possible to ascertain whether the first cycle has the same period as the succeeding cycles. This information is important where maximum precision is desired.

Mathematical Appendix

A simplified equivalent circuit of the keyed oscillators discussed in the text is shown in Fig. 4. Switches S1 and S2 are provided to indicate various stages in the operation of the circuits.

CASE A considers the buildup characteristic of the elementary pulsed sine wave generator of Fig. 1A for which S1 and S2 are normally closed, but at $t = 0$ S2 is opened. The differential equation describing the subsequent action is

$$L\frac{di_2}{dt} + R_L i_2 + q/c = 0 \qquad (1A)$$

or

$$(DL + R_L + 1/PC)i_2 = 0 \qquad (1B)$$

Where $1/P = \int_0^t dt$

The general solution[15] of Eq. 1 is

$$i_2 = (\exp - \alpha_1 t)\,[A_1 \sin\beta t + A_2 \cos\beta t] \qquad (2)$$

In order to evaluate the arbitrary constants of integration the following boundary conditions are substituted, neglecting $I_P R_L$ drop

$t = 0, q = 0, i_2 = -I_p$, and $\left(\frac{di_2}{dt}\right) = \left(\frac{\alpha_1}{\beta_1}\right) I_p$.

The complete solution is therefore

$$i_2 = -I_p (\exp - \alpha_1 t)\,[\cos\beta_1 t - \alpha_1/\beta_1 \sin\beta t] \qquad (3)$$

We are primarily concerned with the potential across the capacitance

$$e_c = \frac{1}{c}\int i_2\,dt \qquad (4)$$

$$e_c = \frac{I_p}{C}\cdot\frac{\alpha_1}{\beta_1}\int(\exp - \alpha_1 t)\sin\beta_1 t\,dt - \frac{I_p}{C}\int(\exp - \alpha_1 t)\cos\beta_1 t\,dt \qquad (5)$$

Performing the indicated integration and evaluating the constant of integration gives

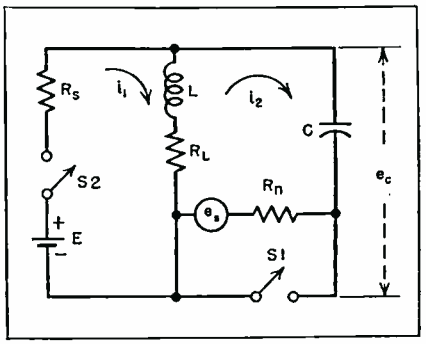

FIG. 4—Equivalent circuit of pulsed oscillator

$$e_c = \frac{-I_p}{\beta_1 C}(\exp - \alpha_1 t)\sin\beta_1 t \qquad (6)$$

If Q is very much greater than unity,

$$\beta_1 = \omega, \text{ and } \alpha_1 = \frac{\omega}{2Q}, \text{ and}$$

$$e_c = -\frac{I_p}{\omega C}(\epsilon^{-\omega t/2Q})\sin\omega t \qquad (7A)$$

or also

$$e_c = I_p (L/C)^{1/2}(\epsilon^{-\omega t/2Q})\sin(\omega t + \pi) \qquad (7B)$$

Equation 7 describes an oscillation whose decay properties depend upon the magnitude of Q. If Q is very high but R_L is still larger than zero e_c decays slowly (see Fig. 1B and 1F). If Q is infinite, that is, if $R_L = 0$

$$e_c = -I_p (L/C)^{1/2}\sin\omega t \qquad (8)$$

This equation expresses the case shown in Fig. 1E and 2 where the oscillator tube is adjusted to cause the effective circuit resistance to vanish. If Q is negative, that is, if R is less than zero, then oscillations build up indefinitely. Actually losses in the circuit due to nonlinearity of the oscillator tube will limit the amplitude of oscillations.

In using the circuit in Fig. 1A, assume one wishes to ascertain the Q required to sustain oscillations for n cycles so that

$$e_n = Ke_0 \qquad (9)$$

then

$$e_0 = I_p (L/C)^{1/2}(\exp - \omega t_n/2Q)\sin\omega t_0 \qquad (10A)$$

and

$$e_n = I_p (L/C)^{1/2}(\exp - \omega t/{}_n 2Q)\sin\omega t_n \qquad (10B)$$

but

$$\omega t_0 = \frac{\pi}{2} \text{ and } \omega t_n = 2(n-1)\pi + \frac{\pi}{2}$$

then

$$K = \frac{e_n}{e_0} = \exp - \frac{(n-1)\pi}{Q} \qquad (11)$$

from which

$$Q = \frac{(n-1)\pi}{l_n(1/K)} \qquad (12)$$

Figure 5 is a plot of K versus Q for several typical values of n.

The amplitude of the first cycle of oscillation may be readily obtained from the Eq. 7A. Let $\varphi t = \pi/2$ and $Q>>1$ then $e_{cmax} = I_p(L/C)^{\frac{1}{2}}$. As a check this can be deduced from energy considerations where

$$\frac{1}{2}LI_p^2 = \frac{1}{2}Ce_c^2 \qquad (14)$$

and

$$e_{cmax} = I_p (L/C)^{1/2} \qquad (13)$$

CASE B refers to Fig. 1C for which S2 in Fig. 4 is open throughout. Before $t = 0$ S1 is closed. At $t = 0$ S1 is opened causing circuit resistance to become negative. Synchronizing pulse e_s causes transient oscillation to begin such that

$$i(DL + R_n + 1/PC) = e_s \qquad (15)$$

from which

$$i = \epsilon^{-\alpha t}[A_1 \sin\beta t + A_2 \cos\beta t] \qquad (16)$$

We are not concerned with steady state condition because e_s is negligible compared with the amplitude of the resulting oscillation. Boundary conditions are $t = 0$, $q = 0$, $di/dt = e_s/L$ giving

$$i = \frac{e_s}{\beta L}\epsilon^{-\alpha t}\sin\beta t \qquad (17)$$

and if $Q>>1$, and $R<0$ then

$$i = \frac{e_s}{\omega L}(\exp R_n t/2L)\sin\omega t \qquad (18)$$

This expression is the equation of an oscillatory current which builds up from zero to some final value determined by tube nonlinearity.

CASE C considers oscillations after application of the negative gate to the grid of the clamp tube. Oscillations will continue in a manner determined by the magnitude and sign of the effective circuit Q. When the negative gate is removed and the cathode follower is permitted to become conducting, oscillations will be damped at a rate determined by the magnitude of R_s. When S2 is closed (corresponding to removal of the negative gate), equations describing the currents in the two meshes are

$$E = i_1 (R_s + DL) - i_2 (DL) \quad (19)$$

$$O = -i_1 (DL) + i_2 (DL + 1/PC) \quad (20)$$

(R_L is neglected as its effect is negligible compared with R_s). Equations 19 and 20 may be solved simultaneously for i_2 giving

$$i_2 \left(D^2 + \frac{D}{R_s C} + \frac{1}{LC} \right) = 0 \quad (21)$$

Roots of the auxiliary equation are

$$\left.\begin{matrix} r_1 \\ r_2 \end{matrix}\right| = \alpha_2 \pm \beta_2$$

It is not necessary for the purpose of this analysis to complete the particular solution for i_2. It is sufficient to observe that when $\beta = 0$ the circuit is critically damped and current in the capacitor can decay to zero without oscillatory overshoot; this is the borderline condition. The value of R_s required to give critical damping is deduced from

$$\beta = \left(\frac{1}{4R_s^2 C} - \frac{1}{LC} \right)^{1/2} = 0 \quad (22)$$

For the overdamped condition

$$R_s < \frac{1}{2} (L/C)^{1/2} \quad (23)$$

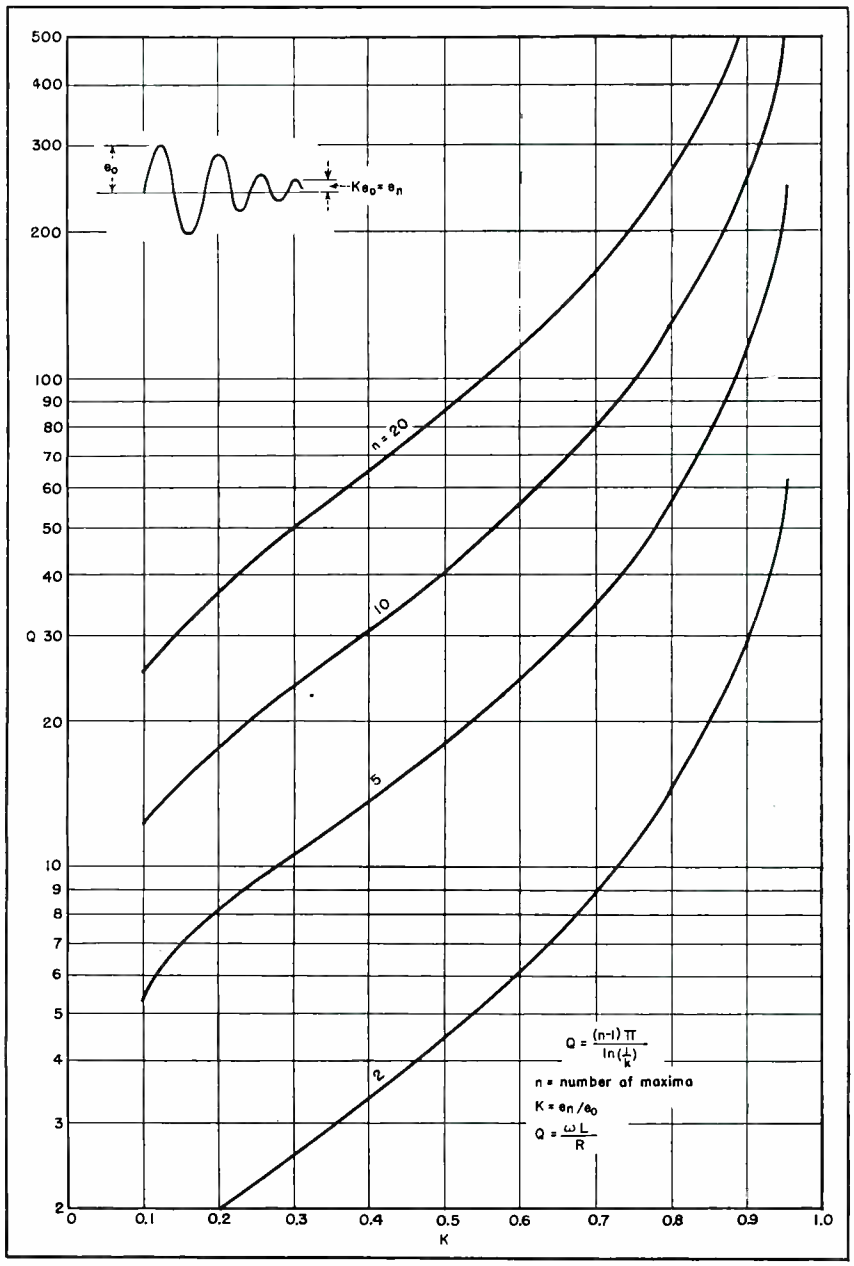

FIG. 5—Graph shows the quality (Q) of a resonant circuit if the oscillations initiated by shock are to decay to a particular fraction (K) of their initial value in a given number (n) of cycles

It should be noted that in circuits shown in Fig. 1E and 2 there are two transients. There is the transient resulting from current I_s which flows when S2 is closed, and the residual alternating current which remains when S1 is closed. By the principle of superposition each condition may be considered separately. Both conditions give similar differential equations but have different boundary conditions, which do not affect the analysis because we are not concerned with currents but rather with rates of decay of currents. It is evident that for rapid damping at high oscillator frequencies a cathode follower having low cathode to ground resistance is essential. Otherwise decay time may be considerably longer than rise time of the pulse modulated oscillator waveform envelope.

If R_s can be made very small so that $(1/4R_s^2C^2) >> (1/LC)$ then $i_2 = A_1 (\exp -t/R_sC)$ and i_2 will decay exponentially to a value of $1/e$ in R_sC seconds.

Substitution of typical values into the last equation gives the following data: either $f = 1$ mc, $C = 100\mu\mu f$, $L = 250$ μh, $R = 790$ ohms, and $t = R_sC$ 7.9×10^{-8} sec, or $f = 10$ mc, $C = 25$ $\mu\mu f$, $L = 10$ μh, $R = 316$ ohms, in which case $t = 7.9 \times 10^{-9}$ sec.

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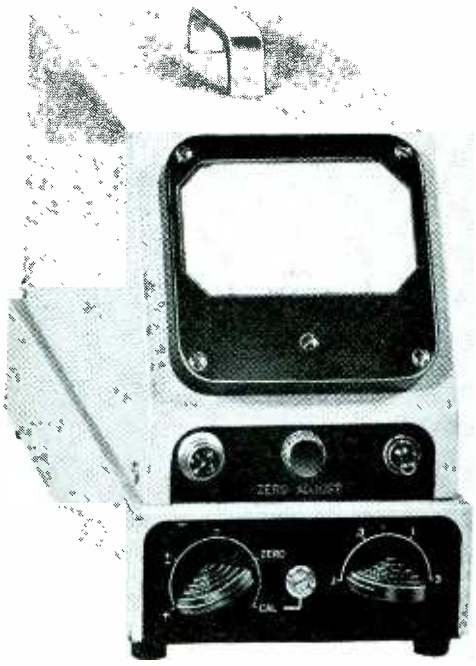
STABLE VOLTMETER



Experimental model of electronic direct-coupled voltmeter

By R. W. GILBERT

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Newark, N. J.

VACUUM TUBE amplification to extend the sensitivity of direct indicating electrical instruments has attracted the attention of numerous investigators, resulting in many effective methods for obtaining stability beyond that normally required for sound amplification. The impedance coupled alternating-current instrument amplifier has been particularly highly developed, largely by properly applied degeneration effective over the frequency range desired. The conductively coupled amplifier, responsive to both alternating and direct current, has however proved more difficult because of circuit limitations imposed by the necessity for both amplifying and degenerating through the conductively coupled circuit loop.

Condition for Stability

Broadly the attainment of stability in the face of variable tube coefficients is a problem of sacrificing a maximum of inherent amplification by degeneration, resulting in less gain but a proportionately greater stability. From this viewpoint it is apparent that the optimum combination is an infinite inherent gain which is completely degenerated, resulting in an amplifier having a nominal overall gain and first order independence of variations in tube coefficients.

At first it would appear possible only to approach but not obtain this condition because infinite gain considered as a separate function would be on the threshold of self-sustained oscillation. However, the superposition of degeneration exerts a stabilizing influence, and, unless inhibited by the time constants of the circuit, a stable overall system is possible. The present circuit is capable of adjustment to and beyond this ideal condition, and in practice reduces the influence of tube variables entirely to a second order effect.

Consider the circuit of Fig. 1 wherein the plate of the triode is conductively coupled to the grid through a battery equal to the voltage normally existing between these elements in a conventional amplifier circuit. Coupling of this nature is essentially degenerative in direction inasmuch as any plate voltage variation is transmitted to the grid as a corrective control to partially restore the original plate voltage. If an input voltage e is injected in series with the grid the voltage change E appearing at the plate is in a direction to reestablish the original grid voltage through the coupling battery. Thus the plate voltage shift is a measure of the input voltage, but less by an amount that is a function of the amplification factor.

For this condition the feedback relationship (Regeneration Theory by H. Nyquist, *B.S.T.J.*, **11**, 1932, Jan., p 126) applies

$$\text{Overall voltage ratio} = \frac{E}{e} = \frac{M}{Mb + 1} \qquad (1)$$

where M is the amplification factor (voltage ratio) of the tube proper in its circuit without feedback, and b is the transfer characteristic of the feedback loop, in this case the plate-grid degenerative connection. But here plate voltage changes are transmitted entirely to the grid so b is unity, and Eq. 1 becomes

$$\frac{E}{e} = \frac{M}{M + 1} \qquad (2)$$

From this equation it is apparent that as M becomes larger the overall amplification factor approaches unity and, which is more important, becomes more independent of changes in M.

This circuit is similar in function to the conventional cathode follower circuit except that the resistance mutual to the input and output circuits is in the form of a plate resistor rather than a

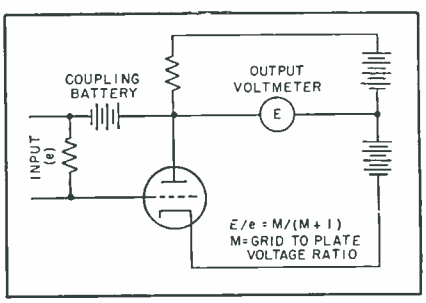


FIG. 1—Degenerative coupling from plate to grid, through a battery to preserve the required operating potentials on grid and plate, stabilizes the tube circuit

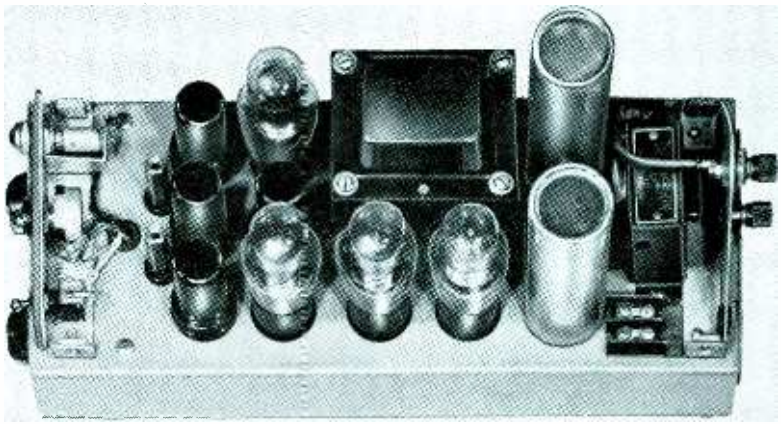
By means of a compound feedback circuit extreme stability is obtained in a conductively coupled electronic instrument. Positive feedback produces an effectively infinite gain that is highly degenerated by negative feedback

cathode resistor. The circuit may thus be considered as a "plate follower" in distinction to the cathode follower type of circuit.

Realizing the Conditions

The absence of cathode resistance permits the introduction of additional tube elements without involving their operation with the degenerative function of the control grid. In the two-tube circuit of Fig. 2 this feature of independence allows the introduction of a second grid to obtain regeneration, resulting in an effective increase in *M*. The second grid of each tube is crossed to the plate of the opposite tube to obtain regeneration in a manner similar to the action of a multivibrator. An adjustable plate-to-plate shunting resistor allows adjustment of the degree of regeneration. In practice the second grid is most conveniently the screen grid of a standard pentode, which is designed to operate at voltages comparable to the plate voltage without secondary emission complications.

If the control grids are temporarily made ineffective, for example by disconnecting and biasing from a separate source, and the regeneration control increased, a point of instability will be reached where the circuit will fall over, one tube blocking and the other conducting in the manner of a half cycle of multivibrator operation. At this point the circuit is critically regenerated and is essentially an amplifier of infinite gain. If the control grids are then reconnected to the degenerative coupling batteries all tendency toward instability will be restrained by superimposed degeneration and the circuit will function as the circuit of Fig. 1 containing a tube of infinite *M*. In fact the regeneration control may be further advanced and the circuit operated in the seemingly impossible region of greater than infinite (negative) internal gain.



Chassis contains power supply and amplifier circuit of voltmeter; indicating instrument is mounted on cover

With the circuit adjusted to this point of critical regeneration, the control grids exert only a transient type of control upon the tube space paths, while the regenerated screen grids and plates do the actual work of establishing the output voltage. If the control grid-cathode voltages are observed while an input voltage is applied, no change is noticeable, and this condition of zero grid excursion may be used in practice as the criteria for adjustment of the regeneration control. If the regeneration control be adjusted above or below the critical point while the circuit is subjected to an input variation, a control grid excursion will appear but of a polarity with respect to the input dependent upon the direction of misadjustment.

In a practical instrument amplifier the feature of zero grid excursion for a tangible plate voltage output means a materially more linear relationship between input and output because the plate and screen grid variational factors are more constant over wider voltage excursions than the control grid. Also the tubes can be operated at

the quiescent grid current point throughout the range of input, minimizing grid current demand in sensitive direct-current applications.

Significance of Circuit Characteristics

When critically regenerated, the circuit also has the interesting property of behaving as an output voltage source of zero variational resistance within functional limits. In operation with an input voltage applied, the output voltmeter may be shunted to demand more output current without affecting its reading. Conversely series resistance may be added to the coupling battery circuits without affecting the output reading. In either case the plate to screen-grid regenerative action supplies the additional output energy without requiring any static change in the control grid potentials, so the overall voltage ratio remains constant. Insufficient regeneration causes a positive variational resistance to appear, and excessive regeneration causes a negative variational resistance. In the latter case shunting the output voltmeter will increase its reading. Naturally if regeneration is increased beyond the critical point to where the negative resistance looking into the output end of the amplifier is greater than the positive resistance within the output voltmeter, the circuit will become unstable and fall over. Also as regeneration is increased from the optimum critical point to the point of instability the overall voltage ratio varies to infinity. These effects have no probable practical significance but serve to demonstrate the fact that considerable latitude exists between the point of optimum adjustment and the region of instability. In fact unless the resistance of the output voltmeter is quite low, complete removal of the regeneration control resistor will not produce instability in standard pentode type tubes.

When used as a d-c amplifier the question of zero stability becomes of interest. No material advantage over conventional d-c amplifier circuits is apparent in respect to stability, but in general the usual precautions apply. Use of two tubes in opposition reduces the effect of contact potential variations to a differential rather than a direct effect, so that regulation of the heater supply voltage, if necessary, is really effective. The major cause of zero drift then becomes the differentials between the two tubes that change with time, which fundamentally cannot be compensated and can only be reduced by the use of matched tubes.

Practical Circuit

The circuit of Fig. 3 is essentially the circuit of Fig. 2 reduced to a practical arrangement. The coupling batteries are replaced by cold-cathode gas voltage regulator tubes which have sufficiently low internal variational resistance not to load the output circuit unduly. The input tubes are followed by a stage of cathode followers primarily to remove the output load and the regulator tube current from the regenerative portion of the circuit. Without the buffer action of the cathode followers it might prove impossible to supply the desired output without loading the input tubes to the point where critical regeneration is not attainable. While a battery plate supply is shown for simplicity, the circuit is particularly adaptable to service power supply with a minimum of filtering because the regulator tubes effectively regulate the element voltages. This regulation together with the zero resistance output characteristic removes virtually all supply voltage ripple from the output.

The gas regulator tubes unfortunately have a small equivalent internal inductance due to the total ion mass in the space path. In an alternating-current amplifier this inductance causes an additional output loading factor that manifests itself increasingly with increasing frequency. This inductance is in the order of six millihenrys in small tubes (Type 991, etc.) and 80 mh in larger tubes such as the VR

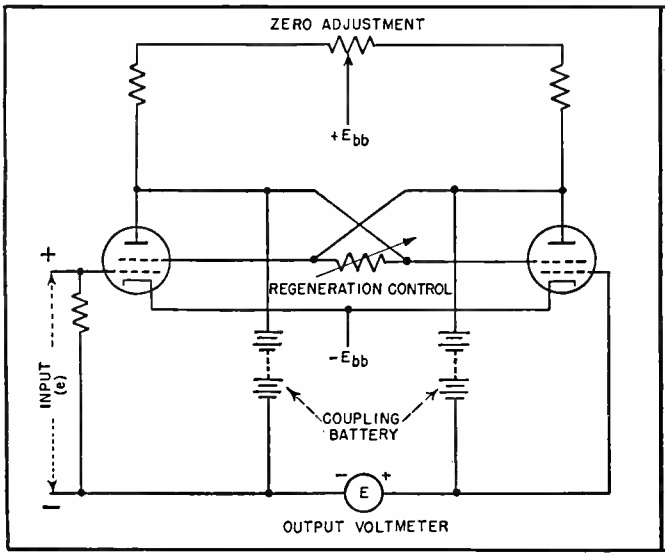


FIG. 2—Regenerative feedback to auxiliary grids increases amplification. Balanced circuit is used to obtain necessary phase reversals

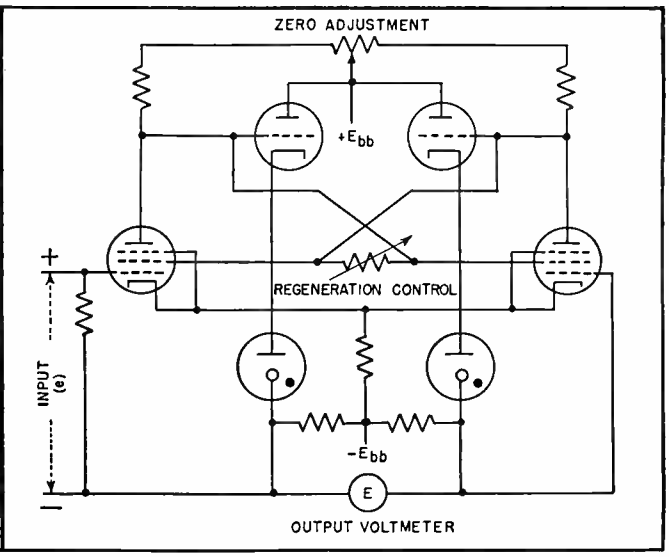


FIG. 3—Practical circuit incorporates cathode-coupled isolation tubes and gas tubes in place of batteries for maintaining proper biases

series, at normal operating current. Capacitive bypassing has limitations because, if sufficiently heavy, the tubes may be damaged when starting. Also resonance against the internal equivalent inductance can actually increase the loading at the resonant frequency. However, as an instrument amplifier application is limited largely to d-c and a-c not exceeding audio frequency, where this inductive loading effect is not serious.

For simplicity of explanation it is assumed that the circuit of Fig. 3 is arranged to provide a voltage ratio of unity, whereas any voltage ratio is possible by incorporating a degenerating network rather than a simple mutual resistance. Also four basic operating combinations are possible; voltage input with voltage output, voltage input with current output, current input with voltage output, and current input with current output. These combinations are shown in Fig. 4 as changes to the circuit of Fig. 3, together with the expressions for the gain in each case. Note that for current input a current balance network is employed rather than adapting the voltage input circuit to current by passing the input current through an input shunt. This current balance arrangement balances the input terminals to zero potential, maintaining effectively zero resistance looking into the input end of the amplifier. Thus in the case of current as well as voltage inputs the circuit demands no energy from the input source.

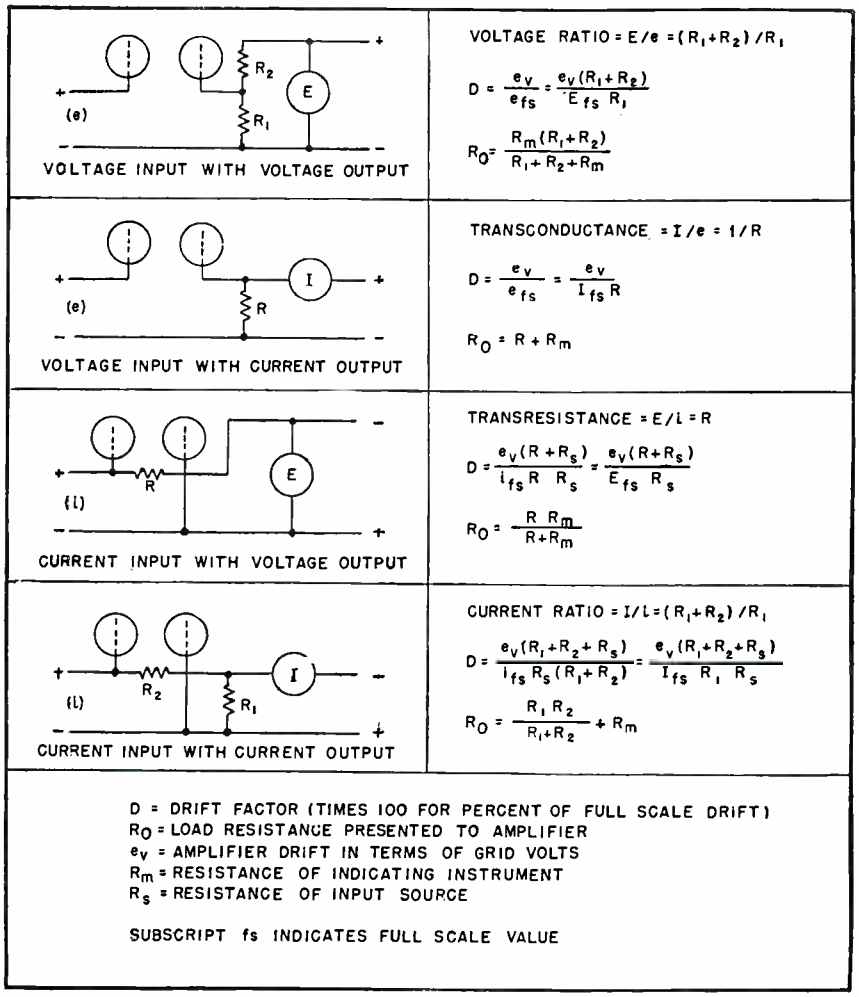


FIG. 4—Variations in the degeneration network of Fig. 3 adapt the instrument to various combinations of input and output. Equations indicate drift and loading

Drift

In common with all conductively coupled amplifiers the circuit is inherently a high input impedance device and is at a disadvantage from the standpoint of zero stability when operated from low impedance, low voltage sources such as a thermocouple. The tendency to zero drift is caused principally by contact potential variations within the input tubes, but all circuit components contribute more or less to the total drift. However, for simplicity the amount of drift that can be expected from the tube circuit proper is best expressed as the equivalent grid potential variation, or the amount of grid potential change required to rebalance the circuit after drift has taken place. The effect of this potential change in terms of output can then be calculated from the constants of the degenerating network, and expressed as a drift factor D for any set of conditions. The expression for the drift factor is given in Fig. 4 for the four basic degenerating networks in terms of the equivalent grid potential drift variations e_v. Note that in the case of current input the resistance of the input current source is effectively in parallel with the grid circuit and enters the expression. The drift factor expresses the ratio of expected drift to full scale output or input, and can be multiplied by 100 to obtain the expected drift in percent. Note also that the load presented to the amplifier output R_o does not enter the drift expression because an optimum adjustment of regeneration is assumed; in case of misadjustment the load resistance will have a small second order effect upon drift.

In practice e_v can be determined experimentally by setting up the unity gain circuit of Fig. 3 with the input terminals short circuited. As the circuit drifts, e_v is read directly on the output voltmeter.

An experimental design of electronic d-c voltmeter using the compound feedback circuit was built. This particular instrument includes features of convenience such as input polarity reversal and center zero switch positions, and means for calibration and zero adjustment without disconnecting the input. It contains an input network for four voltage ranges from 100 millivolts to three volts. An experimental companion instrument for current measurements down to 0.1 microampere full scale, similar in appearance to the electronic voltmeter, was also designed.

Wavelengths of SOUND

The velocity of sonic or ultrasonic energy varies over a range of 50 to 1, depending on the medium. Once velocity is determined, by using the table below, the wavelength for any frequency from 10 cycles to 100 megacycles can be found on the nomograph

By BERTHA W. HENVIS

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Office of Research and Inventions
Naval Research Laboratory
Washington, D. C.

Velocity of Sound in Solids

Material	Longitudinal Bar Velocity in cm per sec	Plate (Bulk) Velocity in cm per sec
Aluminum	5.24×10^5	6.4×10^5
Antimony	3.40×10^5	.....
Bismuth	1.79×10^5	2.18×10^5
Brass	3.42×10^5	4.25×10^5
Cadmium	2.40×10^5	2.78×10^5
Constantan	4.30×10^5	5.24×10^5
Copper	3.58×10^5	4.6×10^5
German Silver	3.58×10^5	4.76×10^5
Gold	2.03×10^5	3.24×10^5
Iridium	4.79×10^5	.....
Iron	5.17×10^5	5.85×10^5
Lead	1.25×10^5	2.4×10^5
Magnesium	4.9×10^5	.....
Manganese	3.83×10^5	4.66×10^5
Nickel	4.76×10^5	5.6×10^5
Platinum	2.80×10^5	3.96×10^5
Silver	2.64×10^5	3.60×10^5
Steel	5.05×10^5	6.1×10^5
Tantalum	3.35×10^5	.....
Tin	2.73×10^5	3.32×10^5
Tungsten	4.31×10^5	5.46×10^5
Zinc	3.81×10^5	4.17×10^5
Cork	0.50×10^5	.....
Crystals, quartz, X-cut	5.44×10^5	5.72×10^5
ADP ($NH_4H_2PO_4$) 45° Z-cut	3.28×10^5	4.92×10^5
Rochelle Salt, 45° Y-cut	2.47×10^5	.....
Rochelle Salt, 45° X-cut	See Fig. 2	
Rochelle Salt, L-cut	.....	5.36×10^5
Tourmaline, Z-cut	.....	7.54×10^5
CaF_2 (fluorite), X-cut	6.74×10^5	7.18×10^5
NaCl (Rock salt), X-cut	4.51×10^5	4.78×10^5
NaBr, X-cut	2.79×10^5	3.2×10^5
KCl (sylvite), X-cut	4.14×10^5	4.38×10^5
KBr, X-cut	3.38×10^5	3.48×10^5
Glass, heavy flint	3.49×10^5	3.76×10^5
extra light flint	4.55×10^5	4.80×10^5
heaviest crown	4.71×10^5	5.26×10^5
crown	5.30×10^5	5.66×10^5
quartz	5.37×10^5	5.57×10^5
Granite	3.95×10^5	.....
Ivory	3.01×10^5	.....
Marble	3.81×10^5	.....
Slate	4.51×10^5	.....
Wood, elm	1.01×10^5	.....
oak	4.1×10^5	.....

Velocity of Sound in Liquids

Material	Temperature in deg C	Velocity in cm per sec
Alcohol, ethyl	12.5	1.24×10^5
	20	1.17×10^5
Benzene	20	1.32×10^5
Carbon bisulfide	20	1.16×10^5
Chloroform	20	1.00×10^5
Ether, ethyl	20	1.01×10^5
Glycerine	20	1.92×10^5
Mercury	20	1.45×10^5
Pentane	18	1.05×10^5
	20	1.02×10^5
Petroleum	15	1.33×10^5
Turpentine	3.5	1.37×10^5
	27	1.28×10^5
Water, fresh	17	1.43×10^5
Water, sea	17	1.51×10^5

Velocity of Sound in Gases

Material	Temperature in deg C	Velocity in cm per sec
Air	0	0.331×10^5
	20	0.343×10^5
Argon	0	0.319×10^5
	300	0.307×10^5
Ammonia gas	0	0.415×10^5
Carbon dioxide	0	0.259×10^5
Carbon monoxide	0	0.338×10^5
Chlorine	0	0.206×10^5
Deuterium (heavy hydrogen)	0	0.890×10^5
Ethane	10	0.308×10^5
Ethylene	0	0.317×10^5
Hydrogen	0	1.28×10^5
Hydrogen bromide	0	0.200×10^5
Hydrogen chloride gas	0	0.296×10^5
Hydrogen iodide	0	0.157×10^5
Hydrogen sulfide	0	0.289×10^5
Helium	0	0.97×10^5
Methane	0	0.430×10^5
Neon	0	0.435×10^5
Nitric oxide	10	0.324×10^5
Nitrogen	0	0.334×10^5
	20	0.351×10^5
Nitrous oxide	0	0.26×10^5
Oxygen	0	0.316×10^5
	20	0.328×10^5
Sulphur dioxide	0	0.213×10^5
Water vapor	0	0.401×10^5
	100	0.405×10^5

THE TABLES give the longitudinal bar and bulk velocities of sound in various solids, as well as the velocity of sound in some liquids and gases.

The effective velocity of sound, V, to be used in these calculations is a rather complex function of the exciting frequency and the shape and dimensions of the vibrating element. Very few three-dimensional elastic solid problems have been studied in detail, but the following comments may be used as a guide in obtaining an approximate value of the effective velocity in the elements of many vibrating systems.

For cylindrical elements of ap-

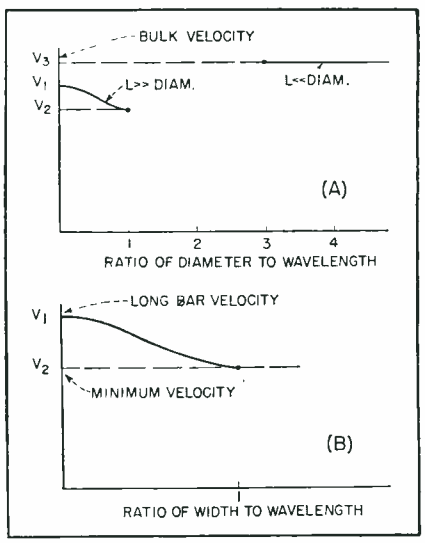

FIG. 1—Variation of velocity of sound with dimensional ratios of solids

Cinch

LAMINATED OCTAL SOCKETS

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1 1/2" Mounting Center
1/16" top plate

No. 6768
1 5/16" Mounting Center
1/16" top plate

No. 6798
1 5/16" Mounting Center
3/64" top plate

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proximately circular or square cross-section, with free sides, the effective velocity varies with the ratio of diameter to wavelength as illustrated by Fig. 1A, where V_3 is the bulk velocity and V_1 is the long bar velocity. For most metal backing materials the ratio V_2/V_1 is about 0.65.

For rectangular elements with free sides whose thickness is less than the width, the effective velocity for the element vibrating in extension (not thickness) varies with the ratio of width to wavelength as illustrated by Fig. 1B. Crystals are usually of such size that this curve is applicable. The ratio V_2/V_1 can be taken as equal to 0.8 for most of the cuts of crystals in general use.

Constraints on the sides of the cylindrical elements have the effect of increasing the ratio of diameter to wavelength. Similarly, constraining the sides of rectangular elements increases the effective ratio of width to wavelength.

The velocity for a zero diameter-to-wavelength ratio is the long bar velocity, and the velocity for an infinite diameter - to - wave - length ratio is the bulk (plate) velocity.

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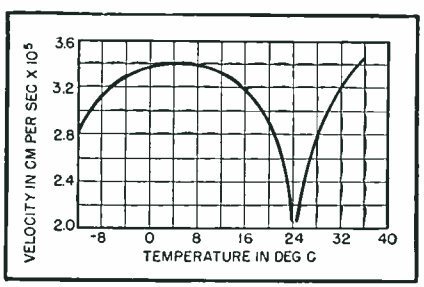

FIG. 2—Variation of longitudinal velocity in 45-degree X-cut Rochelle-salt crystal with temperature

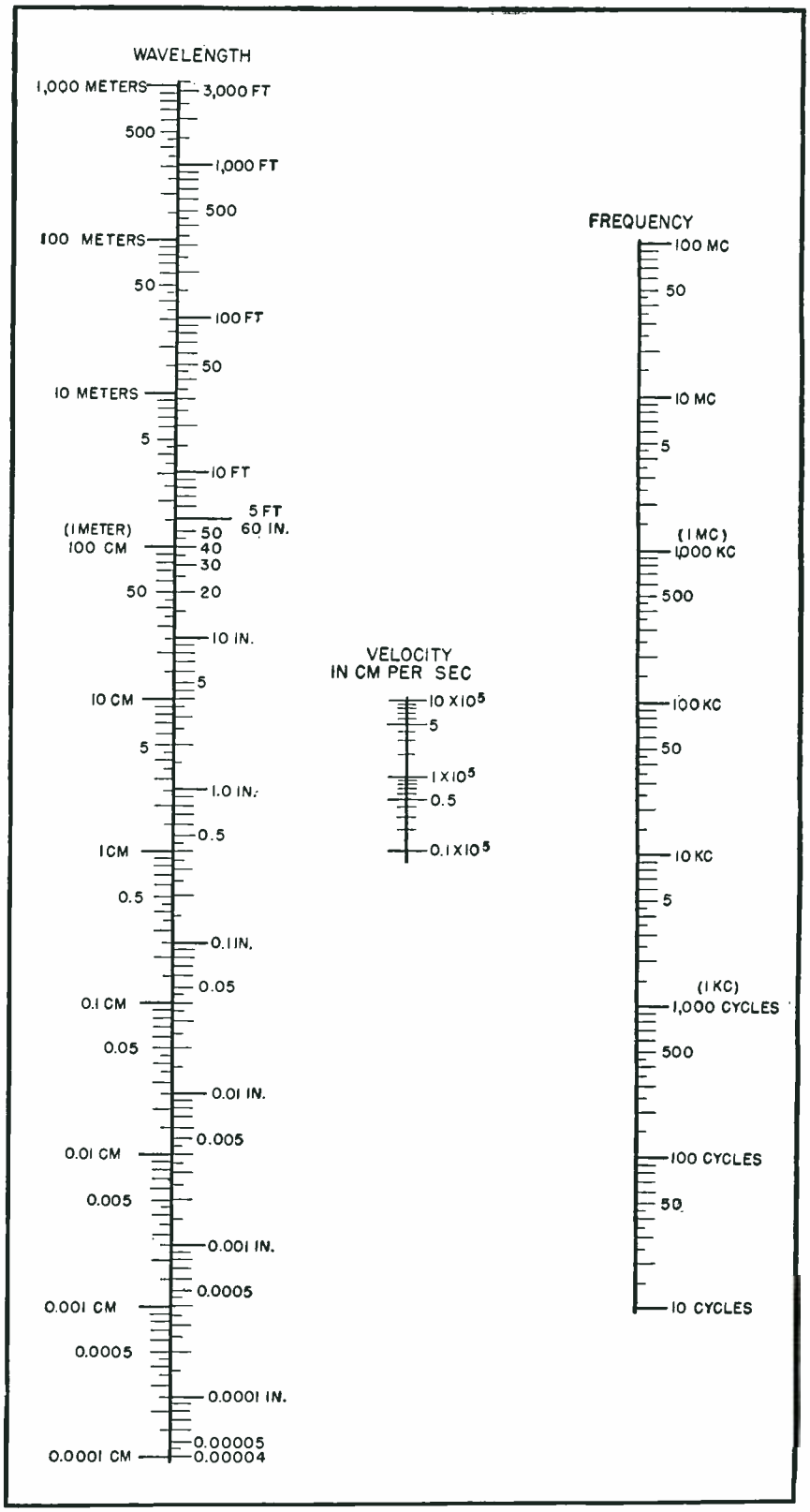

FIG. 3—Nomograph based on relation that velocity is equal to product of frequency and wavelength. When any two known values are connected by straightedge, intersection with third scale determines value sought

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TUBES AT WORK

Edited by VIN ZELUFF

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Microwave Communications System

THE RAYTHEON microwave communications system (ELECTRONICS, Oct. 1946, p 146) is composed of point-to-point radio relay equipment operating in the 2,450-2,700-mc or 3,700-4,200-mc region.

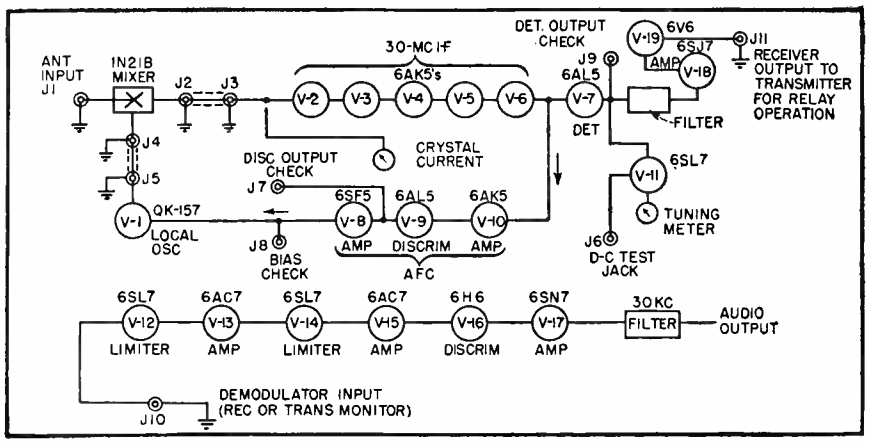
An intelligence band from 30 cycles to 30 kc is transmitted. This band can be channelized in any desired manner for the simultaneous transmission of telephone, telegraph, teleprinter, and other types of information.

The transmission system utilizes the Fraim method of modulation, in which the aggregate intelligence frequency-modulates a 240-kc subcarrier. The peak frequency swing extends from 180 to 300 kc. The subcarrier excitation, which has a square waveform, operates a keyer tube which alternately interrupts a magnetron anode supply at the subcarrier rate. The radiated wave therefore consists of 4,000-mc oscillations which are keyed on and off at a rate which varies between 180 and 300 kc.

The front end of the receiver employs a conventional superheterodyne arrangement in which the incoming signal from the antenna is mixed with a local oscillator to provide 30-mc i-f excitation. The i-f amplifier is followed by a conventional a-m detector. At this point the received signal is simply a frequency-modulated square wave. The output of the detector is transmitted through a bandpass filter to eliminate extraneous noise. The f-m square wave is then limited and frequency-detected in a low-distortion discriminator circuit.

As in all f-m systems, two signal level requirements must be met for satisfactory operation: the carrier-to-noise level in the bandpass filter before the subcarrier limiters must exceed six db under all conditions of circuit fading, and adequate signal-to-noise level must be provided in the intelligence channel for the particular type of information transmitted.

Tests demonstrate that the transmitted power is sufficient to allow for 40 db of fading before the signal drops below the noise threshold. This eliminates the necessity for diversity reception in the majority of installations.

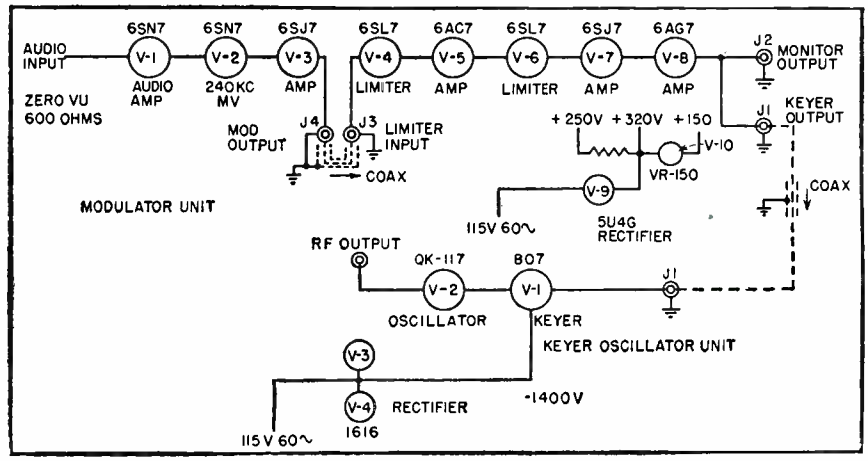


Block diagram of the microwave receiver. A klystron oscillator feeds a crystal mixer for conversion

Antenna System

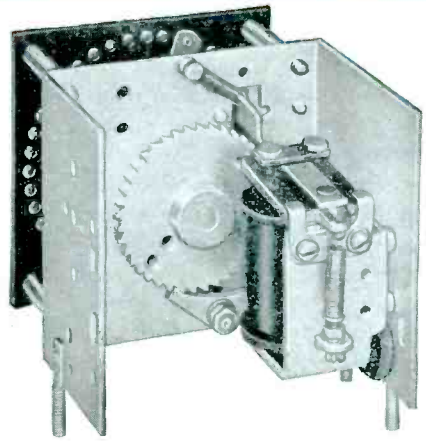
For economical as well as technical considerations, Raytheon recommends that two-way repeater station antennas be mounted on two poles joined by a wooden crossarm and adequately guyed. One transmitting and one receiving antenna are mounted on each pole, as nearly back-to-back as possible. Transmitting antennas should have like polarization and be diametrically spaced. Receiving antennas should have like polarization but differing by 90 degrees from that of the transmitting antennas. All r-f equipment, except the transmission line and antenna, is on the ground.

Three basic types of antennas are used: a two-foot solid parabolic dish with dipole feed, a 3 x 3-foot screen section of a parabolic dish with horn-type feed, and a 46-inch circular section of a parabolic dish with cavity dipole feed. The approximate gains are respectively 25, 28 and 32 db. The appropriate antenna



Block diagram of the microwave transmitter. Jacks permit operation as repeater or terminal equipment and allow monitoring of circuits

HUNDREDS OF CONTROL PROBLEMS SOLVED WITH STEPPING RELAYS



GUARDIAN SERIES R

1 Continuous Rotation
In this type the contact finger advances one step each time the circuit is made and broken. Weight approximately 20½ ozs.

2 Electrical Reset
Resets when a second coil is energized. Weight approximately 23 ounces.

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Steps back one or more contacts at a time instead of resetting completely. Weight approximately 28½ ounces.

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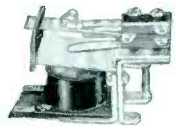
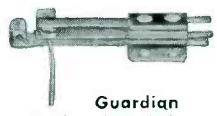


Series 100
Snap-Action Relay



Guardian
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Series I-A Solenoid

Design engineers are discovering new, efficient, money-saving applications daily for Guardian basic-type Stepping Relays. Typical applications include Automatic Sequence selection of circuits; Automatic Sequence cross connection of circuits; circuit control of Automatic Business Machines; control of Production Totalizing and Conveyor equipment; remote selection of records on Coin Operated Phonographs; Automatic Circuit Selection controlled from a pulsing dial; Automatic Wave Changing on short wave transmitters. This Guardian Stepping Relay is furnished for three basic types of A.C. and D.C. operation: Continuous Rotation—Electrical Reset—Add and Subtract. On each of these types the contact finger rotates in a counter-clockwise direction and all three types are designed to follow 10 pulses per second within the rated voltage range of the relay. Special construction prohibits skipping or improper indexing of the ratchet. Guardian Steppers may be furnished as separate units; in combination with relays, contact switches, solenoids, etc., completely assembled and wired to terminals; mounted on special bases or in enclosures. Any *standard* Guardian Stepping Relay can be modified to meet practically all "special" stepper control applications where quantities warrant special designing. For complete details write for Bulletin SR.

GUARDIAN ELECTRIC
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should be chosen for the path circuit conditions, such as distance of transmission and type of intervening terrain. Waveguide feeds have been found more practical than dipole assemblies because of the more stable operation under all weather conditions and the ease of initial adjustment.

Transmitter

The circuit of a 50-watt microwave transmitter is shown in the accompanying diagram. Tube V-2 is a multivibrator whose frequency is directly controllable by varying its bias. In an unmodulated condition the frequency of this subcarrier oscillator is 240 kc. Under modulating conditions, the variation of the audio signal causes the relaxation oscillator to shift in frequency from a minimum value of approximately 180 kc to a maximum value of approximately 300 kc. Tube V-3 is a conventional buffer amplifier.

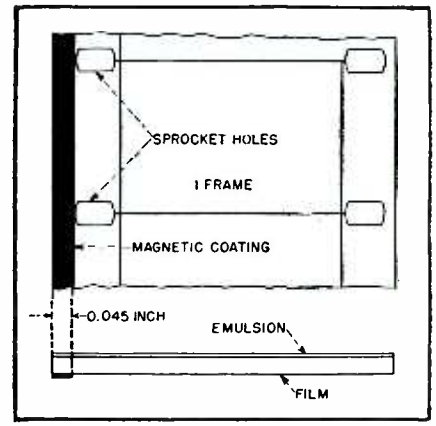
The portion of the circuit so far described represents a complete f-m system, utilizing a 240-kc carrier. This carrier could be transmitted over an open-wire line, a coaxial cable, or, as in this instance, over an additional microwave carrier. Since any concomitant amplitude modulation is undesirable in an f-m system and may add noise in the transmitting end unless removed by limiting, tubes V-4, V-5, V-6, V-7, and V-8 are provided to accomplish this function by allowing the signal to swing their grids from cutoff to plate saturation. The 807 tube performs the switching function; it keys the oscillator QK-117 (4J65) on and off at the subcarrier rate by interrupting the anode supply voltage from the 1616 rectifiers.

In the receiver portion of the system, the incoming signal from the antenna is combined with output from a QK-157 klystron oscillator in a crystal mixer to provide the 30-mc signal. Tubes V-2, V-3, V-4, V-5, and V-6 amplify this i-f signal before a-m detection in tube V-7. Tubes V-8, V-9, and V-10 functionally combine to frequency-control the local oscillator automatically. The detected signal from tube V-7 is transmitted through an 80-400-kc bandpass filter. Tubes V-12, V-13, V-14, and V-15 amplitude-limit the subcarrier before it is converted into amplitude modulation by the f-m to a-m discriminator tube V-16. Tube V-17 is an ordinary audio amplifier which is followed by a 30-kc low-pass filter.

Magnetic Sound for Amateur Movies

A SIMPLE system for putting a sound track on movie film either in manufacture or after the reel has been exposed and developed has been announced by Armour Research Foundation. This has been made possible by development of a magnetic material for coating the film that has a high coercive force.

The new material has a fine grain size of a micron or less. It is not affected by photographic solutions, so that magnetic sound can be recorded simultaneously with the picture, or can be put on afterwards. The magnetic track is put on the film by coating a track 0.045 inch wide and 0.0005 inch thick on the edge of ordinary sixteen-millimeter film. This runs through the projector at the standard sound speed of 36 feet per minute.



The magnetic coating can be applied to one edge of 16-mm film and the opposite edge left blank, coated with nonmagnetic material, or used as a second sound track for more intimate remarks to a select group

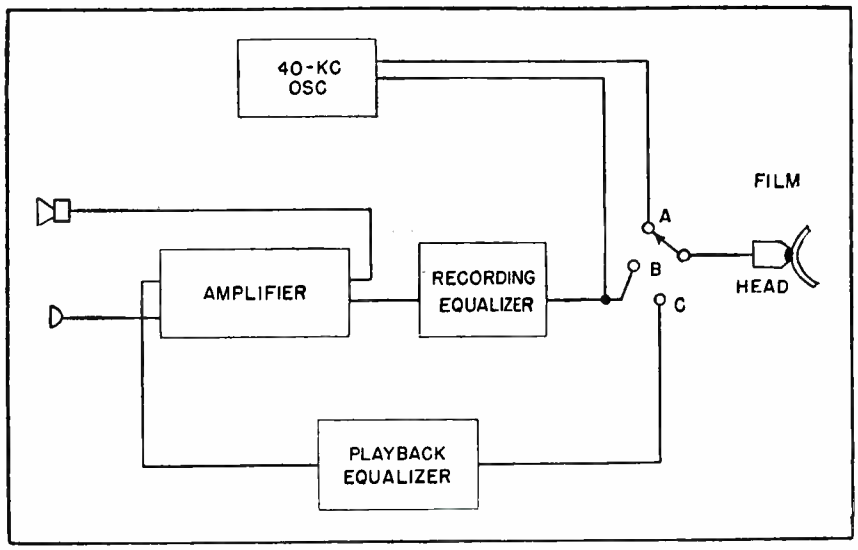
Although the coating makes the film thicker on one edge than the other, no difficulty has been experienced in reeling. To insure symmetry, the opposite edge could be coated with an equal thickness of blank material, or an additional track could be put on that edge. The extra track could be used for a binaural system or for special sound effects.

Instead of placing a track on the outside of the film, 16-mm sound film can be used with the track on the unsprocketed side to allow a wider track and increased fidelity.

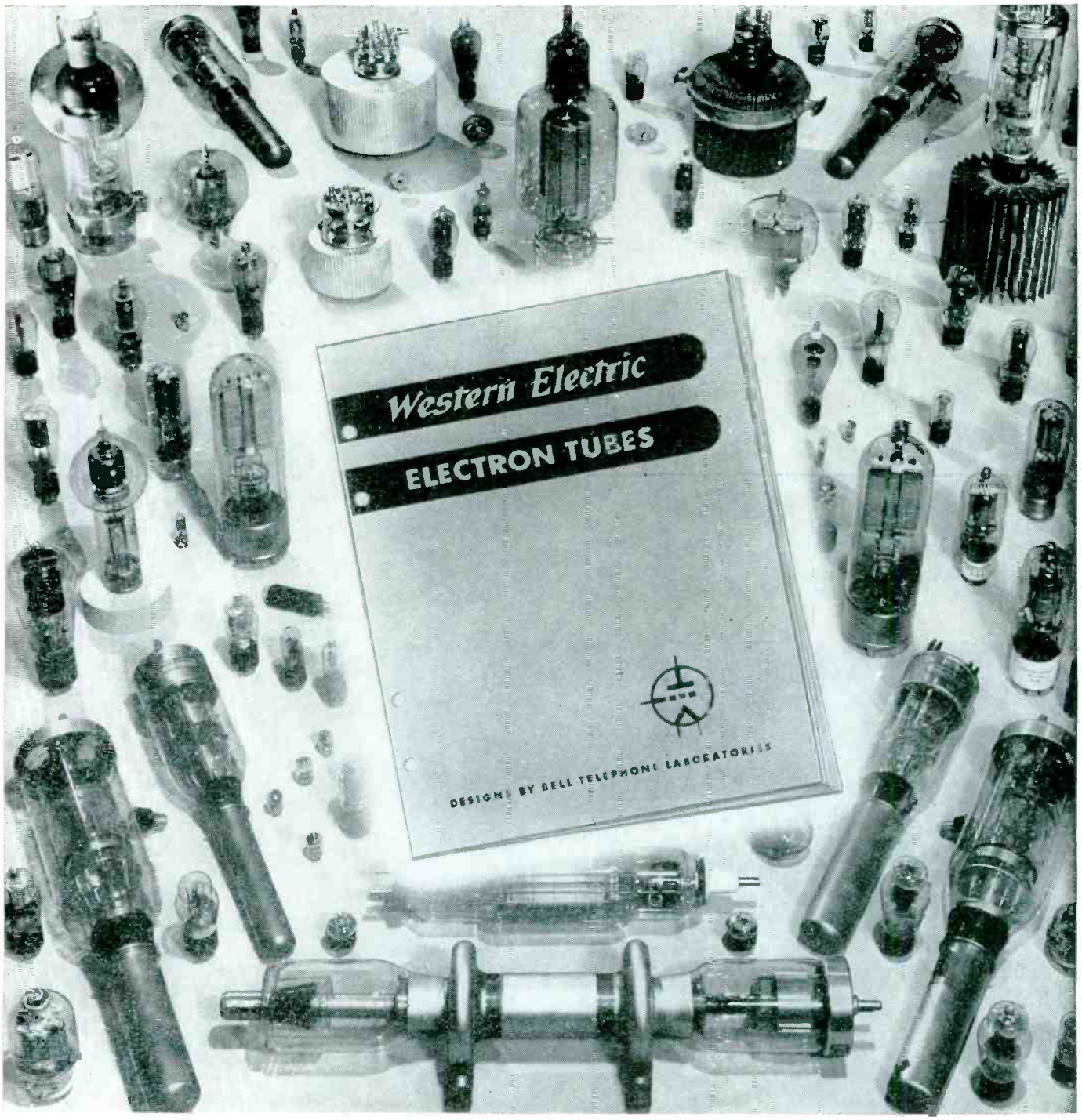
The magnetic head used to play back the sound is spring-pressed against the film while it rides on a flywheel stabilizer. Such a head is easily mounted on conventional projectors and can be connected to an a-f amplifier. By switching circuits the same head can be used for erasing, recording, or playback.

As shown in the block diagram

(continued on p 158)



Essential stages of the magnetic sound system for home movie film



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In concise, tabular form, this new book gives the essential data on 166 codes of electron tubes designed by Bell Laboratories and made by Western Electric. Planned to help the circuit designer quickly find the tube best suited to his needs, it contains technical characteristics, ratings, dimensions and 89 basing diagrams—all arranged for quick, easy reference. Send the coupon for your copy today!

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INDUSTRIAL CONTROL

Edited by VIN ZELUFF

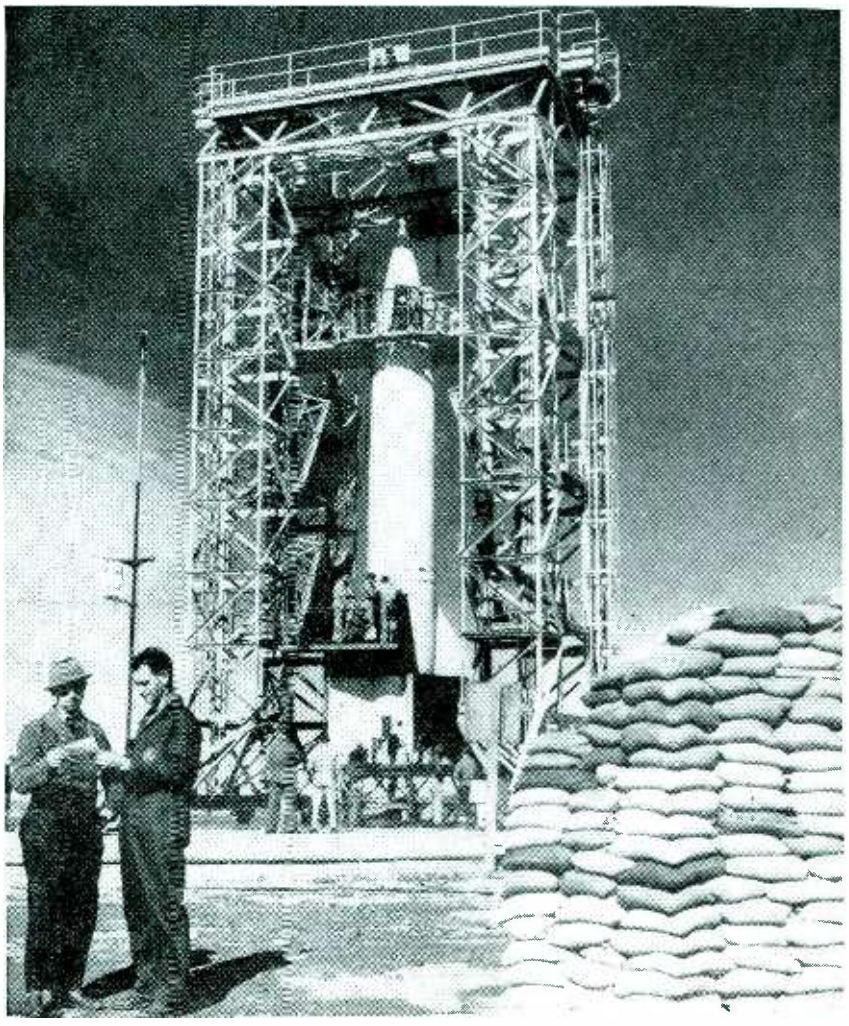
Telemetering In Stratosphere 142
Electrostatic Flocking 142
Fluorescent Lamp Delay Timer 184
First Factory F-M Radiophone 188
Ultrasonics, A New Tool 190

Telemetering In Stratosphere

TESTS of V-2 rockets fired at the U. S. Army Ordnance Proving Ground, White Sands, N. M., now supply 28 items of information to the ground observers every 1/35th of a second. This job is done by 10 electronic tubes in the rocket warhead, powered by a 28-v battery.

The General Electric system is mechanically commutated. Each of a number of quantities of interest is converted to a voltage between zero and plus five volts and then is connected to one segment of a stationary commutator. Twenty-eight such channels are provided and a rotating brush samples each of these 35 times per second. The voltages are converted to pulse-width-modulation of a five-watt transmitter.

At the receiving station, each incoming signal forms a line on a c-r tube whose length is proportional to the quantity being measured.

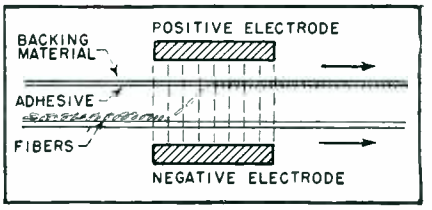


Gyro steering control and telemetering of 28 instruments in flight is done with G-E equipment in tests of the V-2 rockets. The gantry crane shown above has expedited preparation and assembly of the electronic control gear in the missile

Electrostatic Flocking

ELECTROSTATIC coating or flocking of fibers to form a pile fabric is a new industrial technique using high potentials like those encountered in painting, detearing, and depositing of sand particles for sandpaper.

In the electrostatic method of making pile fabrics, the backing material is coated with an adhesive and fed between a pair of electrodes so that the adhesive faces downward. Evenly cut fibers of wool, cotton, rayon, and the like are fed continuously on a moving belt that travels parallel to the backing material. When the fibers are caught in the electric field they are whisked up to the adhesive coating and embedded. Because the fibers all have the same polarity, they repel one another uniformly and space themselves out at equal distances apart. The potential required from the high-voltage power supply varies from 50,000 to 100,000 volts.



Arrangement of electrodes for electrostatic deposition of fibers to form a pile fabric

To obtain good flocking of high density and uniform appearance, the textile fibers must be cut to uniform lengths. This is more economical than subsequently shearing nonuniform flocked fibers to obtain a level pile surface. Fiber cutting machines have been developed that give highly uniform cut lengths, and as a consequence electrostatically flocked materials require no shearing or singeing operations.

The first commercial use of electrostatic flocking of textiles was in the decoration of dress goods, by

(continued on p 184)

When a little means a lot

Whenever and wherever space is at a premium . . . in shavers, hearing aids, pocket radios, guided missiles and other radio, electrical or electronic devices . . . you can use one or more of these four miniature products IRC makes-by-the-million. For complete information, including dimensions, ratings, materials, construction, tolerances, write for comprehensive catalog bulletins, stating products in which you are interested.

MPM Resistors

¼ watt for UHF. Resistance film permanently bonded to solid ceramic rod. Length only 9/16". Diameter 1/16". Available resistance values 30 ohms to 1.0 megohms.

TYPE H Fingertip Control

Composition volume or tone control. Its 13/16" diameter and ½" overall depth include knob and bushing.

ILLUSTRATIONS ACTUAL SIZE

$I = \frac{E}{IRC}$

BTR Resistors

⅛ watt—insulated composition. Length only 13/32". Diameter 3/32". Resistance range 470 ohms to 22 megohms (higher on special orders).

TYPE SH Fingertip Switch

Similar to TYPE H Control (left) in appearance. 13/16" diameter. OFF and 3 operating positions.

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THE ELECTRON ART

Edited by FRANK ROCKETT

Proton Microscope 144
Noise in Gas Tubes 144
Negative Impedance 198
Shielding Filters for Insertion Loss Measurement 198
Noise Suppression Circuit 202
Experimental UHF Equipment 204
Self Balancing Phase Inverter 212

Proton Microscope

A PROPOSED electrostatic microscope would make use of protons instead of electrons, because neither mass nor charge of the beam corpuscles enter the equation for image formation. For the same accelerating potential, the limit of useful magnification for the proton microscope is forty times that of the electron microscope, because of the smaller diffraction pattern of the former. Penetrating power of protons is less than electrons, so such a microscope would be limited to use with extremely thin samples or for reflecting targets. Details separated by 3A should be resolvable. A direct magnification of 20,000 could be expected, which could be increased to 600,000 by photographic enlargement (*Comp. Rend.*, p 770 May 1945).

Noise in Gas Tubes

BY J. D. COBINE AND C. J. GALLAGHER

Radio Research Laboratory
Harvard University
Cambridge, Mass.
(Authors now at Research Laboratory, General Electric Co., Schenectady, N. Y.)

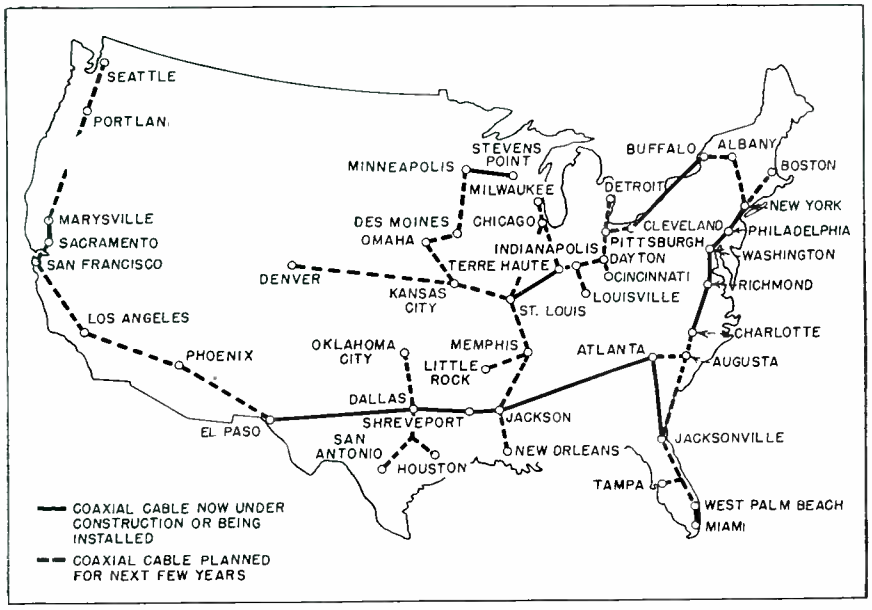
NOISE FOR visual presentation of filter frequency response and for reverberation can be obtained from gas tubes. High level, wideband noise sources, developed during the war for use in radar jammers, provide greater output than previously obtained.

Characteristics of Gas Tubes

Gas tubes have always had a reputation of being noisy, although the character of the noise has not been clearly defined. Recent investigations have shown that the noise generated in hot cathode arcs consists of oscillations of several hundred kilocycles superimposed on a background of random noise. The random noise contains a continuous band for frequencies extending from the very low audio range to five megacycles. A suitably placed magnetic field greatly increased the noise level and eliminated the oscillations.

The spectrum obtained from a typical gas tube without magnetic field is shown in Fig. 1A for two discharge currents. The noise level is expressed in db above 10 $\mu v/(kc)^{1/2}$ because, if the bandwidth of the spectrum analyzer is sufficiently

Coaxial Cable Television Network Facilities



In addition to the New York to Washington coaxial cable in use since August by East Coast television broadcasters and available on an experimental basis in both directions, A T & T is installing cable facilities as shown on the map. Nationwide television network facilities will ultimately be provided by special repeaters on the coaxial lines, and by radio relay now undergoing trial operation between New York and Boston

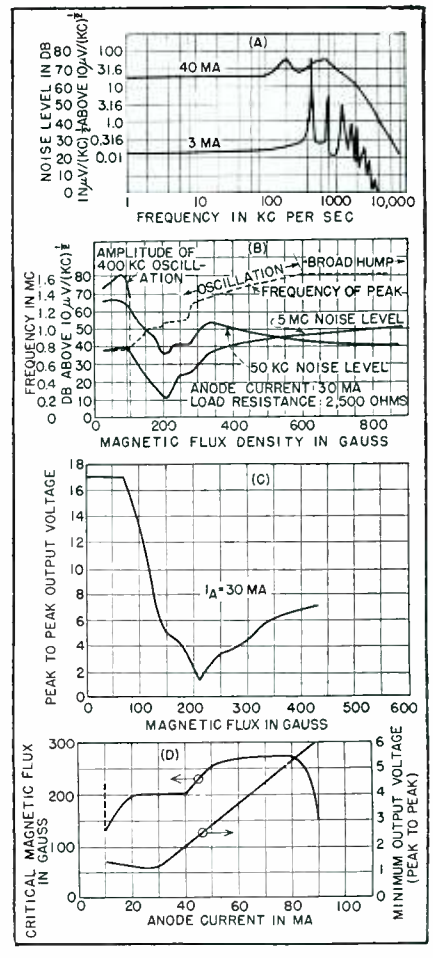


FIG. 1—Noise characteristics of 884 for various operating conditions

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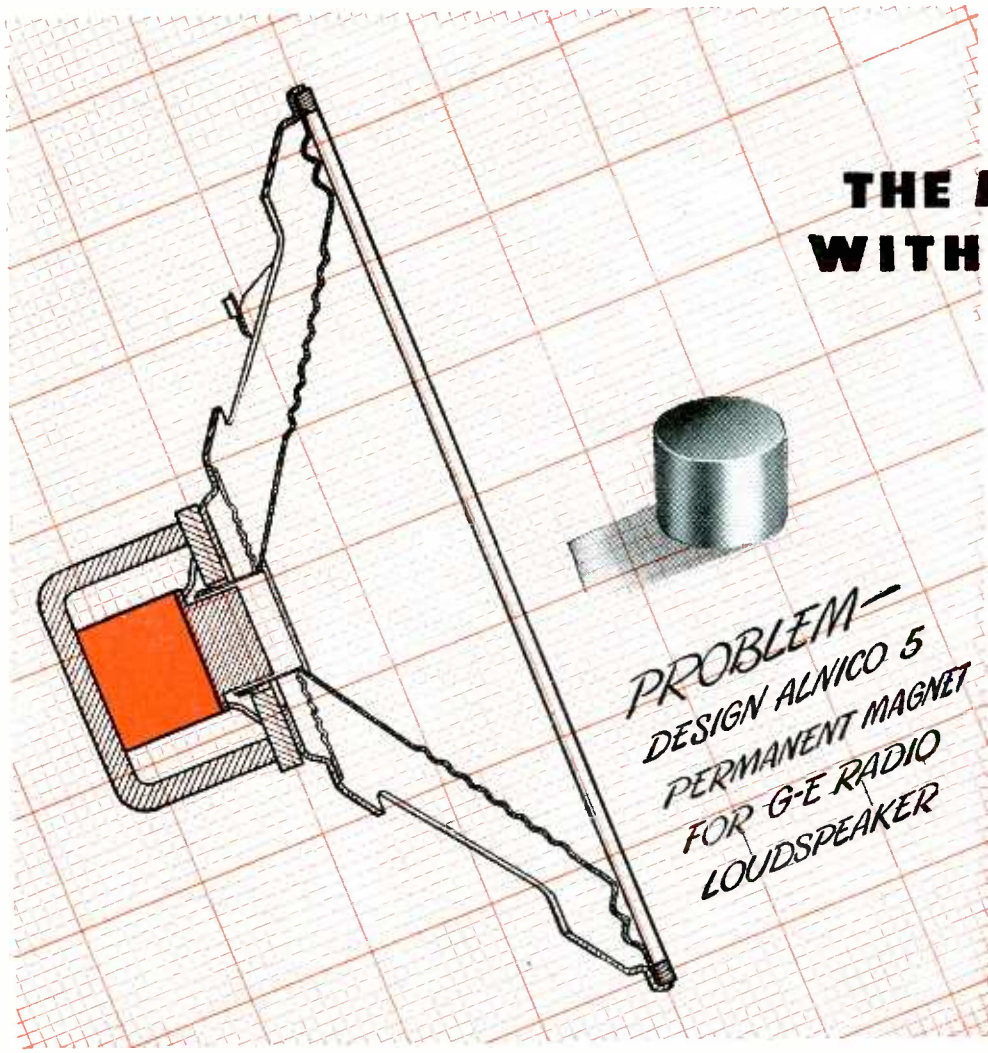

THE MAGNET WITH A VOICE

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General Electric's precise quality control methods used throughout magnet production, plus accurate testing and rigid inspection assure you of receiving magnets of the highest uniform quality for your application.

Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. The large group of sintered and cast ALNICO alloys has been augmented by the lightweight, non-metallic mixture, VECTOLITE, and by the ductile permanent magnets, CUNICO, CUNIFE and SILMANAL. From such a wide choice of materials, you may now find a magnet better suited for your application or a material which will make possible new designs heretofore impractical or impossible.

General Electric engineers, backed by research and application experience, have acquired years of "know-how" in selecting the best permanent magnet material and properly designing magnets for thousands of products. These engineers are at your service. *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

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small, the random noise voltage varies as the square root of the bandwidth.

The two peaks in the curve of Fig. 1A for the higher current represent two distinct oscillations that are not harmonically related. The lower frequency peak is due to plasma ion oscillations; the higher frequency peak is caused by oscillations of positive ions in the potential minimum at the cathode. A summary of the characteristics of a number of hot cathode discharge tubes is presented in Table I. This table gives the frequency and amplitude of the lowest frequency oscillation, as well as the noise level at three selected frequencies. The values are average, there being considerable variation from tube to tube. The last column gives the total rms noise voltage obtained by integrating the spectrum from zero to four megacycles. For comparison, the level of shot noise of a diode for two different currents and with a 3,000 ohm load resistance is presented. The shot noise is much lower than that obtained from the gas tubes.

Table I—Noise Characteristics of Gas Tubes

Tube	Current (ma)	Oscillation		Noise Level			
				decibels[a]			volts RMS
		(kc)	(db)[a]	50 kc	1 mc	5 mc	4 mc
Shot Noise[b]	150	——	——	−14	−14	−14	0.00133
	10	——	——	−26	−26	−26	0.00034
884	40	180	76	66	70	35	0.91
	3	440	76	24	22	−8	——
2A4G	100	450	52	50	24	−5	0.06
WL629	40	210	85[c]	44	58	——	——
WE256A	75	120	51	38	10	−4	0.4
RK62	1.5	650[d]	34	——	1	−10	——
2050	90	150	84	60	51	14	——
	3	90	78	36	14	−10	——
6Q5G	40	550	73	45	50	17	——
FG178A	125	100	78	——	38	——	——
2D21	41	85	94	80[e]	54	18	——
816	125	170	67	60[e]	37	9	——

[a] Zero level is 10 $\mu v/(kc).^{1/2}$
[b] Temperature limited diode with 3,000 ohm plate resistor.
[c] Second harmonic amplitude is 90 db.
[d] Probably another nonharmonic peak below 100 kc.
[e] Approximate.

Effect of Magnetic Field

If a transverse magnetic field is applied across the discharge and the field strength gradually increased, the spectrum of noise undergoes marked changes. Figure 1B shows the change observed in an 884. For this particular tube the amplitude of the low frequency oscillation at 400 kc increased slightly for low magnetic field strengths and then disappeared with no change in frequency as the field was further increased.

The cathode oscillation is differently affected by the magnetic field. The frequency of the peak noise increases with increasing magnetic field, and the spectrum in the vicinity of the peak broadens so that eventually a distinct oscillation is no longer observed. The noise at 50 kc and 5 mc go through a minimum at 210 gauss and then increase. The ultimate level of the 5 mc noise is about 12 db higher than the zero field level.

It is interesting to note that there is an optimum value of magnetic field for which the total variational voltage is a minimum, as shown in Fig. 1C. This optimum value of field is dependent on the current as is the minimum value of the peak-to-peak voltage, as shown in Fig. 1D. Because of variations between tubes, the exact value of the optimum field must be found experimentally for any given tube. This property of reducing the variational voltage has been very useful in control circuits where other tubes are subjected to undesirable random triggering under the influence of a conducting gas tube.

Table II—Noise with Transverse Magnetic Field

Tube	Current (ma)	Flux Density (Gauss)	Noise Level				Type[b]
			(peak volts)	decibels[a]			
				100 kc	1 mc	5 mc	
6D4 (2C4)	5	375	8.2	63	76	38	B[c]
	5	720	——	66	76	43	
	20	375	——	70	77	53	
884	45	1,050	5.6	56	62	48	B
2A4G	100	2,000	8.3	60	60	10	A
WL629	40	2,500	4.1	71	69	43	A
WE256A	75	2,000	——	65	58	33	B
RK62	7	620	——	60	57	12	C[d]
6Q5G	40	2,500	——	55	63	37	C[d]
WE323A	100	1,800	——	62	44	8	A
2050	75	500	——	74	47	13	[d]
FG178A	200	960	9.9	82	70	43	A
2D21	41	1,200	5	72	70	47	[e]
	30	700	5	70	64	46	[f]
GL546	13	740	——	68	70	48	

[a] Zero level is 10 $\mu v/(kc).^{1/2}$
[b] See Fig. 2B.
[c] Standard RRL Noise Unit. Maximum is 80 db at 700 kc.
[d] Oscillations not suppressed.
[e] Anode to cathode noise.
[f] Grid to anode noise.

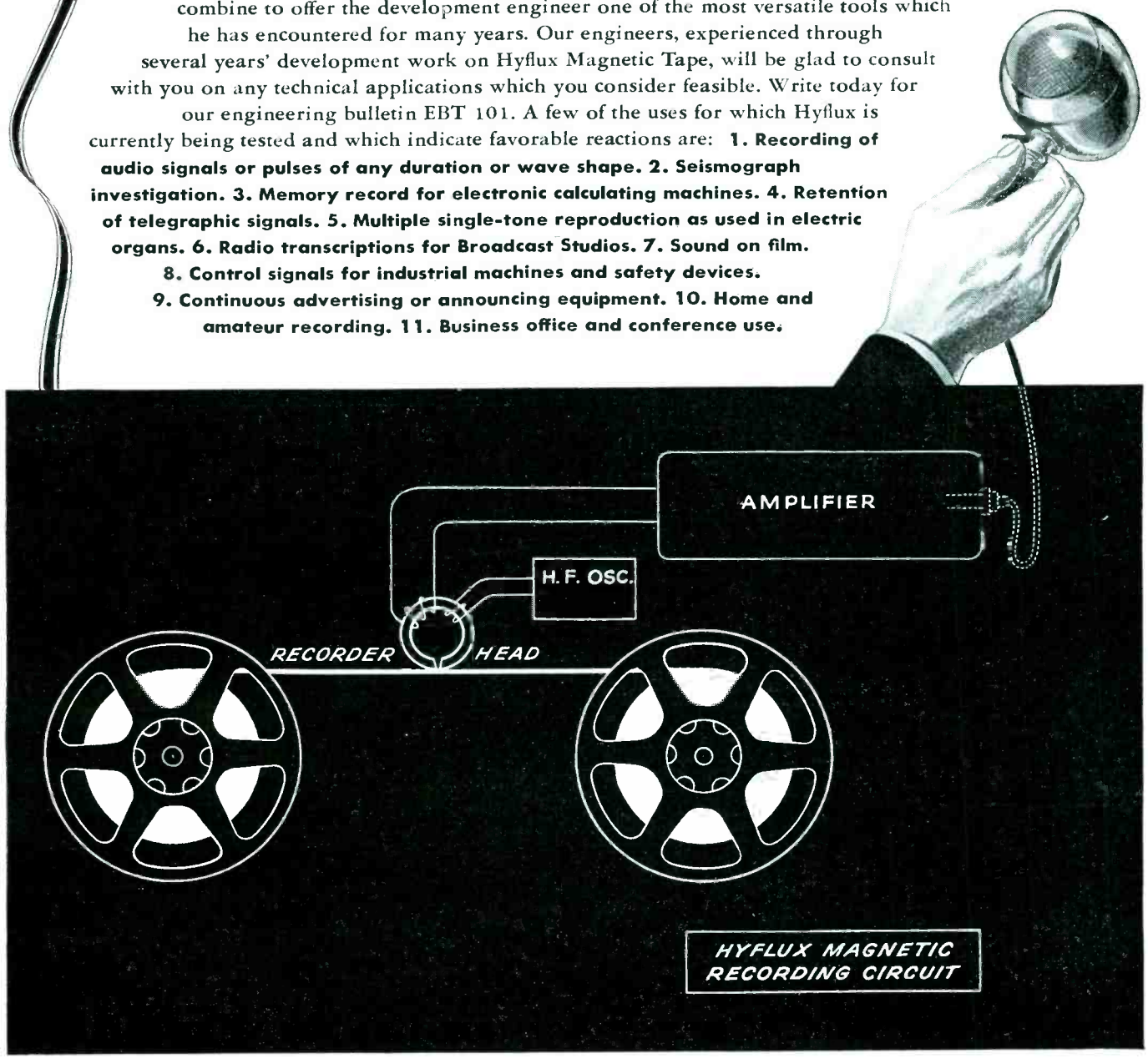
The general shape of the spectrum obtained from a gas tube depends on the type of tube. Figure 2A shows spectra of several types of tubes with magnetic fields. The noise levels are compared with the noise levels from a 931A electron multiplier phototube and a temperature-limited diode.

Shape of the spectrum is determined by tube geometry. Three general types of structure are found in commercial tubes as shown in

(Continued on p 196)

Hyflux Links Electronics and Mechanics

The new Hyflux magnetic tape has changed sound recording from a mechanical operation to a combined electronic and magnetic circuit with mechanical driving mechanism to attain unexcelled reproductive quality. The elimination of mechanical noise inherent in previously used sound recording techniques is a major factor in the utility and flexibility of this new medium. Permanent magnets have been useful for many years in the field of sound in transforming mechanical energy into electrical energy, but the introduction of Hyflux, which is a finely divided magnetic material, establishes a new transformation—that of electrical-to-magnetic-to-electrical energy. The result is a high-fidelity, noise-free, continuous recording adaptable to a wide field of application. Features of instantaneous and repetitious erasure, visual and audio editing, as well as permanency attributable to the high coercive force of the magnetic material, and durability due to the choice of paper used combine to offer the development engineer one of the most versatile tools which he has encountered for many years. Our engineers, experienced through several years' development work on Hyflux Magnetic Tape, will be glad to consult with you on any technical applications which you consider feasible. Write today for our engineering bulletin EBT 101. A few of the uses for which Hyflux is currently being tested and which indicate favorable reactions are: **1. Recording of audio signals or pulses of any duration or wave shape. 2. Seismograph investigation. 3. Memory record for electronic calculating machines. 4. Retention of telegraphic signals. 5. Multiple single-tone reproduction as used in electric organs. 6. Radio transcriptions for Broadcast Studios. 7. Sound on film. 8. Control signals for industrial machines and safety devices. 9. Continuous advertising or announcing equipment. 10. Home and amateur recording. 11. Business office and conference use.**



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NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications reviewed.

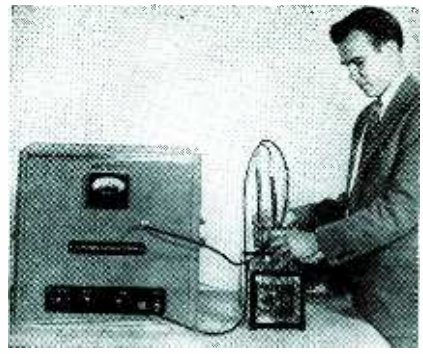
Engineers' F-M Receiver (1)

RADIO ENGINEERING LABORATORIES, 35-54 Thirty-Sixth St., Long Island City 1, N. Y. A new dual-band f-m receiver covering the frequencies

42-50 and 88-108 megacycles has just been released for use by engineers, broadcast stations, and others requiring a stable, high-fidelity means of monitoring or checking performance of f-m transmitters. Model 646 is the standard version, but modifications are available for rack mounting, use with a school public address system, and in cars making surveys or field measurements. The receiver has three i-f stages, two limiters and 10 watts of audio output. High sensitivity and low audio distortion are featured.

Ultrasonic Tester (2)

GENERAL ELECTRIC CO., Schenectady, N. Y. A new materials tester indicates the presence of voids, cracks, porosity and other internal flaws in metals, plastics, and ceramics by means of ultrasonic waves sent through the specimen under test. The instrument consists of a complete wide-band ultrasonic transmitting-receiving system having a high-frequency generator, a crystal transducer to produce ultrasonic vibrations, and a second transducer to convert received mechani-



cal energy into electrical signals. Internal flaws produce measurable decreases in total transmission as indicated by a meter.

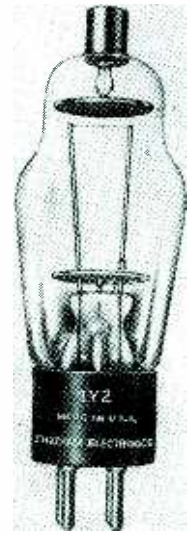
Tape Sound Recorder (3)

INDIANA STEEL PRODUCTS CO., Valparaiso, Ind. The portable recorder illustrated includes recording and playback facilities, is completely selfcontained, and weighs about 30

pounds. The recording medium is a new magnetic tape, called Hyflux, consisting of particles of a material that approaches Alnico in magnetic properties. This material is firmly affixed to a paper tape.

Television Rectifier (4)

CHATHAM ELECTRONICS, 475 Washington St., Newark 2, N. J. The type 1Y2 is a high-voltage rectifier de-



signed for anode supply on direct view or projection type television tubes. Peak inverse voltage rating is 50 kv. Filament voltage is not critical and can fluctuate between 1.0 and 1.65 volts. Filament is amply rugged for 60-cycle operation and requires low filament power, making it equally adaptable to an r-f filament supply. Interelectrode capacitance and absence of back emission prevent undue loading of the oscillatory circuit in r-f applications. Two tubes deliver 50 kv d-c in a voltage doubler circuit or 25 kv d-c singly.

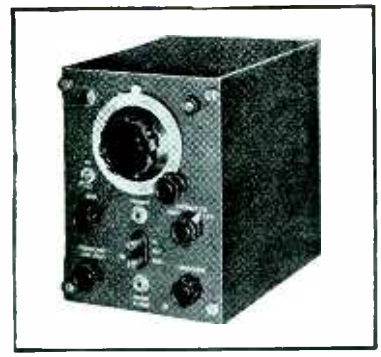
Receiver Frequency Standard (5)

THE HAMMARLUND MFG. CO., Inc., 460 West 34th St., New York 1, N. Y. Designed particularly to aid radio amateurs to conform to legal requirements by maintaining an accurate method of measuring trans-

Visual Alignment Saves TIME

HIGH FREQUENCY VISALGEN

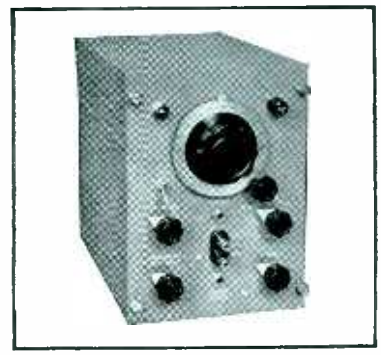
1. Frequency range from 100 kc to 20 mc. Harmonics useful to 120 mc.
2. Linear frequency sweep deviation adjustable from 0 to 900 kc peak to peak.
3. Vernier frequency control of 100 kc allows zero beat calibration of main tuning dial or for vernier frequency adjustment about main dial frequency setting.
4. Output Impedance 1 ohm to 2,500 ohms.
5. Voltage regulated supply for internal oscillator stability.



MODEL 205TS

LOW FREQUENCY VISALGEN

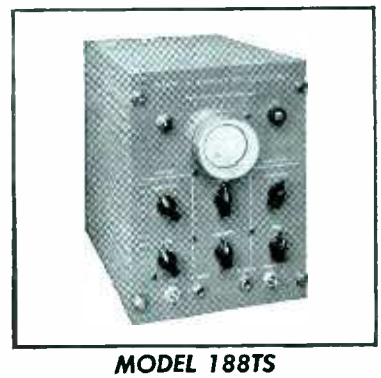
1. Frequency range from 20 kc to 500 kc.
2. Linear frequency sweep deviation adjustable from 0 to 70 kc peak to peak.
3. Low pass filter in the output to minimize spurious output frequencies.
4. Output impedance constant 200 ohms.
5. Output attenuation: 5-step ladder type — 20 db per step.



MODEL 204TS

OSCILLOSCOPE

1. New simplified circuit for use with either model Visalgen.
2. Simplified for visual alignment work.
3. Compact design — light weight.
4. Immediately available. Also available with either model Visalgen and oscilloscope in one cabinet.



MODEL 188TS

HARVEY
OF CAMBRIDGE

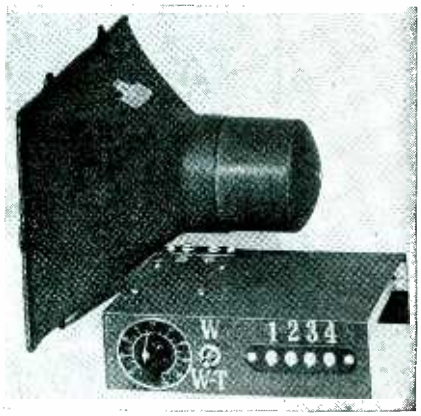
HARVEY RADIO LABORATORIES, INC.

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

mitter frequency, the FS-135-C supplies 100-kc markers throughout the tuning range of a communications receiver. The tiny unit consists of an ingenious circuit and special silver-plated spring-suspended 100-kc crystal. A slight variation of tuning is provided so that the circuit can be set to zero beat with signals from WWV.

Tweeter and Network (6)

ATLAS SOUND CORP., 1447 39th St., Brooklyn 18, N. Y. The model HF-1 tweeter is flat within plus or minus 6 db from 1,200 to 14,000 cycles with the frequency-dividing network furnished. A separate woofer



extends the range down to 50 cycles. The speaker handles 20 watts of speech or music and has a horizontal distribution of 80 degrees and vertical coverage of 40 degrees.

F-M Adapter (7)

STROMBERG-CARLSON CO., Rochester 3, N. Y. The Driscoll f-m adapter is a simple device, listing for $6.35, that has been designed for use on all prewar Stromberg-Carlson f-m receivers to adapt them for reception of signals in the new band. At present, the equipment is available only through distributors who make a nominal installation charge, and in some cases, modify the receiver slightly.

Vest-Pocket Earphone (8)

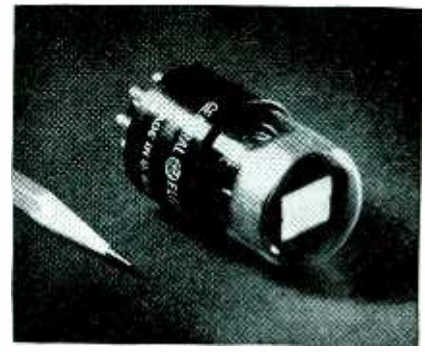
THE BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. The model BA-201 insert-type earphone is manufactured for use with personal vest-pocket radio receivers. It is small ($1\frac{3}{16}$ inch diameter and $\frac{7}{16}$ inch thick) and light in weight ($\frac{1}{4}$ ounce). Using a light-weight Bimorph crystal element, normal loudness results when the receiver is driven with only 1 volt and a power of 10 microwatts. Owing to its rugged construction, a maximum of 50 volts may be applied without damage to the earphone. Its impedance is 120,000 ohms at 1,000 cycles so that no output transformer or choke is required to match to the plate circuit of the output tube.

Instrument Testing Supplies (9)

ARTHUR E. BOOTH COMPANY, 210 West Seventh Street, Los Angeles 14, Calif. New packaged power supply units available in light-weight portable or bench models provide a source of a-c and d-c power smoothly adjustable from zero to maximum output range. Both the a-c and d-c output circuits are completely flexible as to connections for convenient routine testing and checking the calibration of a wide variety of instruments and relays. The present line supplies a full range of alternating and direct currents up to 10 amperes, and a-c and d-c potentials up to 750 volts.

Electron-Ray Indicator (10)

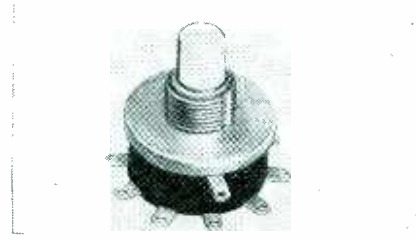
GENERAL ELECTRIC CO., Syracuse, N. Y. The type 6AL7-GT tube is a visual tuning aid for radio receivers. Patterns appear on a fluores-



cent screen at the end of the tube, their shape depending upon the type of circuit used and its adjustment. Deviation from a proper tuning condition can be indicated to the extent of showing on which side of resonance the misalignment occurs.

Rotary Switch (11)

GRAYHILL, 1 North Pulaski Road, Chicago 24, Ill. The new Series 5000 miniature switch is $\frac{3}{4}$ inch in diameter, 13/32 inch deep, and has a contact pressure of $2\frac{1}{2}$ pounds. It



can be used in circuits passing up to 5 amperes, breaking up to 1 ampere at 110 volts. Featuring 360 degrees rotation in either direction, the switch can be moved from one position to another by turning through the least number of positions, as from position 1 to 10 without going through positions 1, 2, 3,

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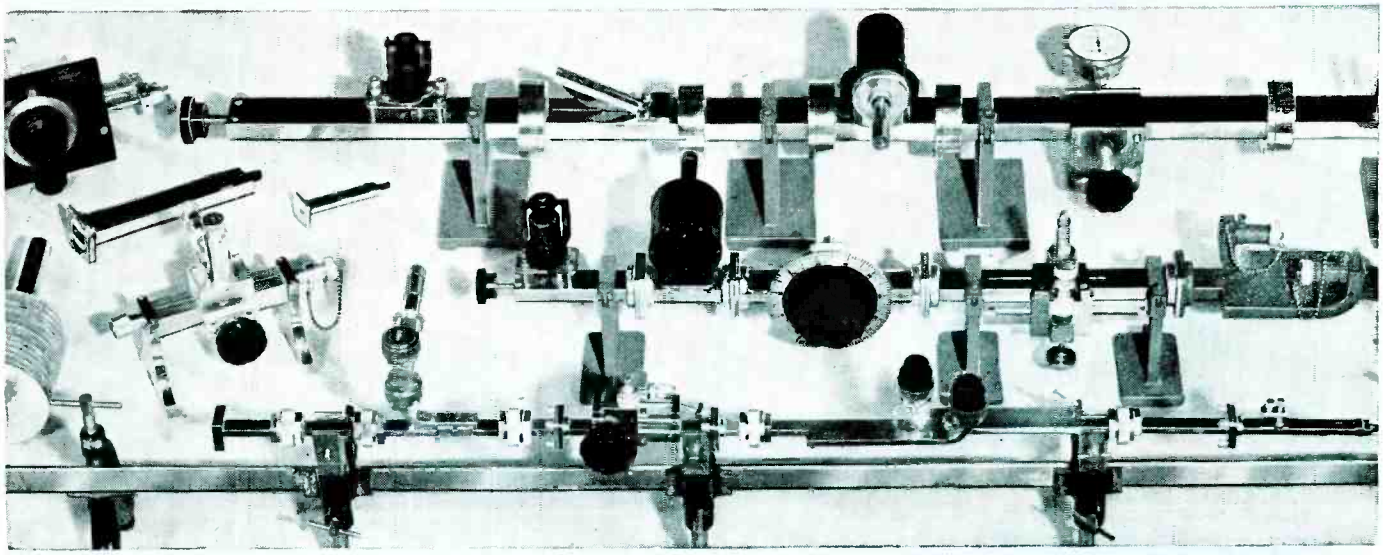

The complete line of De Mornay·Budd standard test equipment covers the frequency range from 4,000 mcs. to 27,000 mcs. It provides all R. F. waveguide units necessary for delicate, precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

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The three test set-ups illustrated above include:

Tube Mount
Flap Attenuator
Frequency Meter
Calibrated Attenuator
Tee
Stub Tuner
Tunable Dummy Load
Standing Wave Detector
Type "N" Standing Wave Detector
Directional Coupler
Hight Power Dummy Load
Cut-Off Attenuator

Stands, etc.

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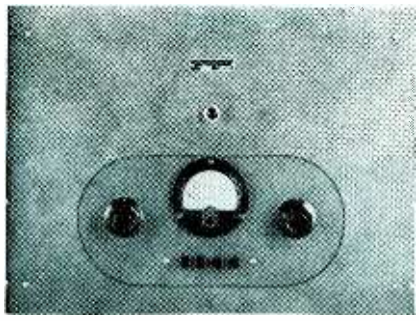
etc. Or, if desired, stops can be placed to allow rotation only through a given number of positions.

Recording Amplifier (12)

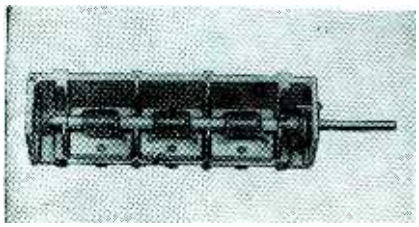
PRESTO RECORDING CORP., 242 West 55th St., New York 19, N. Y. The type 92A amplifier illustrated is rack-mounted with all controls accessible. Four pushbuttons select



various standard recording characteristics—normal response, NAB vertical, NAB lateral, and 78 rpm lateral. Output level and tube plate currents are indicated by a single meter controlled through a selector switch. Frequency response is 20 to 17,000 cycles within 1 db.

Inductive Tuner (13)

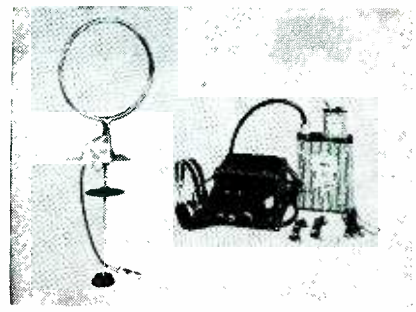
P. R. MALLORY AND CO., Inc., 3209 E. Washington St., Indianapolis 6, Ind. An infinitely variable inductance in the range 44 to 216 megacycles is covered in 3,600 degrees



of rotation of the shaft of the unit illustrated. Several inductors can be ganged for use in television and f-m receiving equipment. The unit can be hand or motor driven.

Range and Loop Receiver (14)

LEAR, INC., Grand Rapids, Mich. The new AMRL-1 radio range receiver and aural-null loop combination are dry-battery powered. The



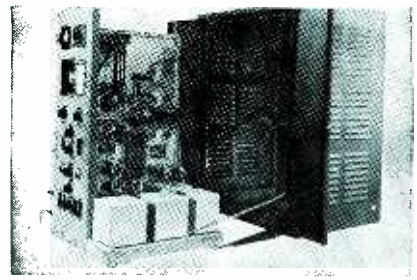
receiver tunes aircraft range beacons in the frequencies 195 to 405 kilocycles. The equipment is simple to install, weighs 12½ pounds, and sells for $159.50.

Fiberglas Tubing (15)

BENTLEY, HARRIS MFG. CO., Dept. P7, Conshohocken, Pa. Samples of Ben-Har Fiberglas tubing are available from the company in grade A with a voltage breakdown strength of 7,000 volts and grade B for 4,000 volts. The nonfraying flexible insulating tubing is supplied in all standard sizes in various colors.

VHF Transmitter (16)

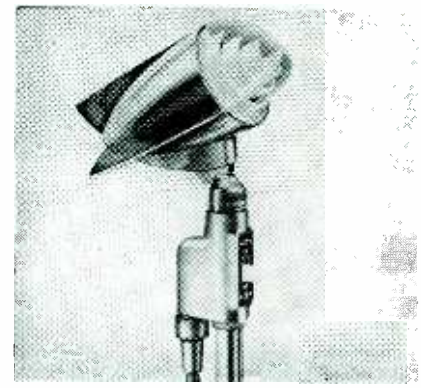
RADIO RECEPTOR CO., Inc., 251 W. 19th St., New York 11, N. Y. The type TV-50-A vhf transmitter can be supplied for any frequency in



the range 100 to 162 mc. Power output varies between 50 and 40 watts with increasing frequency. Audio-frequency response is 150 to 4,000 cycles, within 3 db of the 1,000-cycle response. An audio peak limiter is included to prevent overmodulation. A transmission line monitor rectifier is used.

Crystal Microphone (17)

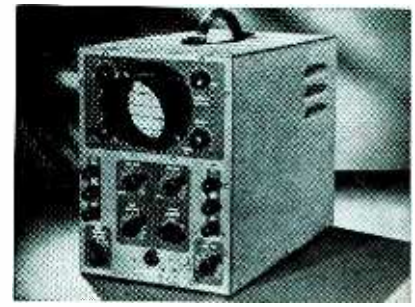
ASTATIC CORP., Conneaut, Ohio. The model 600-S crystal microphone has



relatively high output and wide frequency range, is useful with public address and paging systems, amateur rigs and other communication applications. This new microphone has an overall frequency response that is smooth up to 10,000 c.p.s.

Portable CRO (18)

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Ave., New York 18, N. Y. A new cathode-ray oscilloscope featuring portability and low cost has



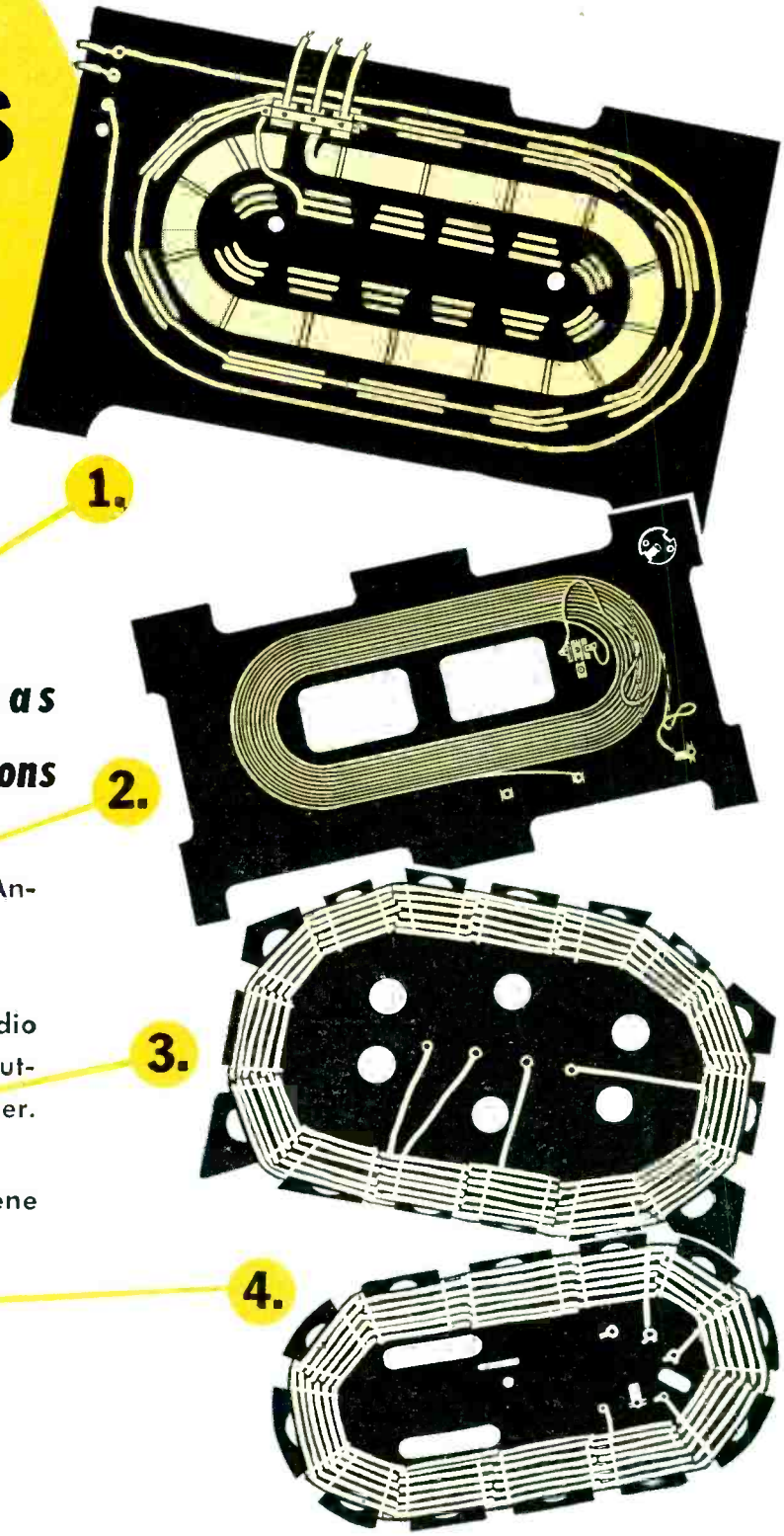
been designed for radio set servicing and general service applications. The new type 131 oscilloscope, weighing 18 pounds, is mounted in a cabinet measuring 10¾ in. high, 8⅛ in. wide and 13¾ in. deep. Signal frequency range from 15 to 40,000 cycles is provided with a five-range selection control and a fine frequency control. Visual study of wave form is provided by a 3-in. cathode-ray tube designed for 650-volt deflection plate operation.

UHF Signal Generator (19)

HEWLETT-PACKARD CO., Palo Alto, Calif. The direct-reading type 610A uhf signal generator has a frequency range of 500 to 1,350 mc, and is a valuable laboratory standard for determining gain or align-

(continued on p 216)

Loop Antennas by Super



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1. Multi-band combination loop Antenna and Radio Back.

2. Broadcast Loop Antenna and radio back combination with phone jack, outside antenna connection, aligning trimmer.

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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Nucleonic news; radar on airliners; heating gets 2,450 mc; new f-m rulings; f-m clinic; taxicab radio survey; Atlanta Conference

IRE Honors Engineers at 1947 National Convention

The Institute of Radio Engineers has issued the following list of honors presented to members for outstanding accomplishments.

The Morris Liebmann Memorial Prize for 1946 was awarded to Albert Rose of RCA for his contributions to television pickup tubes, particularly the image orthicon.

The Morris Liebmann prize for 1947 was awarded to John R. Pierce of Bell Telephone Laboratories for his development of the traveling-wave tube.

Fellowships were awarded to the following: Benjamin De F. Bayly, Frank H. R. Pounsett, Pedro J. Noizeux, Sir Robert Watson-Watt, George P. Adair, G. L. Beers, L. V. Berkner, E. L. Bowles, R. S. Burnap, R. F. Field, D. G. Fink, W. W. Hansen, D. R. Hull, F. V. Hunt, K. G. Jansky, R. D. Kell, C. V. Litton, J. W. McRae, I. E. Mouromtseff, D. E. Noble, R. M. Page, J. A. Pierce, C. A. Priest, W. W. Salisbury, and E. N. Wendell.

Presentation of the awards will be made at the annual banquet Wed. March 5 during the IRE National Convention at the Hotel Commodore in New York City. Guest speaker at the banquet will be Charles R. Denny, Jr., FCC chairman, who will discuss "Frequency Allocations". At the President's Luncheon March 4, Vice-Admiral Charles A. Lockwood will speak on "Electronics in Submarine Warfare".

Mobile Radio on Farm

Construction permits for one land station and one mobile station with 11 units have been granted King Farms Co., Morrisville, Pa. by the FCC. The stations will be used for office-to-car and car-to-car communication on this 6,000-acre truck farm to expedite planting, cultivating, harvesting, and marketing of farm vegetables. The Bell Telephone Co. of Pennsylvania will own, install, and maintain the equipment, but all operating will be done by the King Farms Co. which at peak seasons employs up to 600 workers. The frequency of 156.99 mc is assigned on a temporary basis.

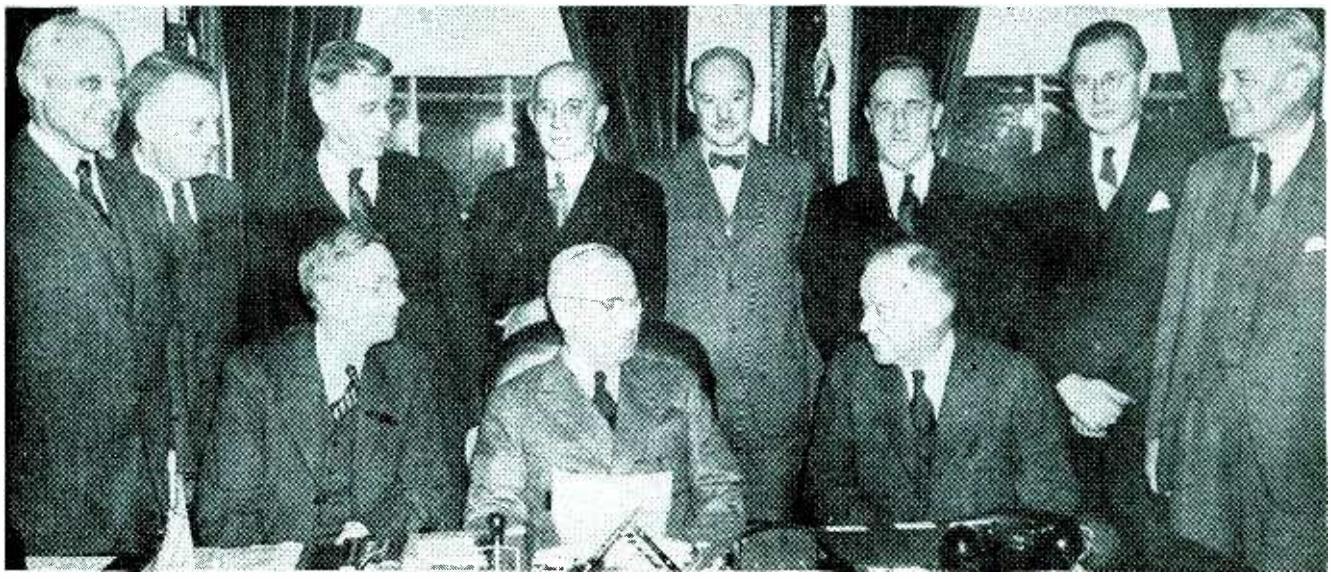
Declassified Papers on Atomic Energy Now Available

THE FIRST 270 atomic energy papers to be declassified by the Atomic Energy Commission or by its predecessor, the Manhattan Engineer District, can now be obtained from the Office of Technical Services of the Department of Commerce at prices ranging from $1 upward depending on length.

These papers constitute the first sizable release of atomic energy information which has been made since the early days of the war, when a top secret classification was

(Continued on p 256)

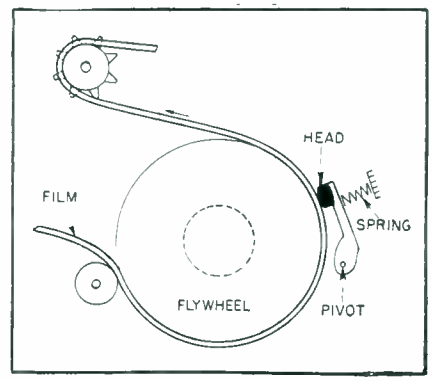
CONGRATULATIONS TO TEN KEY SCIENTISTS



For their work in the wartime Office of Scientific Research and Development, President Truman on January 20 congratulated these key scientists. Left to right, seated: Dr. James B. Conant, president of Harvard Univeristy; President Truman; Dr. Alfred N. Richards, chairman of the OSRD committee on medical research. Standing: Dr. Karl T. Compton, president of MIT; Dr. Lewis H. Weed, National Academy of Sciences; Dr. Vannevar Bush, director of OSRD; Dr. Frank B. Jewett; Dr. J. C. Hunsaker of MIT; Dr. Roger Adams of University of Illinois; Dr. A. Baird Hastings of University of Illinois; Dr. A. R. Dochez of Columbia University.

TUBES AT WORK
(continued from p 140)

of the recording and playback circuits, erasing is done by a 40-kc oscillator when the switch is in position *A*. In position *B* the microphone, amplifier, and recording equalizer are in the circuit for recording. Some of the oscillator output is also fed to the recording head to provide a high-frequency component. In position *C* the head picks up the magnetic variations in the film. These are first equalized by the playback equalizer, then fed through the amplifier and into the loudspeaker.



Mounting arrangement for the magnetic pickup head. The pressure against the coating is on the order of 0.0001 ounce

An overall frequency response curve for the 16-mm system shows that it is flat within ± 3 db from 50 to 5,000 cycles. At normal recording levels the intermodulation distortion is about 5 percent. The background noise is 35 to 40 db below the program level.

The magnetic coating can also be put on 8-mm film between the sprockets and edge of the film, and has the same dimensions as on 16-mm film.

Because 8-mm film moves at half the speed of 16-mm film, its upper frequency limit is about 2,500 cycles. On voice, the sibillants are clear and natural. Quality on music, while not as good as at sixteen-millimeter speed, is comparable to that of low-cost radio receivers. Distortion and signal-to-noise ratio are about the same as at higher speeds.

Soldering Litz Ends

By EMERICK TOTH
Naval Research Laboratory
Washington, D. C.

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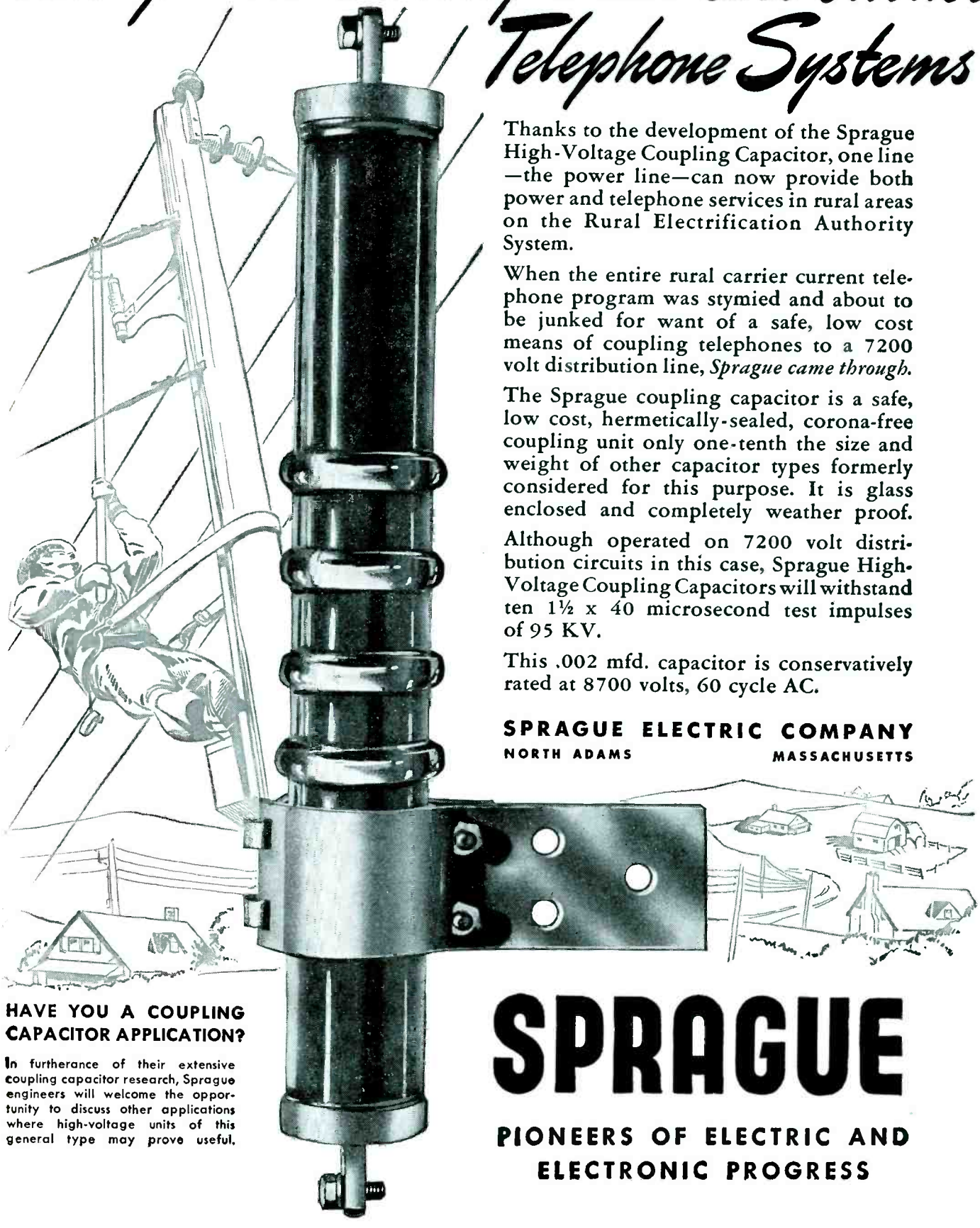

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When the entire rural carrier current telephone program was stymied and about to be junked for want of a safe, low cost means of coupling telephones to a 7200 volt distribution line, *Sprague came through.*

The Sprague coupling capacitor is a safe, low cost, hermetically-sealed, corona-free coupling unit only one-tenth the size and weight of other capacitor types formerly considered for this purpose. It is glass enclosed and completely weather proof.

Although operated on 7200 volt distribution circuits in this case, Sprague High-Voltage Coupling Capacitors will withstand ten 1½ x 40 microsecond test impulses of 95 KV.

This .002 mfd. capacitor is conservatively rated at 8700 volts, 60 cycle AC.

SPRAGUE ELECTRIC COMPANY
NORTH ADAMS MASSACHUSETTS

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In furtherance of their extensive coupling capacitor research, Sprague engineers will welcome the opportunity to discuss other applications where high-voltage units of this general type may prove useful.

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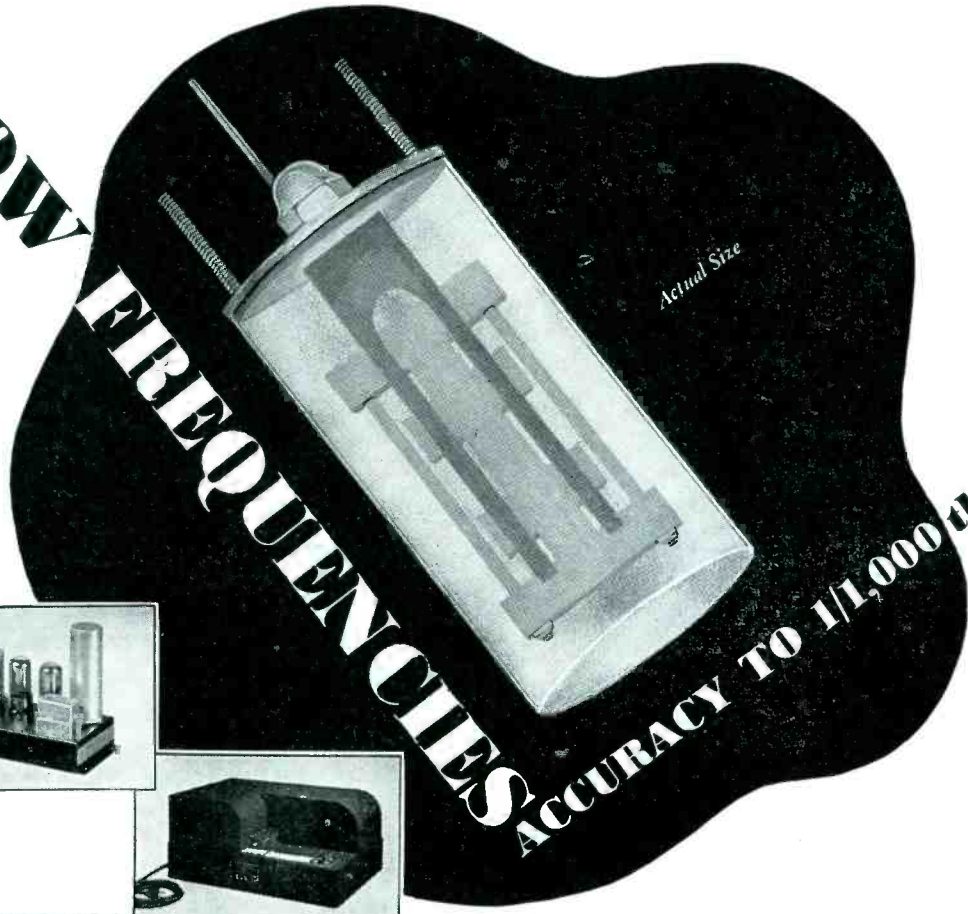

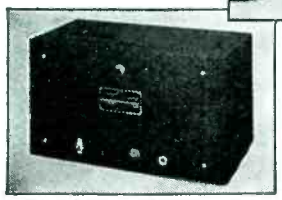

TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

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Dist. of Western Electric & Watch Master Watch-rate Recorders

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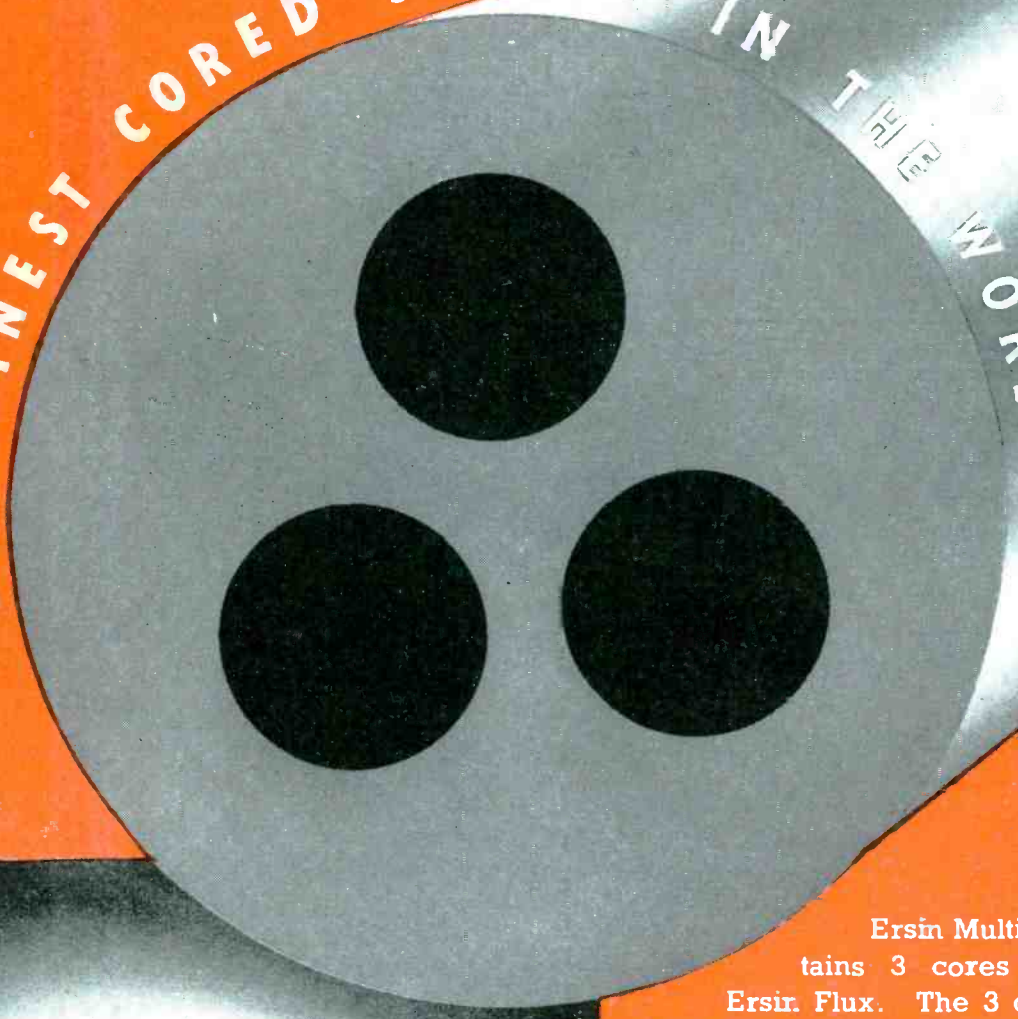

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Ersin Multicore Solder contains 3 cores of extra active Ersin Flux. The 3 core construction gives rapid melting and speedy production of precision soldered joints. Only with Multicore do you get the advantages of guaranteed flux continuity, instant melting and extra speedy fluxing even on oxidised surfaces. Ersin Multicore Solder is made as standard in gauges between 10 and 22 S.W.G. (.128 - .028 in., 3.125 - .711 mm); and in 5 standard antimony free alloys. Ersin Multicore Solder is used by leading manufacturers of radio, television, electrical and telephone equipment in Britain, U.S.A. and Canada and also by many Government departments. If you would like to know more about Ersin Multicore, please write us for detailed technical information and samples.

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SNI-DOR RADIOLECTRIC LTD., 455 Craig Street West, Montreal.

Enquiries regarding other territories to
MULTICORE SOLDERS LTD., Mellier House, Albemarle Street, London, W.1. England.
Tel: REGent 1411. Cables: Lustickon, Piccy, London.

coils of litzendraht wire. These coils ranged in diameter from 12 inches, wound with litz of about 180 strands of number 38 wire, to little fellows of ½ inch ID using 7/41 litz. Over 150 coils were involved, a total of more than 300 coil ends, thousands of individual strands that must be properly tinned and soldered.

Careful tests were made of the following three methods:

(1) Cautious removal of the silk and enamel from the coil end by abrasion against a relatively soft high-speed rotary wirebrush.

(2) Heating of the coil end in an alcohol or Bunsen-burner flame and subsequent plunging of the hot coil end into alcohol.

(3) Application of a small quantity of a paste of zinc chloride and water to the coil end and heating with a soldering iron, immediately followed by tinning with rosin-core solder while the resulting zinc chloride and enamel mixture was still boiling. The silk insulation was burned and stripped off by a very short exposure to a flame, and subsequent wiping with a rag prior to application of the zinc chloride.

Results of Tests

Method (1) was found to damage individual strands excessively, and did not clean all strands in sizes of litz with many strands, such as 70/38 and 180/38.

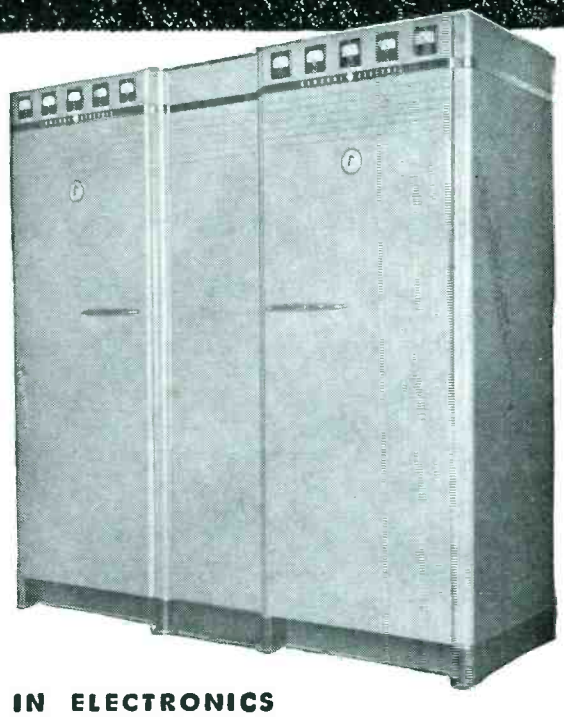
Method (2) was difficult to control. Insufficient exposure to the flame resulted in the enamel not cracking off when the hot coil end was plunged into cold alcohol. Overheating caused individual strands to burn off. Even when satisfactory cleaning was obtained, the copper was left so brittle that soldered coil ends would break easily.

Method (3) provides easy and effective tinning. The appearance of the tinned end was neat and clean after the residue of zinc chloride, enamel, rosin, and solder had been wiped off while still hot with a damp rag. The ease of tinning even 180/38 litz suggested that inside strands were not properly coated. Several samples were cut in cross-section but all strands appeared to be clean of enamel and tinned.

Samples were placed in a salt-spray chamber and subjected to the Navy's standard salt-spray test

100

FM TRANSMITTERS *shipped!*



HERE is the one hundredth FM broadcast transmitter produced by G. E. It was shipped on January 10th. Nearly 150 more, on order, are now being built.

This 3 KW transmitter incorporates the famous Phasitron circuit plus many other technical advances by General Electric. It is one of the units in the complete General Electric line of transmitters which range in power from 250 W to 50 KW.

These FM transmitters have proved their efficiency and economy in stations throughout the country.

For complete information on these transmitters, designed and built to assure you lower costs per hour of operation, write or call your nearest General Electric broadcast sales engineer, or the *Electronics Department, General Electric Company, Syracuse 1, New York.*

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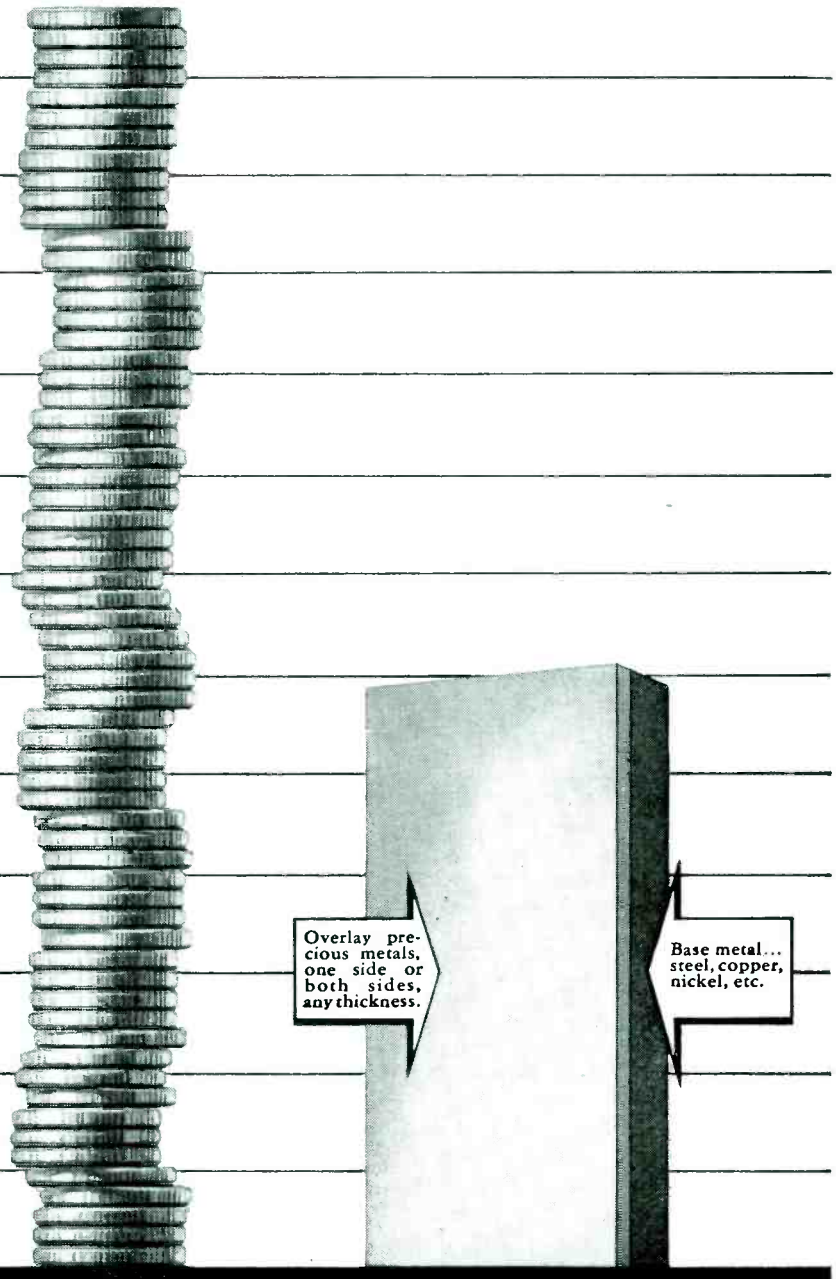

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Because General Plate Laminated Metals . . . sheet, wire and tube . . . are permanently bonded laminations of a thin layer of precious metal to a thicker layer of base metal, they give you precious metal performance at a cost slightly higher than the inexpensive base metal.

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Investigate General Plate Laminated Metals, today. Our engineers are available for consultation on your metal problems. Write:

SHEET . . . Available with precious metal on one side, both sides or wholly covered, inlaid and edge laid in practically any combination of precious to base metal. Base to base metal combinations also available.

TUBE . . . Solid precious metal; laminated precious to base metal lined, or covered one side or both in a wide range of diameters and odd shapes.

WIRE . . . Shaped, solder filled, channel, solder flushed, squares, flats, ovals and irregular shaped.

GENERAL PLATE DIVISION
of Metals and Controls Corporation
ATTLEBORO, MASSACHUSETTS

for two hours. It was found that except for a light accumulation of powdery salt the samples were in no way affected by the test and all 300 coil ends were processed as outlined in method (3) above.

Eighteen months after delivery, one equipment was examined which had been in service in Panama for a year. No trace of corrosion or any other damage was found.

Zinc chloride is very hygroscopic and should be kept in a suitable well-stoppered glass bottle, with only as much paste prepared at one time as is needed for a few hours use.

Square Loop F-M Antenna

AN EIGHT-ELEMENT square-loop antenna multiplies the power of a transmitter by more than eight times but erecting an 80-foot one atop a 30-story building multiplies the construction problems even more. Such an antenna has been erected for WCTN-FM, Minneapolis, on the Foshay Tower in that city where tons of equipment had to be moved thirty stories above the ground.

First square-loop section of the antenna as it cleared the roof

The highest point in the Twin-Cities area is the Foshay Tower, selected for the Federal eight-element square-loop antenna after a survey of all available locations. The building rises 447 feet above the street, is of steel and stone construction, and is patterned after the Washington Monument. All outside work had to be completed before the

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A NEW SYLVANIA CRYSTAL DIODE VARISTOR TYPE V-301

THE V-301 VARISTOR
(SHOWN ACTUAL SIZE)

Ratings*

Max. allowable inverse voltage	25 volts
Max. allowable average current	20 ma
Max. allowable peak current	40 ma
Max. allowable instantaneous surge current	50 ma

*Apply to a single diode.

FEATURES

Lower capacitance **No heater supply required**
Wider frequency range **Improved stability**
Elimination of contact potential effects

For modulator service in telephony, telegraphy and other communications equipment, as well as in certain radar applications, the Sylvania Varistor Type V-301 offers outstanding advantages.

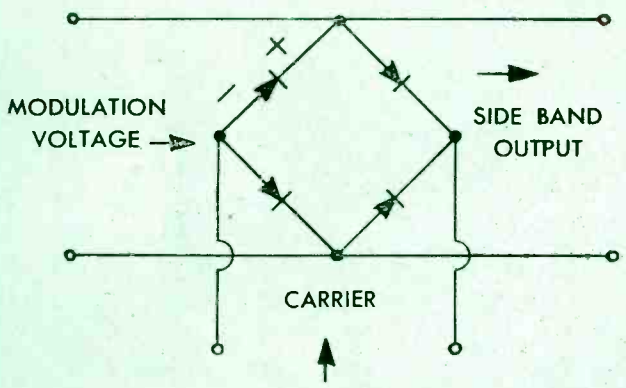
The V-301 consists of four special germanium crystal diodes (similar to the familiar Sylvania 1N34) carefully selected and balanced, and factory-assembled into a single compact unit.

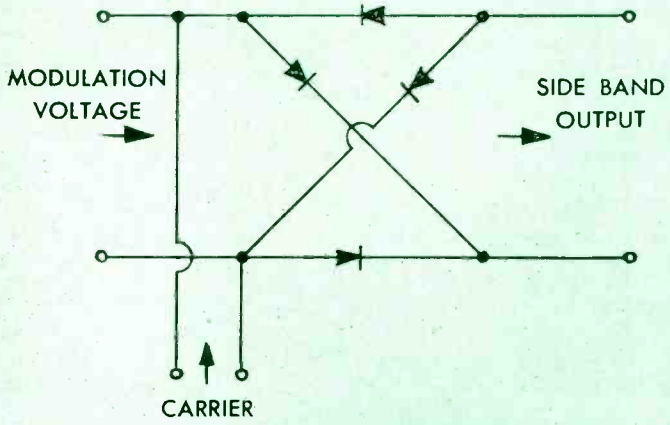
Point contact utilized in the germanium crystal diodes reduces capacitance to the order of a few μμf. As a result, useful frequency range is greatly extended. Stability is improved, and the contact potential effects occurring in vacuum diodes are entirely eliminated.

Also available is the V-307; electrical characteristics are the same but unit is mounted in a can suitable for top or sub-panel mounting. Connections are soldered to eight lugs.

Inquiries are invited.

TYPICAL MODULATOR CIRCUITS USING THE V-301





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Its terminals are ideal for easy, rapid crimping and soldering.

The shaft and bushing are fully insulated from the contact mechanisms, so the rheostat can be mounted on a metal panel. And this little 10 watt rheostat is tested for 1500 volt breakdown.

Other types of Hardwick-Hindle rheostats, and our many resistors offer you valuable exclusive advantages also.

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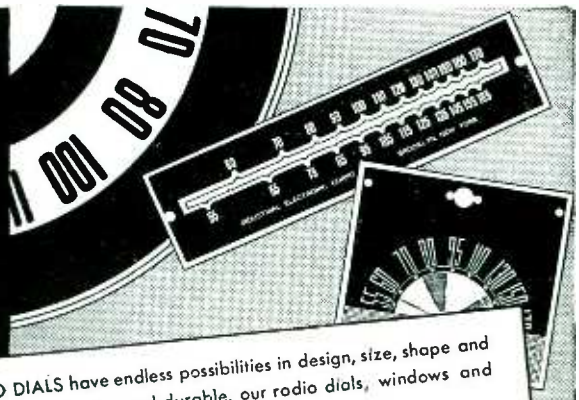

PLASTIC RADIO DIALS have endless possibilities in design, size, shape and color combination. Attractive and durable, our radio dials, windows and scales are preferred by many leading Radio manufacturers.

Not only for dials, but for numerous other electronic and electrical applications, Laminated Plastics are preferable.

Consult with our artists and engineers regarding applications for your particular purpose. Or . . . send blueprints or samples for quotation.

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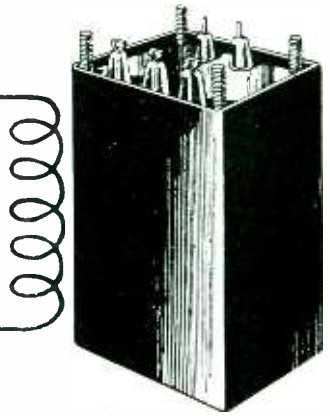

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THERMADOR ELECTRICAL MFG. CO.
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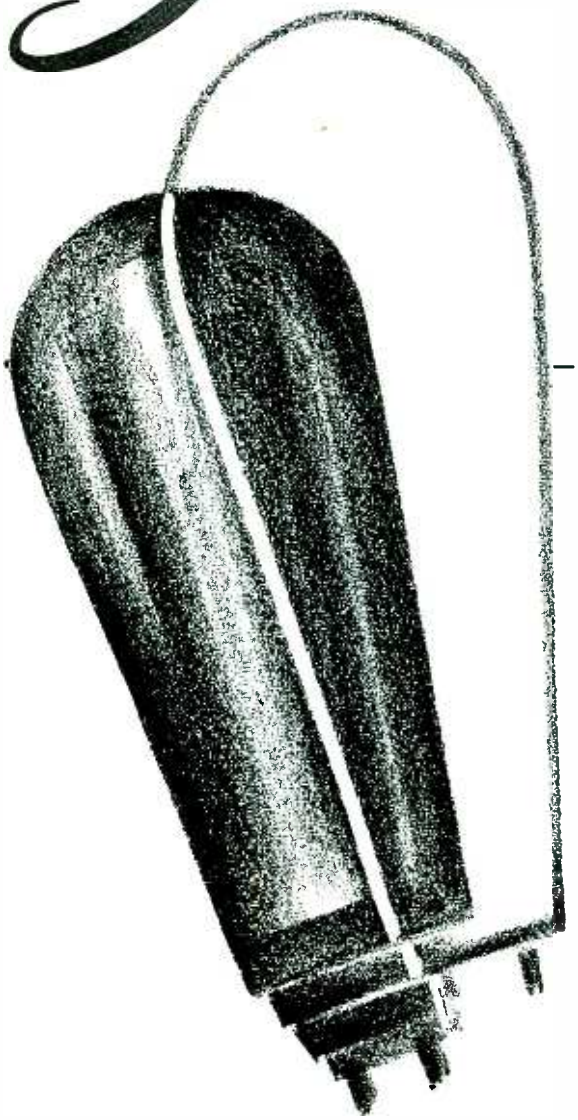
The War Assets Administration has appointed a representative group of competent well established distributors to help dispose of war-surplus electronic tubes and equipment. We suggest that you get in touch with the distributor nearest you. He will know the items available and how they can aid in solving your electronic problems.



ELECTRONICS DIVISION
OFFICE OF AIRCRAFT DISPOSAL

WAR ASSETS ADMINISTRATION

425 Second St., N.W. Washington 25, D. C.

Here is an up-to-date list of WAA approved distributors.

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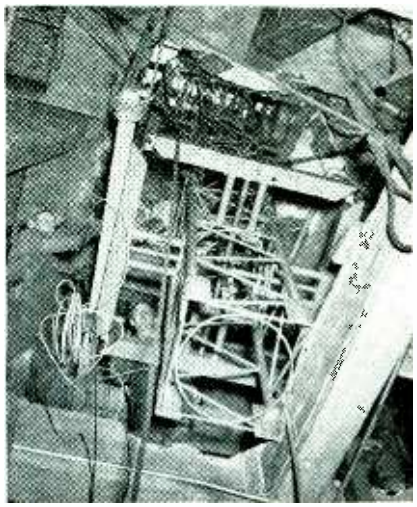
Technical Apparatus Co.	165 Washington St.
BUCHANAN, MICH.	
Electro-Voice, Inc.	Carroll & Cecil Sts.
CANTON, MASS.	
Tobe Deutschmann Corp.	863 Washington St.
CHICAGO, ILL.	
American Condenser Co.	4410 Ravenswood Ave.
Majestic Radio & Television Corp.	125 W. Ohio St.
EMPORIUM, PENN.	
Sylvania Electric Products, Inc.	
FORT WAYNE, IND.	
Essex Wire Corp.	1601 Wall St.
LOS ANGELES, CALIF.	
Cole Instrument Co.	1320 S. Grand Ave.
Hoffman Radio Corp.	3761 S. Hill St.
NEWARK, N. J.	
Standard Arcturus Corp.	99 Sussex Ave.
Tung-Sol Lamp Works, Inc.	95—8th Ave.
NEW YORK, N. Y.	
Communication Measurements Laboratory	120 Greenwich St.
Electronic Corp. of America	353 W. 48th St.
Emerson Radio & Phonograph Corp.	76—9th Ave.
Hammarlund Mfg. Co., Inc.	460 W. 34th St.
Newark Electric Co., Inc.	242 W. 55th St.
Raytheon Mfg. Co.	60 E. 42nd St.
Smith-Meeker Engineering Co.	125 Barclay St.
SALEM, MASS.	
Hytron Radio & Electronics Corp.	76 LaFayette St.
SCHENECTADY, N. Y.	
General Electric Co.	Bldg. 267, 1 River Rd.
WASECA, MINN.	
E. F. Johnson Co.	206—2nd Ave., S. W.

945

arrival of Minnesota's bitter winter.

Planners of the station engaged the original designer of the Foshay Tower and its original builder because they were thoroughly acquainted with its construction. An unfinished elevator shaft from the basement to the 30th floor was used as the route to the roof. Through this shaft the antenna sections, equipped with their loops and other components, were hoisted to point of final assembly beneath the peak.

First step in the erection was to cut an opening large enough to accommodate the over-all width of the antenna loops through the tip of the tower. The top section of the antenna, surmounted by a 300-mm aircraft warning beacon, was then assembled and raised through the opening by a system of steel cables attached to hand-operated winches.



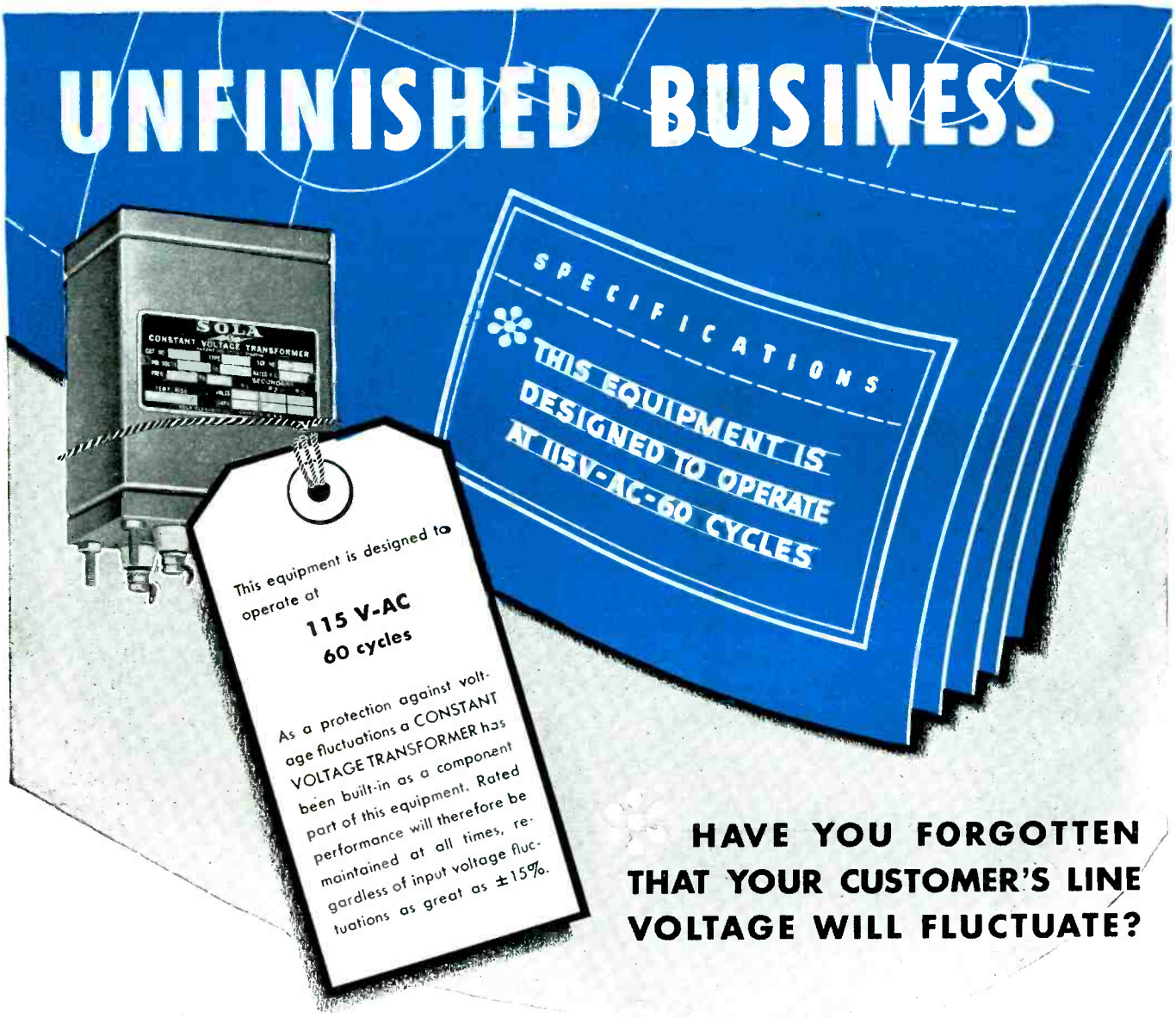
Viewed from underneath, while another section is added to the antenna

A second section was added to the first and both were pushed through the opening in the peak. This process of building from the bottom was continued until all eight sections and their associated components were in place and the completed antenna was in position.

The final step was to anchor the base of the antenna to a 27-foot inner support tower, fastened to the main cross beams of the building.

The new antenna is operating at 97.1 mc for WTCN-FM, which holds one of the highest effective radiated power ratings in the United States. Present operating power is three kilowatts into the antenna from a Federal FMTB 3000 f-m transmitter. This produces an effective ra-

UNFINISHED BUSINESS



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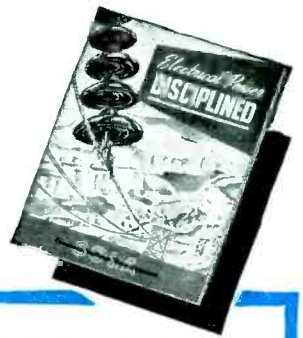
115 Volts . . . ± 15%. Is that what you meant when you specified the label rating. That's what your equipment will be up against when it's at the mercy of commercial line voltages.

If your equipment will not stand that tolerance, you're saddling your customers with a serious problem and one which few will understand. Your equipment will be blamed for any breakdown or unsatisfactory performance—not the fluctuating voltage that caused it.

You can relieve your customers of this problem, eliminate costly service calls . . . and . . . accomplish all this at an actual saving in original design costs. The answer is . . . "include a SOLA Constant Voltage Transformer as a built-in component."

SOLA Constant Voltage Transformers are available in 31 standard designs in capacities from 10VA to 15KVA . . . or special units can be custom built to your specifications. Whether your product is designed for home, science or industry—Constant Voltage is *your* problem. May we make recommendations for your equipment?



This book provides the answer to *your* Constant Voltage problem.

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NEW . . . Simpson Model 305RC Tube-Tester with "No Backlash"* Roll Chart

With the addition of the new Simpson "No Backlash"* Roll Chart to the 1947 version of our Model 305, this famous instrument becomes beyond question the finest tube-tester on the market in its price range. Read the description of this new Roll Chart in the panel below.

Model 305RC provides for filament voltages from .5 volts to and including 120 volts. It tests loctalc, single ended tubes, bantams, midgets, miniatures, ballast tubes, gaseous rectifiers, acorn tubes, Christmas tree bulbs, and all popular radio receiver tubes.

Like other Simpson tube-testers, the Model 305RC incorporates 3-way switching which makes it possible to test any tube regardless of its base connections or the internal connections of its elements. This method, the result of exhaustive research and expensive construction, protects the Model 305RC against obsolesence to a degree not enjoyed by competitive testers. No adapters or special sockets are required. In addition to having a complete set of sockets for every tube now on the market, this tester has a spare socket, to provide for future tube developments.

The Model 305RC has provision for testing pilot lamps of various voltages as well as Christmas tree bulbs. It tests gaseous rectifiers of the OZ4 type—also tests ballast tubes direct in socket for burnouts and opens. Has neon bulb of proper sensitivity for checking shorts. This tube-tester is fused, and has the latest improved circuit. It provides for line adjustment from 100 to 130 volts, with smooth vernier control.

Model 305RC is distinguished for its beautiful exterior. It has a two-tone metal panel in red and black on a satin-finished background. Sockets and controls are symmetrically arranged for quick operation. The large, modern, fan-shaped instrument has an exceptionally long scale. It has "good" and "bad" English markings, also a percentage scale for matching and comparing tubes. Cases, both portable† and counter style, are made of strongly built hardwood, durably and beautifully finished.

Size, 11"x11"x6". Wt. 10 lbs. Shipping wt., 15 lbs.
Dealer's net price, portable or counter model.....**$59.50**
For 60 cycle 115 volt current only.
For 220 volt or 60 cycle, add..... **7.50**
Standard Model 305, with book-type speed chart **49.50**

Counter Model 305RC. Same instrument as portable model, but set in fine walnut finished hardwood case, with tilted, easy-to-use panel.

†Finished hardwood cases are standard on portable models. When these are not available, the instrument is housed in attractive simulated-leather covered case.

*6 Exclusive Features Make This the Finest Roll Chart Ever Designed for Tube-Testers . . . . .

- "No Backlash" feature of this Roll Chart automatically takes up all slack in the paper chart and, by keeping it in constant tension, makes it impossible to turn the selector wheel without turning chart. Gives precision selection at all times. Also prevents chart from tearing or getting out of alignment.
- Gearing is such that only 6 turns of selector wheel will run the entire length of the 12½ ft. chart.
- Easy to read. The clear Lucite window is just wide enough to show 2 tube settings, or both settings on a multi-purpose tube.
- Entire unit removable by taking out four screws. Just lift from receptacle to make new entries or install new chart.
- Chart ingeniously fastened to rollers, affording easy replacement and constant alignment.
- Rigid, light-weight construction. Gear driving mechanism incorporates heavy-duty precision brass gears and parts.

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Simpson
INSTRUMENTS THAT STAY ACCURATE

diated power in excess of 25 kw. Later, a 50-kw will be installed for 400-kw effective power.

Reports of consistent service have been received from St. Cloud, 60 miles from the transmitter. Rochester, 78 miles and St. Peter, 58 miles, all in Minnesota, and Grantsburg, Wisconsin, 64 miles. Other reports from Little Falls, 80 miles from Minneapolis and Duluth, 130 miles distant, also reported noise-free reception at those distances.

Metallized Capacitor Data

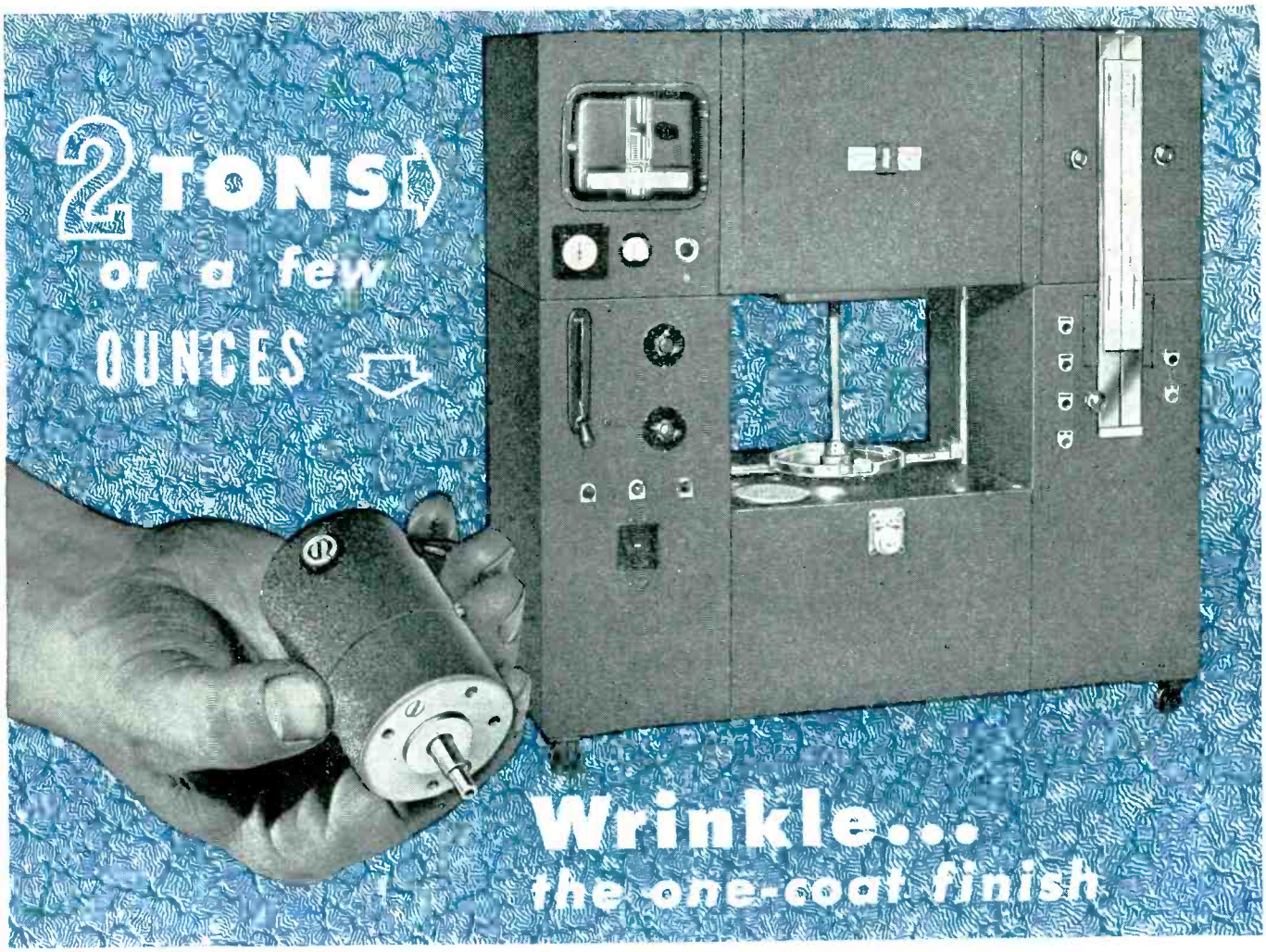
BECAUSE OF the interest shown by radio engineers in the metallized paper capacitors using a vapor-deposited zinc film developed in Germany, James Cornell of Solar Mfg. Corp. delivered a paper at the Rochester Fall Meeting that presented a picture of American developments in this field and supplied data with which design engineers may apply metallized paper capacitors to their circuit requirements.

Solite capacitors, the pioneer metallized paper units made available in this country, are fixed capacitors in which pure aluminum electrodes have been applied to the dielectric by means of a high-vacuum vaporization process. The resultant capacitors are not only considerably reduced in size but are also self-healing.

Standard impregnated paper capacitors consist basically of windings of two 0.00035-inch metallic foils separated by a minimum of two or more plies of Kraft capacitor tissue. The multiple-ply dielectric is employed so that there will be little chance of failure from metallic particles or weak spots in the tissue.

Self-healing

In the Solite capacitors there is no foil. Instead, the capacitor electrodes are 25 to 100 millicron thick metallic coatings deposited on the paper. This thin film has the property of self-healing, permitting the use of a single-sheet dielectric. During the course of processing metallized paper, metal inclusions in the paper and weak spots in the tissue are removed, allowing the single tissue to be worked at its maximum electrical stress. For working volt-



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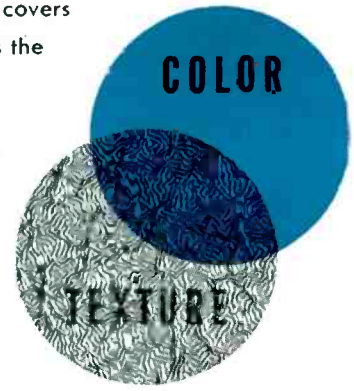
Wrinkle saves *hours* in the finishing department, makes *dollars* in production profits, whether on the Henry W. Dietert Company *Dilatometer* (weighing 3,500 pounds) or on the few ounces of Electric Motor Corporation's fractional horsepower motor shell.

It's wise to economize with WRINKLE.

Your friends in the more than 200 licensed manufacturing outlets for Wrinkle one-coat finishes will be glad to show you how to save hours, make dollars, with Wrinkle.



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age ratings above 200, multiple layer or interleaved constructions are used.

The metallized paper capacitor will not break down at its rated working voltage until a weak spot develops in the dielectric. If this happens, the resulting arc discharge through the paper removes the weak spot and vaporizes the aluminum film around the weak spot, clearing the fault. The aluminum is redeposited as aluminum oxide, an excellent insulating material, and the capacitor has healed itself.

In addition to the space-saving feature, the weight of a Solite capacitor is only ⅓ to ¼ of the conventional design when using aluminum foil. Lead foil capacitors, preferred by some manufacturers, are still heavier.

Test Voltage

A breakdown test of two to three times rated working voltage has been considered standard for small capacitors of conventional design but this does not hold for metallized paper units where the test voltage must be restricted to 1.5 times the working voltage. By taking full advantage of the self-healing properties, the working voltage stress has been safely increased since the removal of the incipient faults in the dielectric has made the insulation more reliable. This accounts for the smaller spread between test and working voltage.

If a direct voltage is applied to a metallized paper capacitor and an oscillograph is used for detecting voltage breakdown, occasional breakdowns of weak spots in the dielectric paper will show as the test potential is increased. In time these incipient faults clear and there is no further indication of spark discharge.

As the test voltage approaches the dielectric strength of the Kraft tissue, the oscilloscope shows a rapid increase in the number of spark discharges. If the capacitor is subjected to a voltage close to its ultimate breakdown voltage or to its sparking voltage (lowest applied voltage which will cause continuous self-healing action), the metallic coating would rapidly deteriorate as minute areas of film would be taken out by each discharge, until

The new 6BJ6
AMPLIFIER
PENTODE
Actual Size

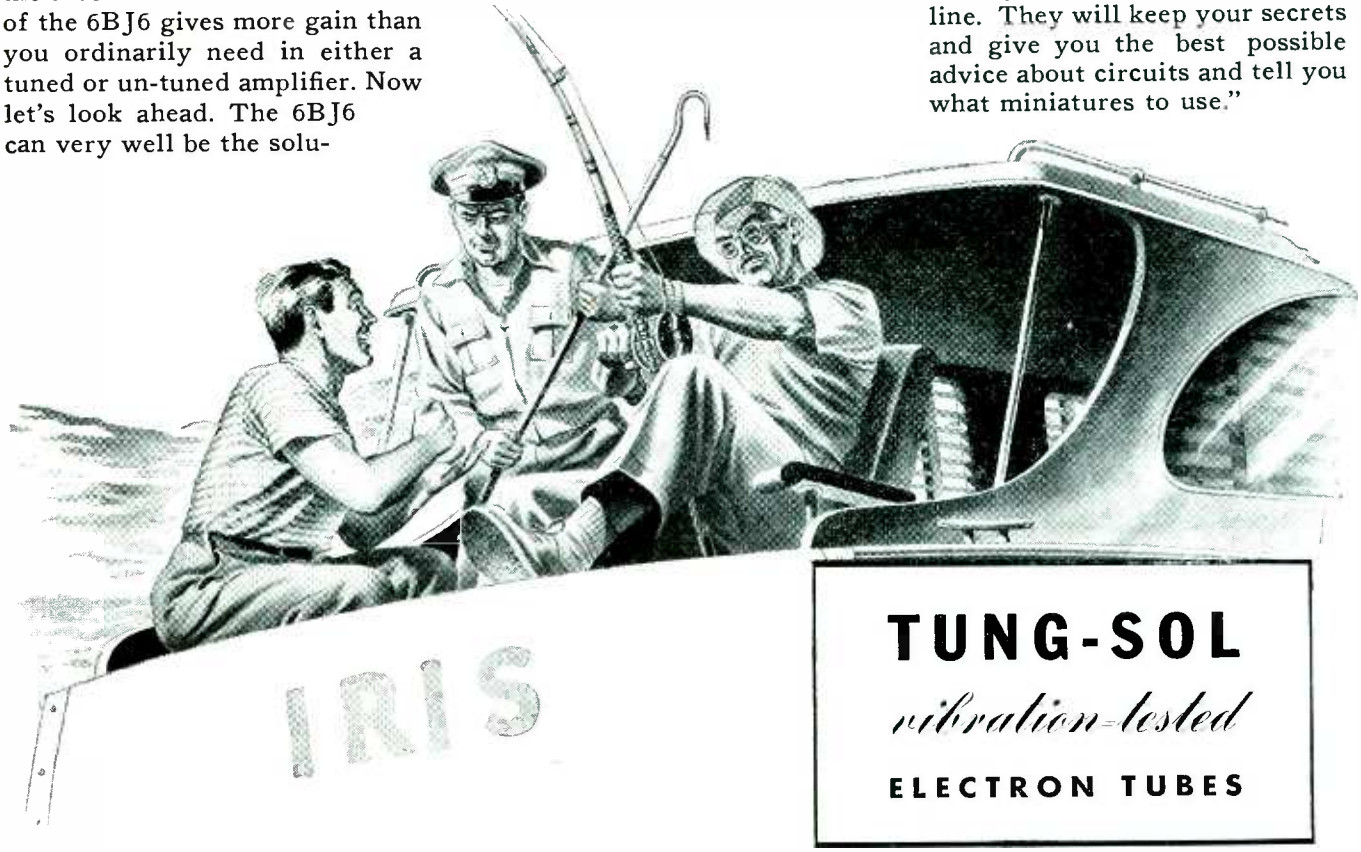
. . . Impromptu Discussions about Miniature Tubes

"Joe, I see that TUNG-SOL have brought out their new Amplifier Pentode, the 6BJ6, in miniature. It's an all purpose radio or intermediate amplifier with remote cut-off control characteristic. It's rugged and reliable . . . far beyond that you would expect in a 6.3 volt, 150 milliampere heater.

"The Economy of heater power can be very useful in a lot of ways. For instance, you can replace the 12BA6 i. f. amplifier in a five tube AC/DC receiver with one 6BJ6 and then you can use another to get the advantages of an input r. f. amplifier. And performance . . . the 3850 umhos transconductance of the 6BJ6 gives more gain than you ordinarily need in either a tuned or un-tuned amplifier. Now let's look ahead. The 6BJ6 can very well be the solution to AC/DC operation in FM receivers. It not only permits more tubes in a series operated heater string, its merit factor at the higher frequencies stands comparison with that of other popular-priced tubes. Thorough internal shielding, total imput and output capacitances of less than 10 uuf, extremely low grid-plate coupling capacitance, and the inherent low lead inductance of the miniature structure all result in extremely stable gain to well above 100 MC. With AVC, an un-bypassed cathode resistance of 82 ohms provides adequate stability of input impedance.

"The 6BJ6 is a 'natural', too, for mobile and aircraft communications. The heater consumption is less than one watt per tube. This is important wherever the power source is a storage battery. In a multi-tube receiver or in the low power stages of a transmitter, power saving of about one watt per tube can be a deciding factor especially when you don't have to offer apologies as to performance.

"Joe, you should get in touch with a TUNG-SOL engineer when you are planning your new line. They will keep your secrets and give you the best possible advice about circuits and tell you what miniatures to use."



TUNG-SOL

vibration-tested

ELECTRON TUBES

TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY

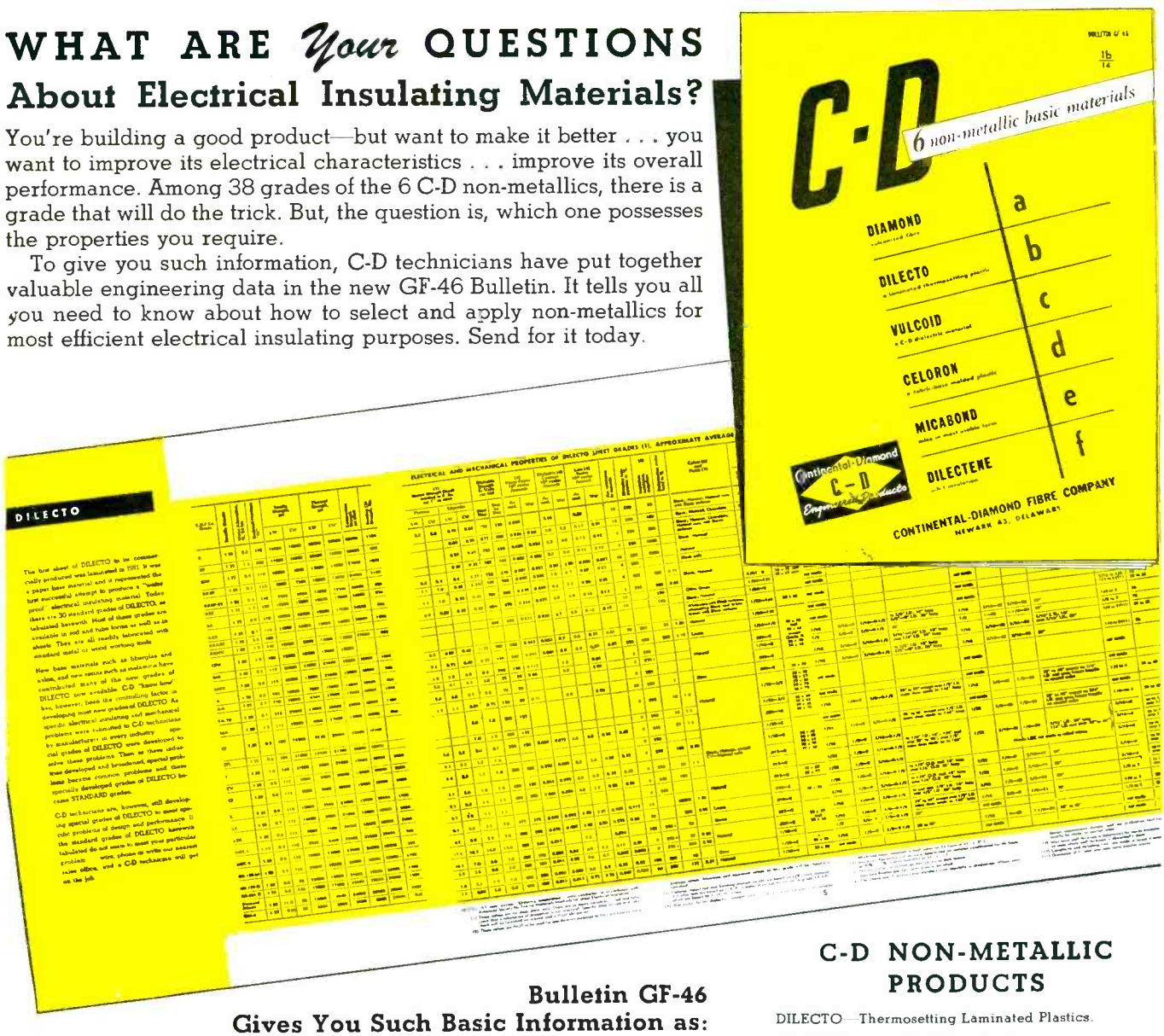
Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

WHAT ARE *Your* QUESTIONS About Electrical Insulating Materials?

You're building a good product—but want to make it better . . . you want to improve its electrical characteristics . . . improve its overall performance. Among 38 grades of the 6 C-D non-metallics, there is a grade that will do the trick. But, the question is, which one possesses the properties you require.

To give you such information, C-D technicians have put together valuable engineering data in the new GF-46 Bulletin. It tells you all you need to know about how to select and apply non-metallics for most efficient electrical insulating purposes. Send for it today.



Bulletin GF-46 Gives You Such Basic Information as:

- Physical Properties
- Electrical Properties
- Composition of Material
- Recommended Uses
- Grades, Types and Sizes
- Fabrication Information

If your need for help on insulation problems is urgent, phone or wire our nearest office and a C-D technician will be around to see you—quickly.

Continental-Diamond C-D Engineered Non-Metallics

D-1-47

C-D NON-METALLIC PRODUCTS

DILECTO—Thermosetting Laminated Plastics.

CELORON—A Molded Phenolic Plastic.

DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.

HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

DIAMOND Vulcanized FIBRE.

VULCOID—Resin Impregnated Vulcanized Fibre.

MICABOND—Built-up Mica Electrical Insulation.

STANDARD & SPECIAL FORMS

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

DESCRIPTIVE LITERATURE

Bulletin GF gives Comprehensive Data on all C-D Products. Catalogs are also available.

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES
WEST COAST REPRESENTATIVES: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental-Diamond FIBRE COMPANY

Established 1895..Manufacturers of laminated Plastics since 1911—NEWARK 16 • DELAWARE

an appreciable area would be robbed from the winding. If the sparking voltage is applied long enough, the ultimate result would be complete self-destruction of the capacitor.

Working Voltage

By plotting the frequency of breakdowns as a function of the test voltage, it is possible to determine the sparking voltage and to set the rated working voltage at such a value that there will be negligible arcing or spark discharges in actual service. In rating Solite capacitors, the working voltage has been consequently set at about 60 percent of the sparking voltage under the worst conditions of operation.

As the operating temperature of the capacitor under test is increased, the frequency of breakdowns at a given test voltage is also increased. Consequently, it is necessary to de-rate the capacitor working voltage with an increase in operating temperatures. Therefore, two working voltage ratings are shown for Solite capacitors—room temperature w-v d-c and maximum temperature w-v d-c. This latter rating must not be exceeded under service conditions.

Power Factor

Metallized paper capacitors show an extremely low power factor, both at 60 cycles and at 1,000 cycles, averaging about 0.3 percent at room temperature. The low value is due to the combination of a noninductive winding, the short length of section inherent in metallized paper construction, and the use of hydrocarbon waxes or oils as the impregnating medium, coupled with the dry-assembly process of manufacture. The power factor loss attributable to the impregnant itself is the same regardless of whether foil-paper or metallized paper is used.

In making life tests on metallized paper capacitors, protective resistors must be used in series with each test sample in order to limit discharge current. Otherwise, momentary arcing of a single capacitor in a test bank will cause discharge through the fault of the entire stored energy in all other capacitors in the bank. In this respect, the life testing arrangement for metallized paper capacitors resembles that for dry electrolytics.

1 MILLION

INSTALLED IN RADIO RECEIVERS IN LESS THAN A YEAR

*AIRLOOPS . . . *back panel and loop antenna in one unit*

It was less than a year ago that large scale production of **AIRLOOPS** began to feed radio set assembly lines and in this short time more than a million receivers, fitted with **AIRLOOPS,** went into service throughout the world.

The enthusiastic acclaim and acceptance of the **AIRLOOP** is well earned. It has demonstrated that its many superior features improve set performance and lower the cost of radio assembly and manufacture. Time and use have proved the **AIRLOOP** the most significant post war development in radio components . . . no set builder can afford to overlook the values **AIRLOOPS** contribute to set performance.

FRANKLIN *Airloop*

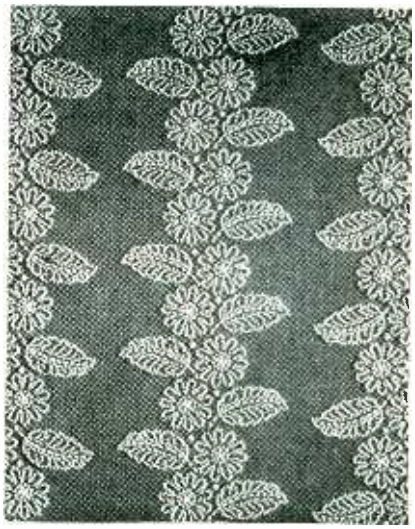
. . . . . flat sheets of copper die-stamped into perfect super sensitive loops . . . are air dielectric throughout . . . are lower in cost . . . are back panel and loop in one unit . . . have high uniform "Q" over entire band . . . have low distributed capacity . . . have 27% greater effective loop area . . . have electrical and mechanical stability . . . increase set sensitivity . . . eliminate individual loop adjustment . . . eliminate haywire.

FRANKLIN AIRLOOP CORPORATION

43-20 34th ST. LONG ISLAND CITY 1, N. Y.

INDUSTRIAL CONTROL

(continued from p 142)



By applying adhesive through a stencil prior to electrostatic treatment, a tufted material having a design such as shown above is formed

means of which "Dotted Swiss" and embroidery effects were obtained. In making such decorated textiles, adhesive is applied with a stencil in the pattern desired, and the fibers are electrostatically pulled into the adhesive. The decorated material is then cured and the process is complete. The decorated fabrics are able to withstand repeated laundering and drycleaning. The process is a development of Behr Manning Corp. of Troy, N. Y.

A pile fabric that feels like velvet has also been developed. This has a backing of cloth, paper, or any other material put up in continuous sheet or web form, such as cellophane, plastics, etc. To this backing a dense, even pile of fibers is adhesively anchored. Methods have been devised for patterning and embossing this material, and many effects have been obtained which cannot be duplicated by conventional textile weaving machinery.

Densities of 300,000 erect fibers per inch are obtained and standard wear tests show ratios of three to one in favor of electrostatically flocked materials.

Fluorescent Lamp Delay Timer

COMMERCIAL fluorescent lamp sizes as well as the standard germicidal lamps can be measured for starting lag with the circuit shown in the accompanying diagram.

First the input voltage is ad-

FIBROUS GLASS TUBING*

IF IT'S TURBO—
IT SAFEGUARDS!

...a special insulator for the really "tough" jobs!

*TURBO Fibrous Glass Tubing in four grades—Single Saturated, 1200 V; Double Dip, 2000 V; Triple Strength, 3500 V; Magneto Grade, 7000 V.

ASK THE DESIGNER! He knows that glass stands near the top of the list of dielectrics which offer greatest resistance to heat, corrosion, flame, oxidation, rot and other deteriorants. Woven of soft, flexible fibrous glass yarn, TURBO Glass Tubing is inherently an excellent insulator. Combined with TURBO varnish impregnants in the manufacturing process, it becomes an ideal material for exceptionally difficult applications. Below are listed some of the other quality TURBO insulating materials extensively used in industry:

Saturated Sleeving..... An all purpose insulation for any but the higher dielectric ranges. Varnish impregnated cotton yarns. Flexible, strong, resistant to acids and oils. Good moisture and flame resistance. Dielectric breakdown—1200 V., per ASTM test.

Plastic Insulated Wire..... Number 18 and finer stranded and solid conductor with a seamless extruded plastic insulation. Surpassing dielectric properties. Resistant to oils, organic solvents, acids, alkalies and oxidation. Minimum shrinkage and burning effects in soldering and potting.

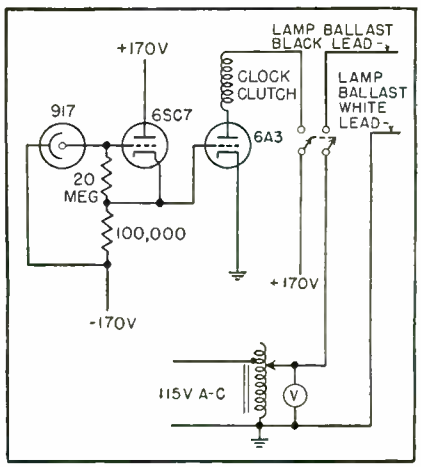
Varnished Tubing..... A superior braided cotton insulation featuring saturation impregnation of flexible varnishes. Strong, flexible, non-peeling, non-cracking, moisture, oil, acid and flame resistant. Dielectric breakdown ASTM test—Magneto grade—7000 V., Radio grade—4000 V.

Mica & Mica Products..... All forms—plate, block segments, films. Rigid control in all stages—grading selection, fabrication and testing insures uniformity and quality in finished products. Meets all tests involving physical and electrical stability. Specific problem-collaboration is invited.

TURBO

WILLIAM BRAND & COMPANY
276 FOURTH AVE., NEW YORK 10, N.Y. - 325 W. HURON ST., CHICAGO 10, ILL.

justed to suit requirements of lamp under test. Then the switch is closed, energizing the clock clutch coil and the lamp ballast. When the test lamp does not light, no current will flow from the 917 photocell through the grid resistor of the 6SC7 cathode follower. Consequently, the cathode follower draws a maximum of plate current, and the 6A3 triode is thus made positive. Low plate to cathode resistance of the 6A3 permits operation of the clock clutch.



Circuit of phototube relay for time lag measurement

When the test lamp lights, current through the 917 photocell causes the grid of the 6SC7 to become negative, reducing the plate current. Since the 100,000-ohm cathode resistor will then have less voltage drop, the 6SC7 cathode becomes negative with respect to ground. The grid of the 6A3 connected to this cathode will be cut off and clock clutch will drop.

The operating current of the clock clutch coil ranges from 40 to 50 milliamperes and is easily handled by the 6A3 tube. Use of the cathode-follower circuit permits the use of high series resistance in the phototube circuit for high sensitivity and convenient cable length between the phototube and the 6A3. The circuit is suggested by Trevor Temple of Sylvania Electric Products. The phototube selected should be sensitive to radiation characteristic of lamp being tested. The cathode follower may be any high mu, low plate current triode. The output tube should be capable of supplying relatively large plate current at nominal plate voltages. A large input resistor to the cathode follower

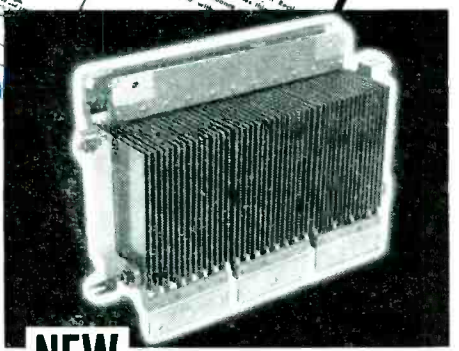
FOR POWER CONVERSION AC to DC

Specify Federal's Standard Rectifier Equipments

WHEN YOU NEED D-C from an A-C source, consider the time - and money-saving advantages of Federal Selenium Rectifiers. They operate *silently*, without tubes or moving parts which require frequent replacement. They're ruggedly constructed to withstand shock and vibration. Service life is practically unlimited, with almost no attention or maintenance. And they run *cooler*, too —start *instantly* when the power is turned on.

The Selenium Rectifier is an IT&T development, pioneered and perfected in this country by Federal. And Federal rectifiers have given years of outstanding service with all types of equipment in all branches of industry — every unit backed by many years of experience in design and manufacture.

Made by America's Largest and Oldest Manufacturer of Selenium Rectifiers!



NEW 48-plate Federal Selenium Rectifier provides more power output in less space than any previous unit of its type.

Federal Telephone and Radio Corporation

In Canada:—Federal Electric Manufacturing Company, Ltd. Montreal.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N. Y. C.

An IT&T Associate — Federal Telephone & Radio

Newark 1, New Jersey

may be used, particularly if available radiation is small. The value of the cathode resistor is not critical, but it should not exceed 0.5 megohm. Adjustment of clock clutches may be required, since, as they are supplied, there is a wide range in the values of pull-in current.

First Factory F-M Radiophone

FIRST INDUSTRIAL plant authorized by the FCC to use two-way radiophone is that of the Haskell and Barker freight car plant of Pullman-Standard Car Manufacturing Company. The installation consists of a Motorola central station and six mobile sets. Four receiver-transmitters are located in 45-ton diesel switch engines, while two more have been installed in locomotive cranes, used to unload materials at production lines or to perform routine maintenance. The central control station is housed in a special sound-proof room in the scale house of the plant.

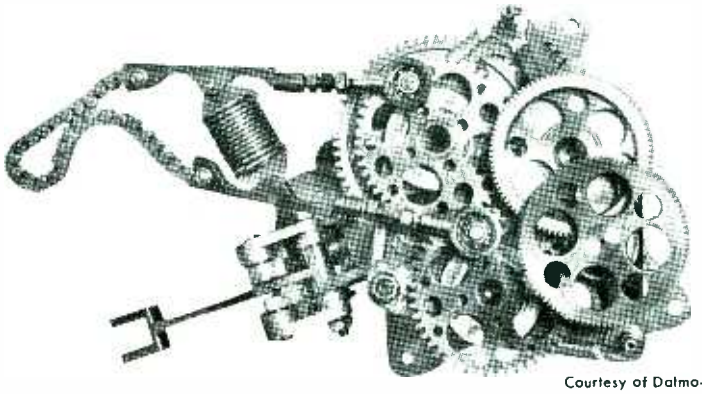
The switch engines and cranes are used on more than 22 miles of criss-crossed track that traverse the 80-odd acres occupied by the big Haskell & Barker plant. In the past, where and when this equipment would be needed and used made work schedules a difficult problem. When emergencies arose, it took the yardmaster an hour or more to locate an engine or crane and get it where it was needed, wasting many man hours on the

Manufacture of freight cars is speeded up by Motorola two-way f-m radio equipment at Pullman-Standard Car. Yard cranes and locomotives used to unload materials at production lines are controlled from a central station

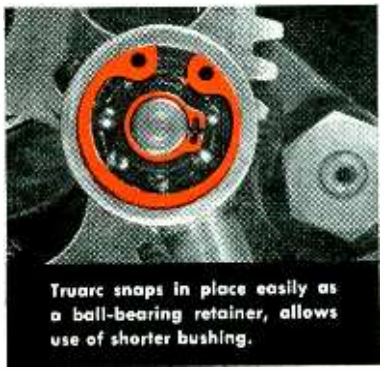
36 TRUARC rings reduce weight, eliminate parts in complex radar aircraft antenna!

● Waldes Truarc Retaining Rings cut machining, assembly, maintenance time

Tiny rings easily installed keep link pins in position, are easily removed for maintenance.



Courtesy of Dalmo-Victor



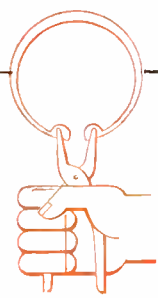
Truarc snaps in place easily as a ball-bearing retainer, allows use of shorter bushing.

Gears stay secure: Truarc saves space in this gear and worm application.

Assembly in cramped space with practically no clearance is simplified with Truarc ring.

"TRUARC NOT ONLY REDUCES WEIGHT IN OUR APS-4 AIRCRAFT ANTENNA," states Dalmo-Victor, of San Carlos, California, "but also saves numerous machining, drilling and threading operations and reduces assembly and maintenance time. Waldes Truarc Retaining Rings are easy to install and remove, give equal pressure over a continuous surface because of their perfect circularity, and eliminate large numbers of tools hitherto required. They do not deteriorate under the most rigorous operating conditions."

Wherever permanent maintenance of tolerance is important, Truarc rings keep moving parts in accurate relationship. In all industries, designers find Truarc a better way of fastening machine parts; production and maintenance men find Truarc cuts costs. Send us your drawings; Waldes Truarc engineers will be glad to show how Truarc can help you.



WALDES
TRUARC
U. S. PATENT RE. 18,144 AND OTHER PATS. PEND.
RETAINING RINGS

● *Send for New Truarc booklet, "New Development In Retaining Rings"*

Waldes Kohinoor, Inc., 47-10 Austel Place 18-L
Long Island City 1, N. Y.

Please send booklet, "New Development In Retaining Rings" to:

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State____

WALDES KOHINOOR, INC., Long Island City 1, New York

production line. With radio equipment, the yardmaster keeps track of every locomotive and crane and directs it in a matter of seconds.

The equipment is frequency modulated and operates in the new 152-162-megacycle band. Solid ground-wave coverage within the operating area of the plant is expected. The diesel locomotive installations use a generator connected directly to the engine, which operates a standard battery system, supplying power for the radio. Steam cranes have a six-volt gasoline driven generator supplying the power.

Ultrasonics, A New Tool

THE EARLIEST study of ultrasonic vibrations is credited to the German, Koenig, who produced tuning forks in 1876 capable of 90,000 vibrations per second. The Galton whistle developed by Edelmann produced 100,000 vibrations per second by means of air forced into a cylinder with a movable piston.

Magnetostriction was discovered by Joule when he found that a magnetized bar, brought into a magnetic field, changed in length and, if the changes were rapid, the bar would emit waves of high frequencies.

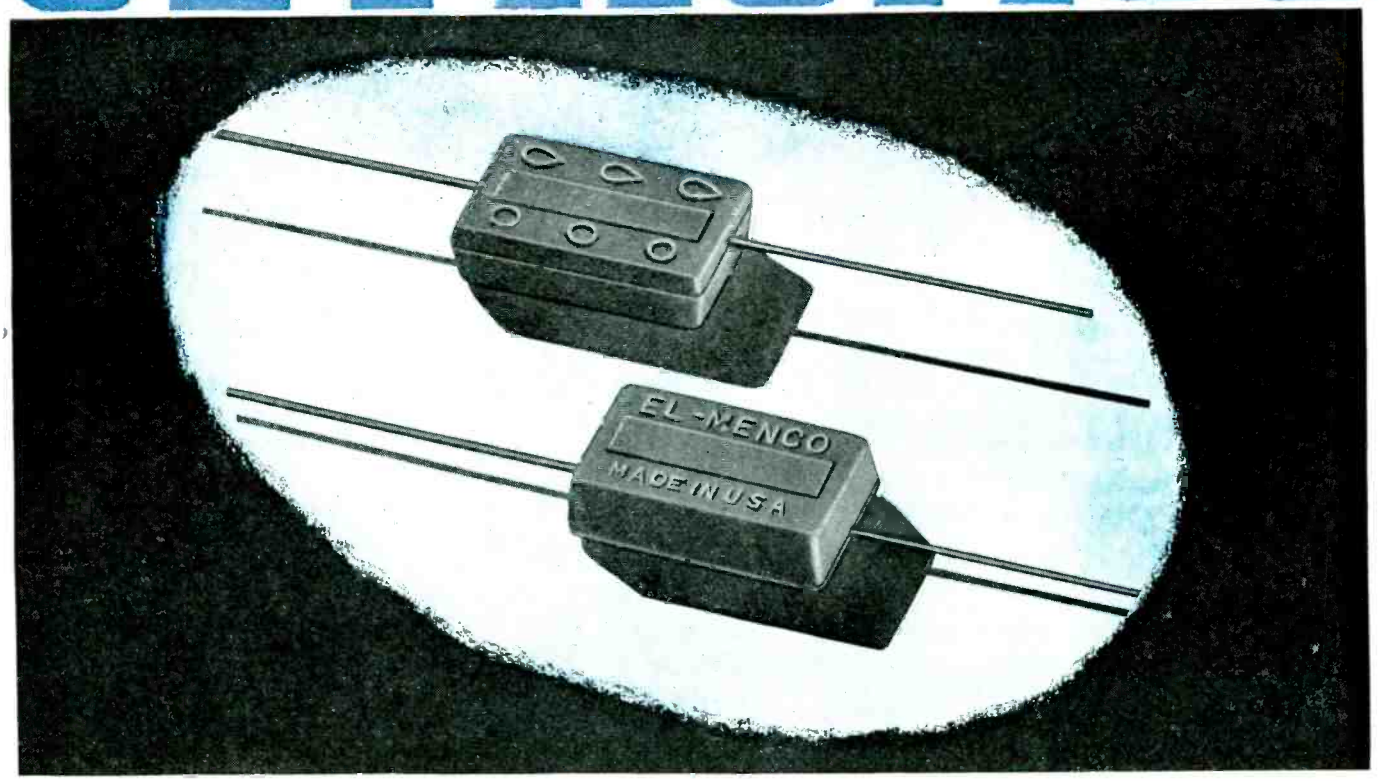
Chief difficulty in the study of these high-frequency waves was the problem of a suitable generator. Before World War II, ultrasonic generators were available to German manufacturers but these were very expensive, difficult to obtain, and were unsuited for general use. One of the first practical ultrasonic generators available was perfected by Langevin, who developed the submarine detector. The piezoelectric method originated with the Curie brothers in 1880.

A wide-spread inquiry into the principles of ultrasonics has been undertaken by many laboratories and a considerable amount of observed ultrasonic phenomena has indicated a large variety of industrial and other applications. Many industrial laboratories are unaware of what others in the same fields of research are achieving and to help disseminate useful information, some of the phenomena reported by Televiso Products Company are given below.

Immiscible liquids, such as water

EL-MENCO

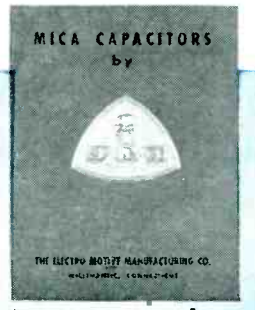
GOOD PRODUCTS BUILD GOOD NAMES



Because the makers of EL-MENCO Capacitors have always insisted on quality at any cost, the name EL-MENCO is now recognized as the identification mark of leadership.

EL-MENCO Capacitors – Molded Mica – Mica Trimmer. We are bending every effort to satisfy all manufacturers who want these quality products. Send us your specifications and we will do our level best to supply you.

THE ELECTRO MOTIVE MFG. CO., Inc. Willimantic, Conn.



Our new catalogue for manufacturers and engineers is now available . . . send for your copy.

MOLDED MICA **EL-MENCO CAPACITORS** MICA TRIMMER

Foreign Radio and Electronic Manufacturers communicate direct with our Export Department at Willimantic, Conn. for information.

and oil, or water and mercury, can be transformed into stable emulsions by treatment with intense ultrasonic waves. Experiments reveal that absorbed gases have a stabilizing effect in water-mercury emulsions thus produced. At frequencies between 300 and 400 kilocycles, very fine emulsions of mercury, tin, sulphur, copper, lead, bismuth, silver, and paraffins can be produced in water.

Fine Grain Film

The action of ultrasonics on photographic emulsions improves the stability and increases the resolving power and sensibility of the film. The injurious grouping of grains in the photographic emulsion is not only prevented by ultrasonics, but when present is even abolished. Thus, this application may result in finer-grain film as well as in increasing the speed of present-day film.

Considerable promise lies in the application of ultrasonics to the manufacture of catalytic agents. Several effects have been observed in the ultrasonic dispersions of metals in liquids. If a cathode is subjected to ultrasonic waves during electrolysis, the deposited metal is flung out into the liquid in a dispersed form at high speed. Practically all metals which can be separated by electrolysis can be dispersed in this way and the degree of dispersion can be controlled by the power of the ultrasonic waves, the electrode material, and the cathode surface.

Oxidation

Chemical effects of ultrasonics may be accompanied by a slight heating effect yet reactions are produced which cannot be duplicated by heat. Strong oxidation reactions, for example, are produced by ultrasonics in an aqueous solution of carbon tetrachloride in the presence of potassium iodide and starch. The blue color of the starch appears immediately. Unstable substances such as nitrogen tri-iodide (NI_3) will explode when subjected to the ultrasonic waves.

Highly polymerized molecules can be split up at around 700 kilocycles. Starch can be transformed into dextrine, and substances like gelatin and gum can be decomposed. It is possible that ultrasonics can

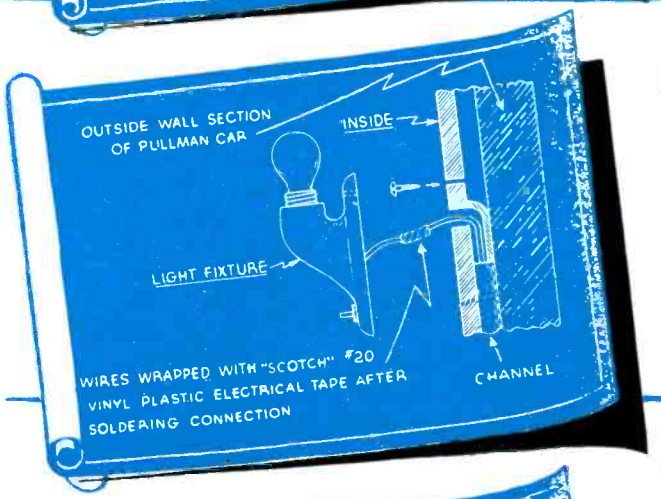
A new Electrical Tape that is simplifying the manufacture and maintenance of Electrical Equipment

SCOTCH *Electrical* TAPE

WITH VINYL PLASTIC BACKING

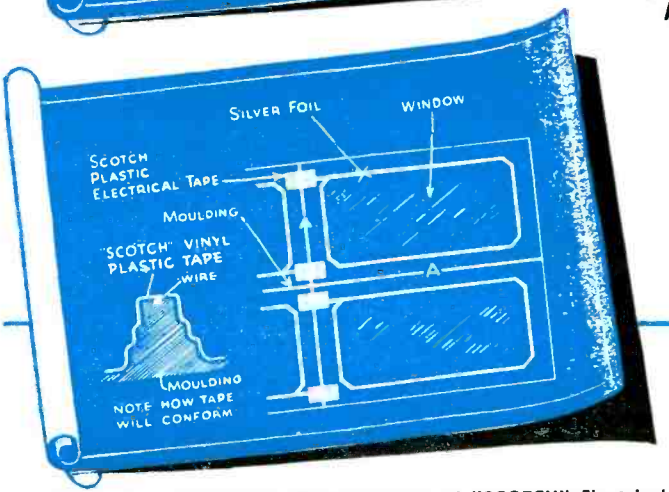
A FAMOUS MAKER OF CONTROL INSTRUMENTS

uses "SCOTCH" Electrical Tape with Vinyl Plastic Backing in place of string lacing to fasten wire harnesses. They band the harness every two inches with the tape, also at each place where a lead comes off. The new method saves time, makes a neater job, produces a more flexible cable.



A GREAT RAILROAD SYSTEM

uses "SCOTCH" Electrical Tape with Vinyl Plastic Backing in equipment maintenance. It takes the place of the rubber and friction tape combination in "over-stuffed" junction boxes. Another use is splicing wire to lighting fixtures to permit splice to fit easily into wire channel, replacing bulkier tapes.



A MANUFACTURER OF BURGLAR ALARMS

facilitates construction, minimizes upkeep and promotes uninterrupted efficiency of his equipment by using "SCOTCH" Electrical Tape with Vinyl Plastic Backing to protect soldered joints on windows, replacing a tape that absorbed moisture and had a tendency to dry up and fall off, particularly after the window was washed.

There are over thirty different types of "SCOTCH" Electrical Tapes, with backings and adhesives to cover an extremely wide range of electrical construction and repair requirements. Write for complete information. If you wish, a "SCOTCH" Tape engineer will call.

"SCOTCH" is the registered trade-mark for the adhesive tapes made in U. S. A. by

MINNESOTA MINING & MFG. COMPANY

THE 3M COMPANY

900 Fauquier Avenue SAINT PAUL 6, MINNESOTA

be employed in the refining of petroleum to accomplish the same results now obtained by cracking. On tests using paraformaldehyde, a breaking-up action takes place.

Melts, Gels

The effect of ultrasonics on gels is of considerable value. Iron hydroxides can be liquefied by ultrasonic treatment, but no permanent change takes place in the gel. Apparently, the liquefaction of gels is caused by the creation of cavities and their collapse. The peptization of a gel in liquid is accelerated.

Melts such as tin and aluminum solidify more rapidly when subjected to ultrasonics, and the structure has a finer grain after such treatment. Considerable work in this field has been done in an effort to speed the nitrogen hardening of steel.

Liquids can be degassed by ultrasonics because the liquid expands under treatment, thus reducing the pressure and allowing the dissolved gas to emerge. A possible commercial application here is the production of fused metals free from gas inclusion.

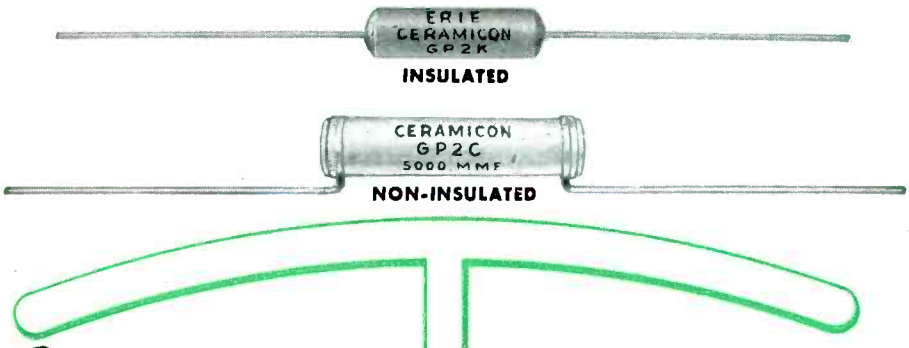
A coagulative effect has been noticed on aerosols. Since substances such as dust, smoke, mist, etc., are merely dispersed solids or liquids in a finely divided state in a gas, this application of ultrasonics may achieve the smokeless city.

Organic Matter

Reminiscent of so-called death rays, small fish and frogs are killed instantly by supersonic exposure. In a physiological salt solution, red corpuscles are quickly destroyed. Effects on bacteria are inconsistent to date—in some cases a diminution in virulence occurs and in others an increase is observed.

Experiments in the sterilization of canned foods, liquids, and dry cereals have achieved complete results in many instances. Another food application of ultrasonics lies in its use as a homogenizing process in the production of milk and similar products. Paint, for example, can be homogenized with ultrasonics. Paint mixtures thus treated have been found to be smoother and to last longer than those not treated. Drying qualities are also improved.

Have You Tried Ceramic Condensers for General Purpose Applications?



Specify Erie "GP" Ceramicons

REG. U.S. PAT. OFF.

for best performance

Many leading radio manufacturers have already switched to ERIE "GP" Ceramicons for general purpose applications. These ceramic condensers have all the well-known dependability of other ERIE Ceramicons with their sturdy compactness and ease of installation, *plus* an unprecedented economy for general purpose applications.

ERIE "GP" Ceramicons are designed for practically all applications in which the condenser is not directly frequency determining; for AVC Filtering, Resistance-Capacitance Audio Coupling, Tone Compensation, Volume Control R.F. By-Passing, Audio Plate R.F. By-Passing, Oscillator Grid Coupling, R. F. Coupling, Antenna Coupling. The production of large quantities at one time of a given capacity value accounts for their economical price . . . *there is no sacrifice in quality.*

Condensers classified as GP1 have a temperature coefficient between +130 and -1600 P/M/°C and are available up through 150 MMF. Condensers classified as GP2, manufactured in capacities of 120 MMF and higher, may include all of the above dielectrics and, in addition, the ERIE Hi-K type.

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. Write for full details.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • • TORONTO, CANADA

(continued from p 146)

Fig. 2B. Type A, represented in Fig. 2A by the FG178A, has a circular-plate anode with the cathode some distance away on the axis of the anode so that the magnetic field can be concentrated at the cathode. The spectrum of this type structure has high low-frequency noise, with no peak and a steady decrease in

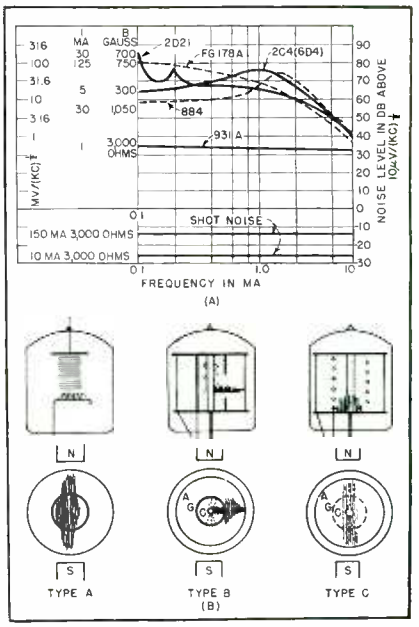


FIG. 2—Characteristic noise from several types of gas tubes

level as the frequency increases. The Type B tube, represented in Fig. 2A by the 884 and the 2C4(6D4), has closer spacing and the cathode is surrounded by the anode structure so that both anode and cathode are in a strong magnetic field. The grid is a solid sheet of metal completely surrounding the cathode except for a small slit which defines the current beam. The spectrum obtained with this structure shows a maximum in the vicinity of one mc. Type C, not represented in Fig. 2A, is similar to Type B except that the grid is an open wire structure. With this type tube (Dumont 6Q5G) it was not possible to eliminate the oscillations for any orientation of the magnetic field. Similar difficulties with the oscillations were found with the 2050 and 2D21 gas tetrodes.

The characteristics of the various types of tubes studied with transverse magnetic field are summarized in Table II. Representative values are given. For most types there is wide variation between

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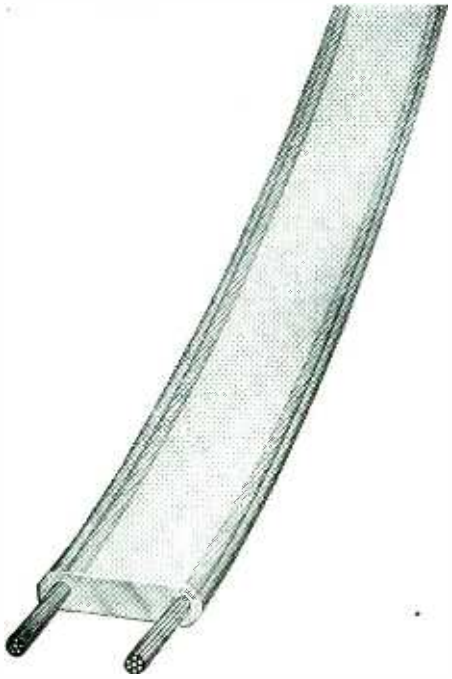

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tubes. Great uniformity was found in the 6D4 tube, with maximum deviations between tubes of the order of one db or less.

(Work reported in this paper was done in whole or in part under Contract No. OEMsr-411 between the President and Fellows of Harvard College and the Office of Scientific Research and Development.)

Negative Impedance

A THERMISTOR is made to develop an impedance having a negative resistance and an inductive reactance. A shunt containing positive resistance and capacitive reactance is proportioned to neutralize the inductance of the thermistor, leaving just negative resistance at the operating frequency. Bias for the thermistor is supplied from a circuit having a battery, variable resistance and reactance, the reactance giving the bias circuit a high impedance so that it does not load the negative impedance portion of the circuit appreciably (U. S. Patent 2,410,076 granted October 29, 1946 to Kenneth S. Johnson, assignor to Bell Telephone Labs.).

Shielding Filters for Insertion Loss Measurement

By GERSHON J. WHEELER
Radio Engineer
Boston, Mass.
Naval Research Lab. Field Station

MEASURING INSERTION LOSS of filters is really a problem in shielding, especially at high frequencies. Radio-frequency coupling between units of the measuring equipment may cause incorrect results and lack of reproductibility, which can be prevented only by an unbroken shield.

The method of shielding developed at Radiation Laboratory, MIT will be described, but first, for a better understanding of the problem, the electrical arrangement will be outlined. A typical set-up for making insertion loss measurements is shown in Fig. 1. Pad No. 1 terminates the generator output in its proper impedance and the filter input in twenty ohms. Pad No. 2 terminates the filter output in twenty ohms and isolates the receiver. (Twenty ohms on each

side of the filter is an arbitrary value which is used extensively.) Measurements are made with the filter in and out of the circuit, adjusting the attenuator so that the

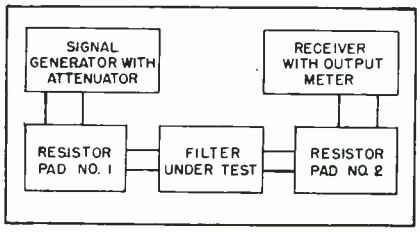

FIG. 1—Basic method of measuring insertion loss of filters is to determine generator output necessary to give same reading of output meter at receiver with and without filter in circuit. Unless complete shielding is used results are not reliable

receiver output is the same for both conditions. The ratio of the signal generator output voltages, expressed in decibels, is the insertion loss of the filter.

Filter Shielding

The filter is mounted on a brass plate, either by soldering or by mounting lugs, in such a manner that the input and output bushings are on opposite sides of the plate. This plate is placed in a copper box which it divides into two completely shielded compartments as illustrated in Fig. 2. Good electrical contact between the plate and the box itself is accomplished by means

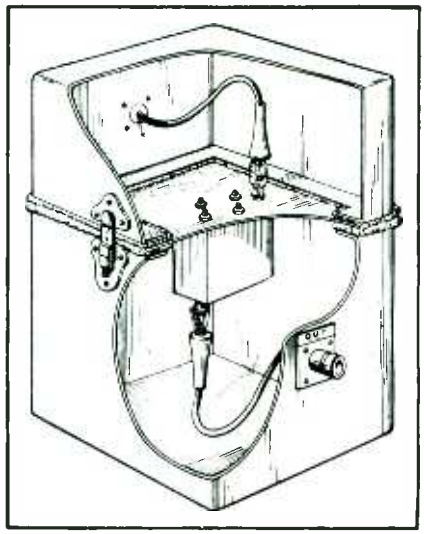

FIG. 2—Filter is mounted on plate inside shield box

of special resilient woven metal gaskets (manufactured by the Metal Textile Corporation). Connections to the filter are made by clip leads. These leads are clipped to each other when the filter is out.

The resistance pads may be built

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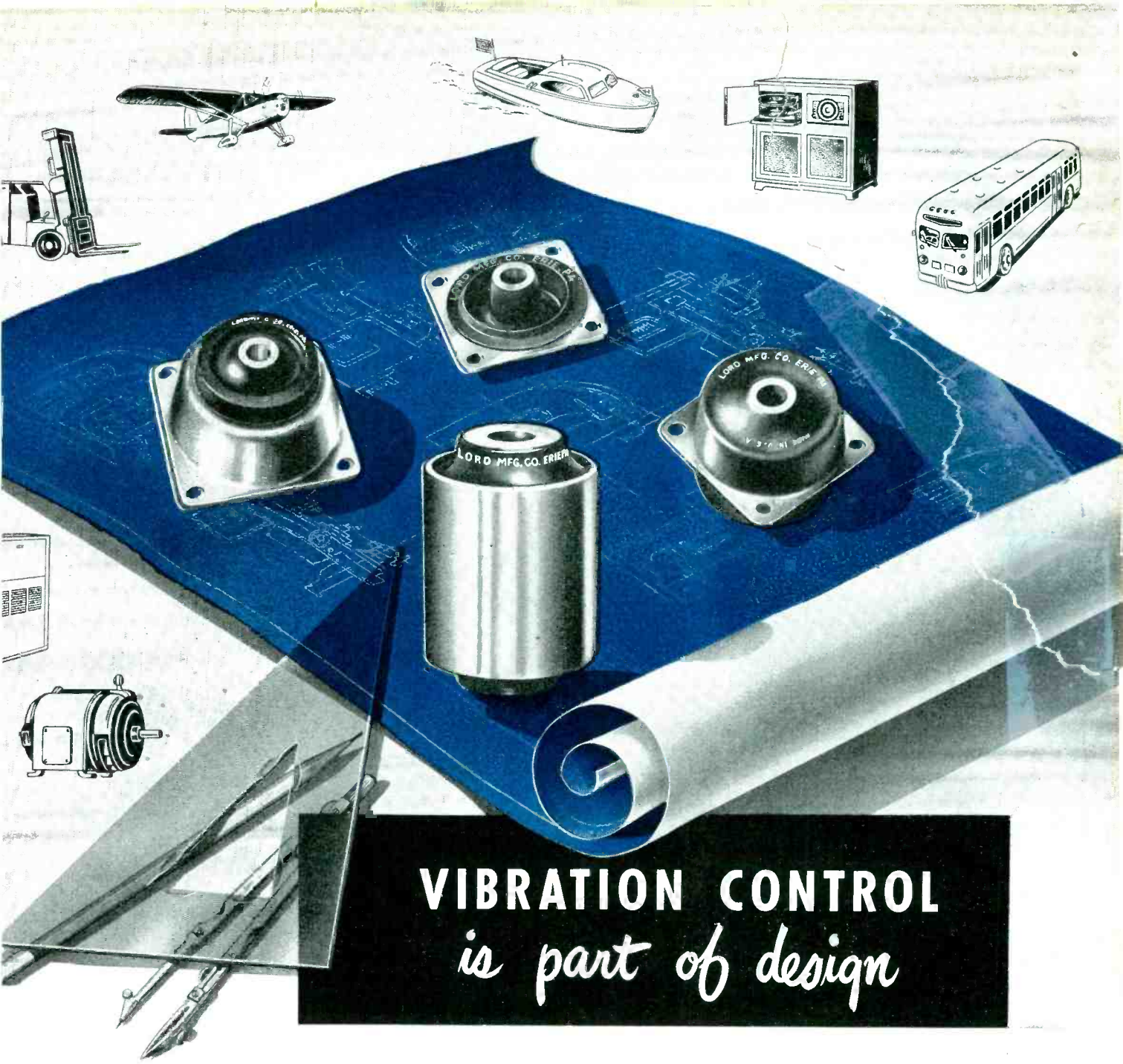

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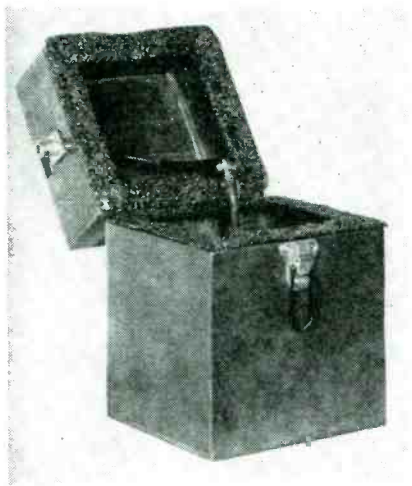
into the box or in small brass tubes which fasten to the connectors outside the box. Concentric cables are used between components in the circuit. These cables are terminated in connectors having good shield conductivity, such as type N connectors.

The box may be used with any standard signal generator and any standard receiver covering the frequency range desired. Sensitivity of the system is limited only by the resistance pads and the sensitivity of the receiver used. The box itself presents no further limit on the over-all sensitivity.

The shielding has been found ef-



Filter to be measured is placed inside metal shield can

fective at all frequencies measured (up to 400 mc). No trace of leakage could be detected at any frequency with an electromagnetic probe. Consequently, the system can be left ungrounded. Measurements made with and without a ground connection checked over the whole frequency range.

The box is especially useful when many filters are to be measured. Each filter is mounted on its own brass plate. One reading is obtained with no filter in the circuit and then one with each filter in the circuit. The reading with each filter is then compared to the reading with no filter. The technique is accepted as standard by the Joint Army-Navy Committee on Radio Noise Filters.

Noise Suppression Circuit

BY BALANCING noise voltages in the output circuit of a diode demodulator against each other, ampli-

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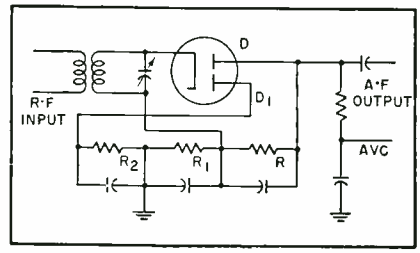

Second anode of detector diode is used to develop noise suppression voltage

tude noises are suppressed. In the circuit shown in the accompanying diagram, R and R_1 are identical (0.1 meg) and R_2 is very large (10 meg). The voltages across R and R_1 are of opposite polarity to ground. In the absence of noise, the a-c and d-c voltages across R_1 are negligible compared with those across R_2, and the voltages across R are approximately equal to the sum of those across R_1 and R_2 so that nearly the full signal voltage developed by diode D appears at the output. A noise impulse is shorted by the very large capacitor shunting R_2 but appears across R_1 where it nullifies the equal but opposite noise impulse appearing across R. (Recent Inventions, *Wireless World*, p 384 December 1946).

Experimental UHF Equipment

TRANSMITTERS AND RECEIVERS operating on 303 and 332 mc (about 100 and 90 cm) and having novel circuits are being used as an experimental radio-telephone link between two plants of N. V. Philips in Holland. The link carries 48 3-kc wide telephone channels spaced, by single- sideband modulation of subcarriers, between 12 and 204 kc, which frequency modulate the r-f carrier. The transmitter consists of a reactance-tube push-pull modulator, a feedback stabilized oscillator, frequency multipliers, and power amplifiers. The receiver is a superheterodyne with a push-pull triode converter, intermediate amplifiers, limiters, discriminator, and audio amplifiers. Although most of these circuits are engineered from conventional designs, the coupling network in the transmitter power amplifier and the triode frequency converter in the receiver are unusual.

Because of the importance at high frequencies of interelectrode

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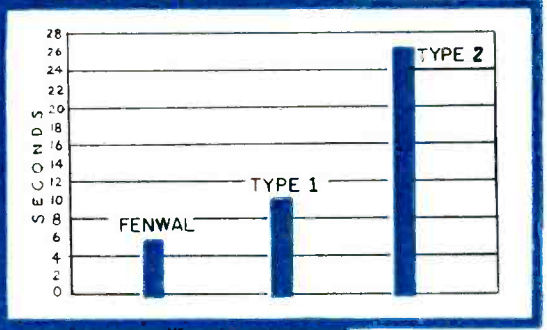

RESPONSE TIME IN SECONDS

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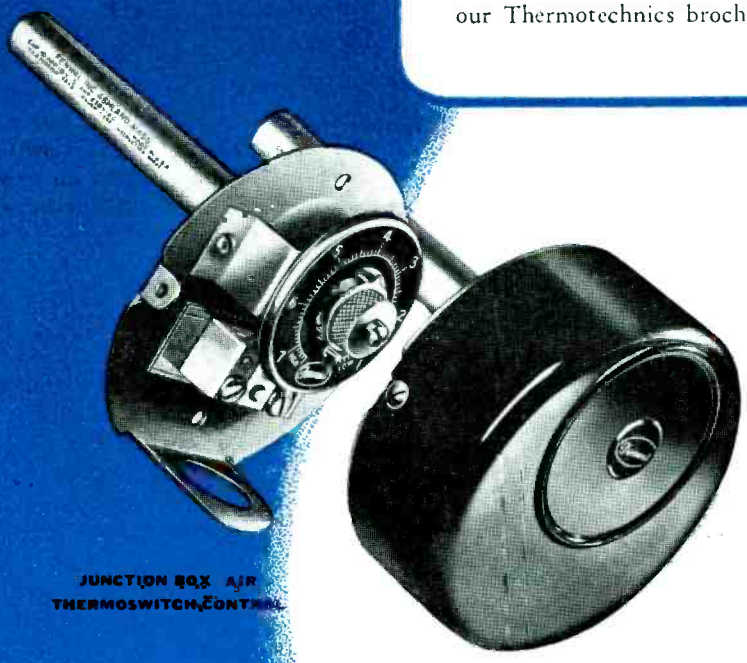

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capacitances and lead inductances, conventional coupling is ineffective. Furthermore, in laying out the transmitter and receiver it was desirable to use several chassis, dividing the circuit between stages. To provide a h-f coupling that would permit wide separation of stages, a new coupling network was developed.

Ordinarily the anode of one amplifier is connected directly, so far as r-f is concerned, to the grid of the following tube; between the connecting point and ground a high impedance, usually a resonant circuit, is connected. Inductance of tube leads makes direct r-f connection impossible at high frequencies, and interelectrode capacitances reduce the maximum obtainable high impedance to ground. However, if the coupling is formed by the interelectrode capacitances C_A and C_G, and the lead inductances L_A and L_G, augmented by an external series inductance L, as shown in Fig. 1A, a tuned circuit will be formed.

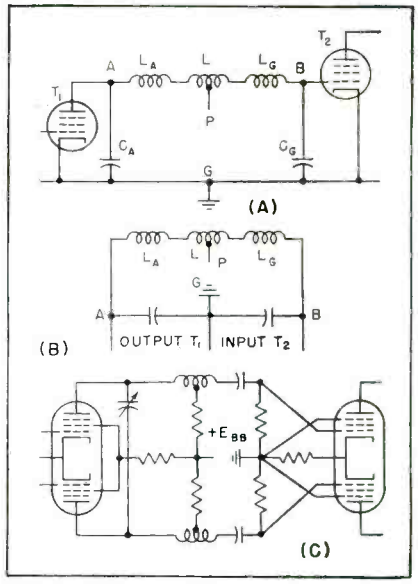

FIG. 1—UHF amplifier coupling network utilizes stray reactances

Furthermore, this tuned circuit will have two points at r-f ground potential; one between the two capacitors, the other on the tripart inductance, just where being determined by the magnitudes of the two shunt capacitances, as shown in Fig. 1B. With the capacitances and inductances proportioned so that the neutral point is on the external inductance, the circuit can be broken and a lengthy connection inserted. As the connection is at r-f ground, it need not be shielded and

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therefore will not introduce much additional shunt capacitance. If the midpoint does not fall on the external inductance, or if no external inductance is used, the circuit provides coupling, but cannot be broken. The circuit makes effective use of the unavoidable stray reactances within the tube. The network is used in both transmitter and receiver where it is necessary to break the mechanical continuity. A practical adaptation is shown in Fig. 1C.

Triode Converter

At the receiver the signal is passed directly to the mixer. An r-f amplifier is usually desirable to preserve the signal-to-noise ratio, but the mixer circuit that was developed has such low noise that pre-amplification was not needed. Image interference was avoided by choice of the operating frequencies. Omission of the r-f pre-amplifier greatly simplifies the uhf end of the receiver.

Multigrid mixers fail at high frequencies because lead inductances to the shield grids prevents them from remaining at a-c ground. Diode mixers are undesirable because of their low conversion gain. For these reasons triodes were considered for the mixer.

Frequency conversion in a triode, as in any converter, involves three principle voltages: the signal input voltage, the heterodyning voltage (both of which are applied between grid and cathode), and the intermediate voltage (which appears in the plate circuit along with other non-essential voltages). If a push-pull connection of two triodes is used for the converter, two of these three voltages must appear in the circuit in push-pull, and the third must be in the same phase in both tubes.

A symmetrical dipole and bal-

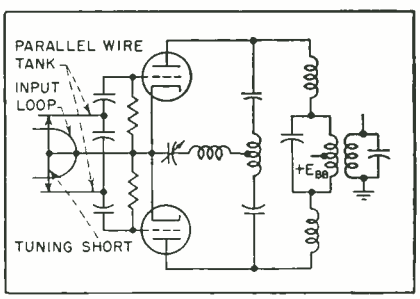
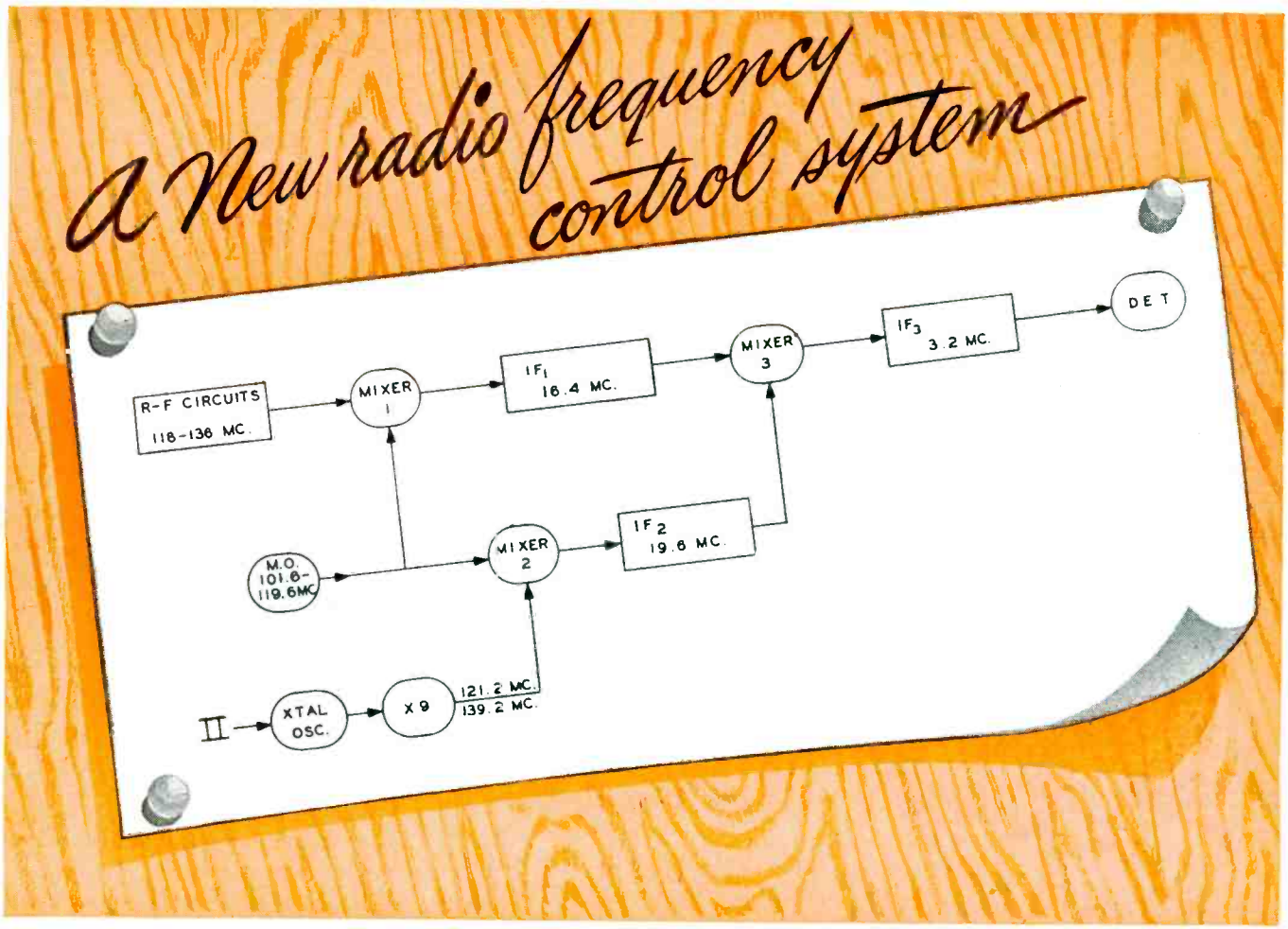


FIG. 2—Triode mixer has balanced input and output and a symmetrical, self sustaining heterodyning loop



The Collins Drift Cancelled Oscillator

The DCO (Drift Cancelled Oscillator) circuit, an exclusive Collins development, is a new frequency control method that meets the needs of modern communication problems. Basically it provides the multiplicity of channels and the freedom from the spurious responses inherent in Master Oscillator operation, but with the stability of a single crystal.

The Collins 51M-2 VHF ground station receiver is the first of a series of Collins products employing the DCO principle. The diagram shown above illustrates the 51M-2 circuit. Injection voltage for the first mixer is supplied by the M.O. operating at the injection frequency. There are no unwanted harmonics as there would be if a low frequency crystal were used to generate the injection voltage. The M.O. also provides the injection voltage for Mixer 2, where it combines with the output of the crystal oscillator and produces IF_2. Mixer 3 combines IF_1 and IF_2 to obtain IF_3. Both IF_1 and IF_2 reflect in the same sense any M.O. instability, hence the M.O. drift is cancelled out. The stability of the receiver is determined only by the 0.005% accuracy of the crystal.

Use of the DCO principle in the 51M-2 results in spurious responses 100 db below that of the desired signal and permits operation of several receivers from a single antenna:

51M-2 SPECIFICATIONS:

Application: single channel ground station reception.

Freq. range: 118-136 mc.

Sensitivity: 1 microvolt r-f input 30% modulated for a 6 db signal to noise ratio.

Stability: 0.005%.

Spurious response: down 100 db.

Avc: output constant within 3.0 db with input range of 1 microvolt to 1 volt.

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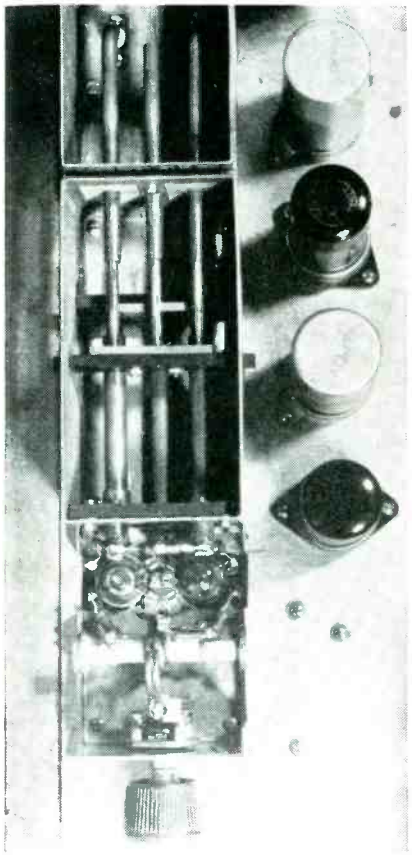
anced line is used for the input, so it is most convenient to apply the uhf signal in balance to the converter. The local oscillator voltage is then applied in equal phase to both tubes. Then the intermediate-frequency output appears in push-pull in the anode circuit. There are thus two loops; a balanced (push-pull) one, and an asymmetrical one arranged as in Fig. 2.

With the asymmetrical circuit, which is not usually tuned to the local oscillator, it is difficult to couple power from the oscillator. An additional series tuning element can be added to resonate the



Triode mixer has low noise

impedance into which the oscillator operates. This oscillator tuning element is added in a part of the circuit through which balanced currents do not flow. Furthermore, because the asymmetrical grid circuit presents a low impedance to the oscillator making it difficult to develop a large local signal on the mixer grids, the input impedance of the mixer grids can be increased at the oscillator frequency by making the asymmetrical anode load slightly inductive. If the plate circuit inductance is properly proportioned, the loop itself oscillates. A

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separate local oscillator is then not needed, which eliminates the noise introduced by a separate tube. As far as the conversion action of the push-pull triodes is concerned, it makes no difference how the heterodyning potential is generated between grids and cathodes; mixing being determined solely by the magnitude of this potential and the nonlinearity of the transfer characteristic.

Just as back coupling was introduced in the asymmetrical loop by placing inductance in the anode circuit that would be reflected into the grid circuit through the grid-anode capacitance as a negative impedance, so back coupling can be used in the balanced circuit to increase the input impedance of the triodes to the uhf signal, thereby decreasing the loading on the input circuit and making it possible to develop a large input potential.

Were the push-pull mixer perfectly balanced, there would be no interaction between balanced and asymmetrical loops. However, in a practical circuit there will be some unbalance and hence interaction. Thus the two circuits cannot lie close in frequency. This consideration determines the intermediate frequency. Too low an i-f would place the two circuits close together in frequency. To render the coupling harmless the heterodyning frequency should be at least one twentieth the incoming signal frequency (*Philips Technical Review*, p 121 April 1946; p 194 July 1946, the first being a description of the transmitter, the second covering the receiver).

Self Balancing Phase Inverter

U. S. Patent No. 2,383,846, Granted Aug. 28, 1945

To JAMES BRUCE CRAWLEY
Radio Corp. of America

UNBALANCE between output voltages of phase inverter circuit used to convert a single-ended circuit to push-pull is corrected by feedback into auxiliary control grids. The circuit, shown in Fig. 1, is for the most part a conventional two-tube phase inverter. Tube V_1 first amplifies the signal. A portion of the output of V_1, preferably equal in

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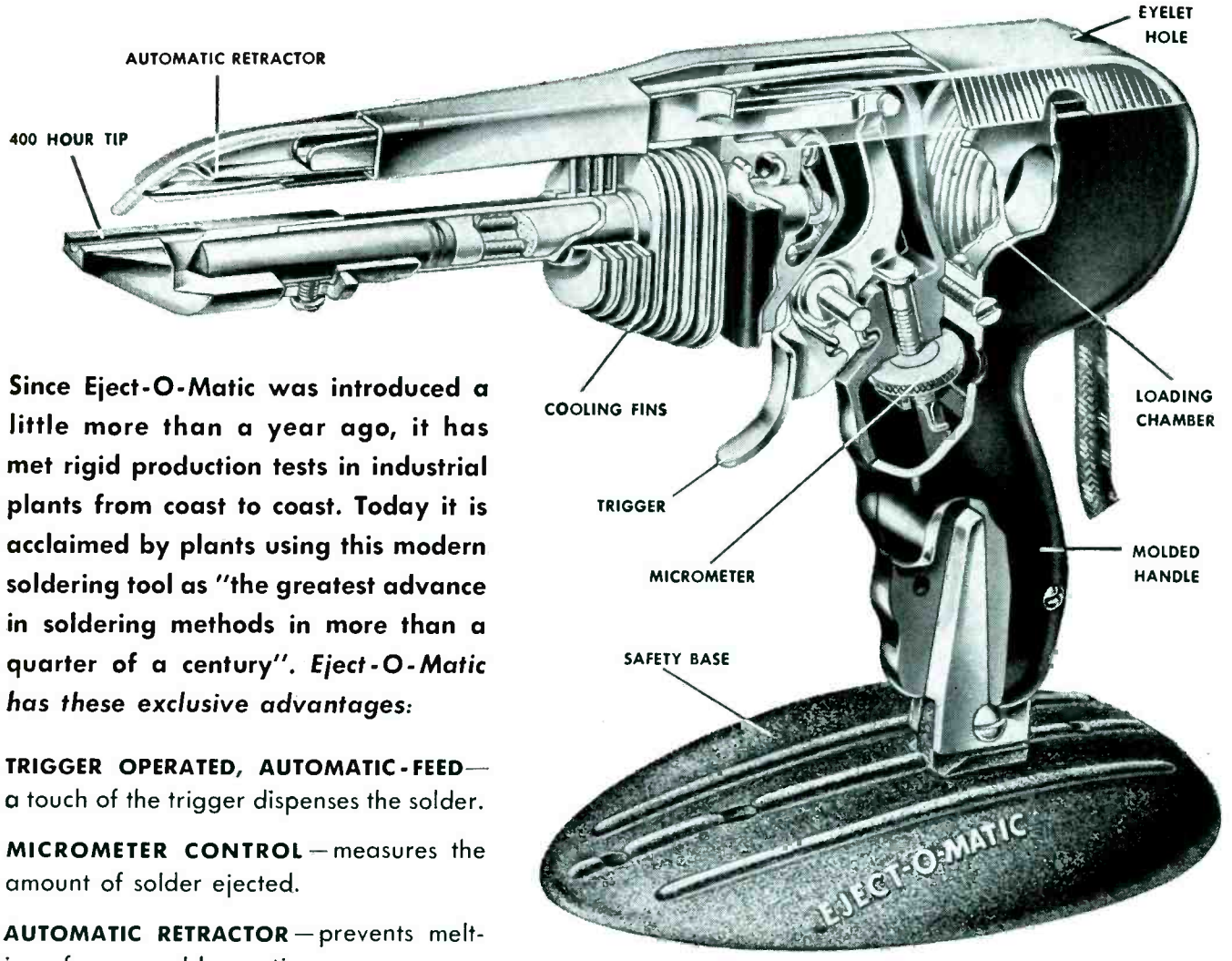

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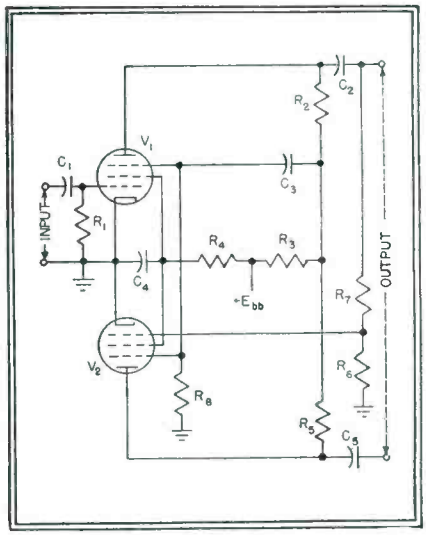


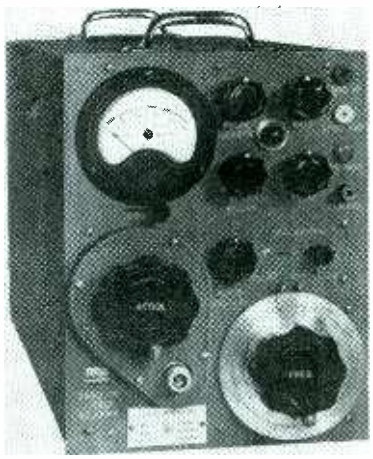
FIG. 1—Duplex feedback preserves balance of inverter

magnitude to the input to that tube, is obtained from potential divider $R_6 - R_7$ and fed to the grid of V_2. Because of the reversal of phase introduced by V_1, the input to V_2, and hence its output, is the reverse of that of V_1, and thus the output of the circuit is balanced about ground.

However, as seen from the circuit, the suppressor grids of the two pentodes used in this inverter are not connected in the usual manner. Resistor R_3 is common to the plate circuits of both tubes. The suppressor grids of the two tubes are connected to each other and also, through d-c blocking capacitor C_3, to the high side of R_3. Any unbalanced voltage in the common portion of the plate circuit of the inverter will thus appear across the suppressor grids of the two tubes. In particular, that unbalanced voltage so fed back will be of such polarity as to cause degeneration in the tube producing the larger signal output and regeneration in the tube producing the smaller signal output. From this feedback action the inverter balances itself.

Output of a high-frequency oscillator is used to test the conductance between elements of vacuum tubes. A cathode-ray indicator tube gives an indication of the loading presented to the oscillator by the tube under test. (2,380,095, Tube Testing Device, Walton De Verter, July 10, 1945).

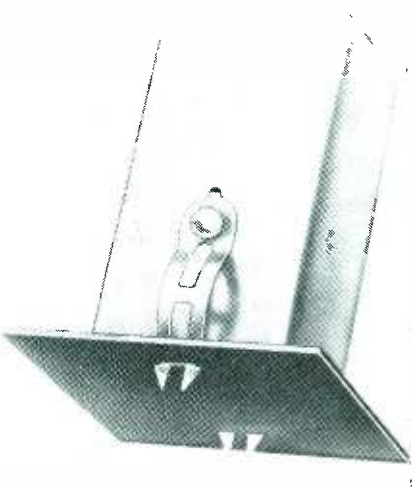
(continued from p 152)



ment, obtaining antenna data or measuring standing-wave ratios, and reading single-stage or conversion gain, signal-to-noise ratios, circuit Q, or transmission line characteristics. The unit will supply accurately known voltages ranging from 0.1 microvolt to 0.1 volt. The r-f output may be continuous, amplitude-modulated, pulsed, or square-wave modulated. Pulse length can be readily controlled between 2 and 50 microseconds, and pulse rate is variable from 60 to 3,000 times per second.

Shield Can Fastener (20)

THE PALNUT CO., 77 Cordier St., Irvington, N. J. The Palnut shield can fastener snaps quickly into chassis holes and automatically locks. It will not let go until deliberately released. When inserted in chassis holes, two pronged ends

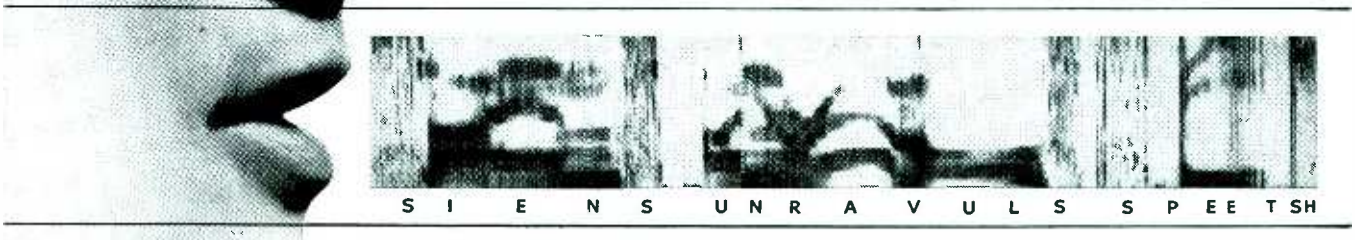


Writing with your voice

Years ago Alexander Graham Bell dreamed of "a machine that should render visible to the eyes of the deaf, the vibrations of the air that affect our ears as sound." He never realized that dream, but his researches led to the invention of the telephone.

Today Bell Telephone Laboratories have turned the dream into a fact – translating the spoken word into readable pictures.

By this new invention of the Laboratories, the talker speaks into a microphone. Vibrations of the voice are unraveled through electronic circuits, and then are reassembled as luminous patterns which travel across a screen. Each syllable of sound has a distinctive shape and intensity.



Science unravels speech

Visible speech is still in its infancy, and is not yet available to the public. But educators of the deaf are now evaluating it. Indications are that the deaf can learn to read the patterns and, by comparing the patterns their own voices make with the patterns of correct speech, can improve their diction.

Patterns of visible speech also provide a means for analyzing and recording sound in the study of phonetics and of languages. Eventually, visible speech may make possible visual telephony for the deaf.

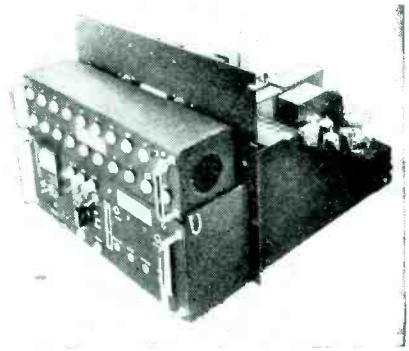
This is but one of many contributions by Bell Telephone Laboratories to the understanding and control of sound.

BELL TELEPHONE LABORATORIES *EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE*

compress to enter, then snap outwardly when pushed through. The prongs grip the underside of the chassis with a continuous spring pull that holds the can firmly to the chassis. When mounted according to specifications, this fastener accommodates a wide range of chassis thicknesses. Variations in hole locations in cans and in chassis thickness are easily taken care of by the long spring arch construction.

Grid Pulse Life Tester (21)

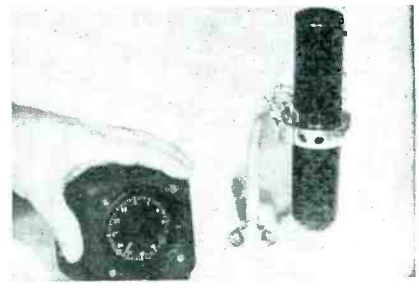
CHATHAM ELECTRONICS, 475 Washington St., Newark 2, N. J. New equipment for testing receiver type tubes under pulsed operating conditions consists of four units. The



modulator unit delivers a positive pulse adjustable from 50 to 350 volts. Pulse current of 10 amperes has a duty cycle of 0.01. Width of the pulse can be varied between 1 and 25 microseconds. Repetition rate is variable between 500 and 2,500 times a second.

Electron Gun Compass (22)

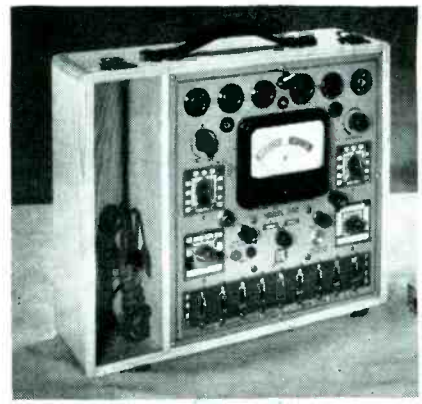
MINNEAPOLIS-HONEYWELL REGULATOR CO., 2753 Fourth Ave., S., Minneapolis, Minn. Containing no moving parts, a new device depends upon an electron beam aimed at a four-segment target to provide direction signals for guiding a ship or plane to a preset course. The magnetic field of the earth makes



the beam deflect to the west, but the compass indicator is oriented to read conventionally north. The Cathotrol can be tied in to an autopilot for exact control of aircraft. Other uses include that of magnetometer substitute in prospecting for oil and ores.

Tube Tester (23)

ELECTRONIC MEASUREMENTS CORP., 114 Liberty St., New York 6, N. Y. The Series 200 mutual conductance



tube tester illustrated checks all tubes according to mutual conductance on a micromho scale that is also marked for "good" and "reject" values.

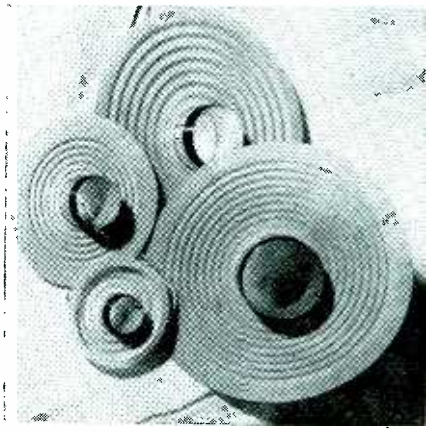
Adjustable A-C Supply (24)

SUPERIOR ELECTRIC CO., 277 Church St., Bristol, Conn. The new voltbox a-c power supply has been designed primarily to meet the needs of electric light company testmen but the many features of this instrument will prompt its use in diversified applications. The unit offers a compact, portable source of metered, continuously adjustable a-c voltage and current. Three ranges of output voltages and two ranges of output current are available. The variable voltage and current feature is achieved by two Powerstate variable transformers operating in conjunction with auxiliary transformers. Voltage and current are varied independently and are electrically isolated from each other. For metering purposes, a triple-range voltmeter and a double-range ammeter are supplied. When it is required to measure external voltages and currents, these meters can be employed for such purposes by throwing the lever-action switches located below

each meter. The circuit has been designed to permit the use of this device on either 115 or 230 volt, 50/60 cycles power lines. The output voltage ranges are 0-30, 0-150, and 0-300 volts while the current ranges are 0-5 and 0-20 amperes. A circuit-breaker offers complete instrument protection.

Aluminum Voice Coil Speakers (25)

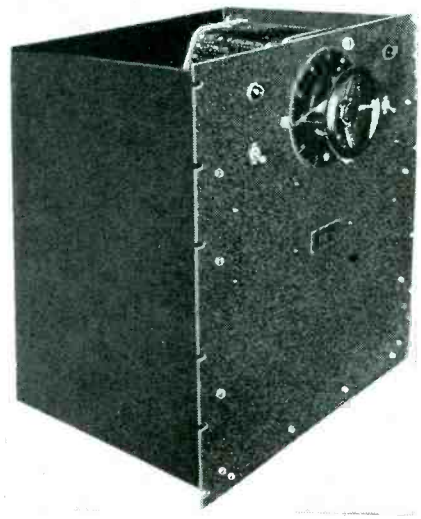
GENERAL ELECTRIC CO., Syracuse, N. Y. The line of loudspeakers currently being manufactured uses an aluminum foil based voice coil, as illustrated. The use of aluminum



offers advantages in that it can handle higher wattages; the voice coil is unaffected by temperature and humidity, the coil will not warp or crack, and better control of gaps is afforded.

D-C Power Supply (26)

SUPERIOR ELECTRIC CO., 177 Church St., Bristol, Conn. The 0-3,000-volt d-c power supply illustrated has been designed for continuous duty, small regulation, and easily ad-



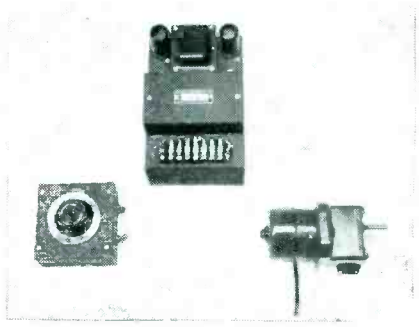
justed output voltage. The maximum d-c output current is 0.5 ampere. It operates from a 115-volt, single-phase, 50/60-cycle source. The power supply uses a full-wave bridge rectifier consisting of four type 866/866A tubes. A time-delay relay is provided which allows the filaments to be adequately heated before high voltage is applied. All major components are either potted or hermetically sealed.

Contact Tape (27)

D. E. MAKEPEACE CO., Attleboro, Mass. Bar contact tape for use on spring contact arms can be supplied by the company, which also provides an assembly service when desired. Palladium and palladium alloys on pure nickel base, silver tape or other combinations can be attached to contact arms to provide low-cost and satisfactory make and break of circuits.

Remote Position Control (28)

YARDENY LABORATORIES, INC., 105 Chambers St., New York 7, N. Y. The Synchro-Link works on the



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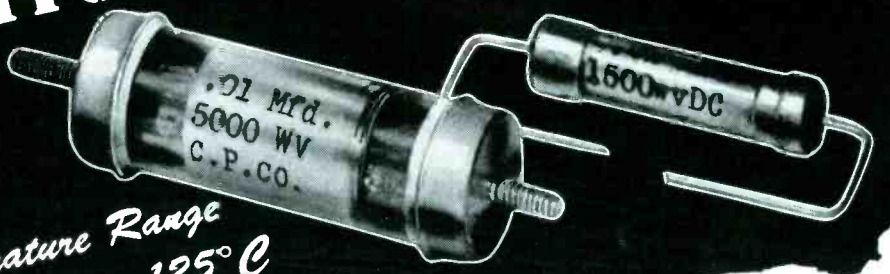

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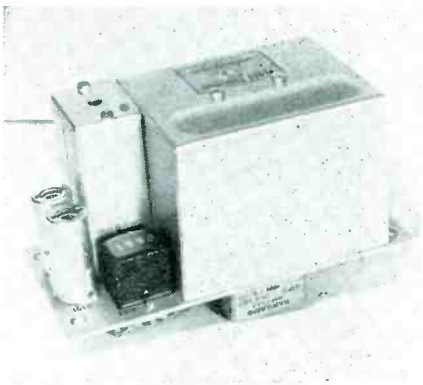
principle of a self-balancing electronic bridge. It consists of a master control with calibrated dial, a vacuum-tube chassis, and the load control potentiometer geared to a motor or otherwise coupled to the load. Several slave units can be controlled by the same master station. Further details are available in a single-sheet leaflet.

Improved Fleet Control (29)

THE HAMMARLUND MFG. CO., Inc., 460 West 34th St., New York 1, N. Y. An improved model of the dial-operated fleet control system for taxis, police, and utility cars



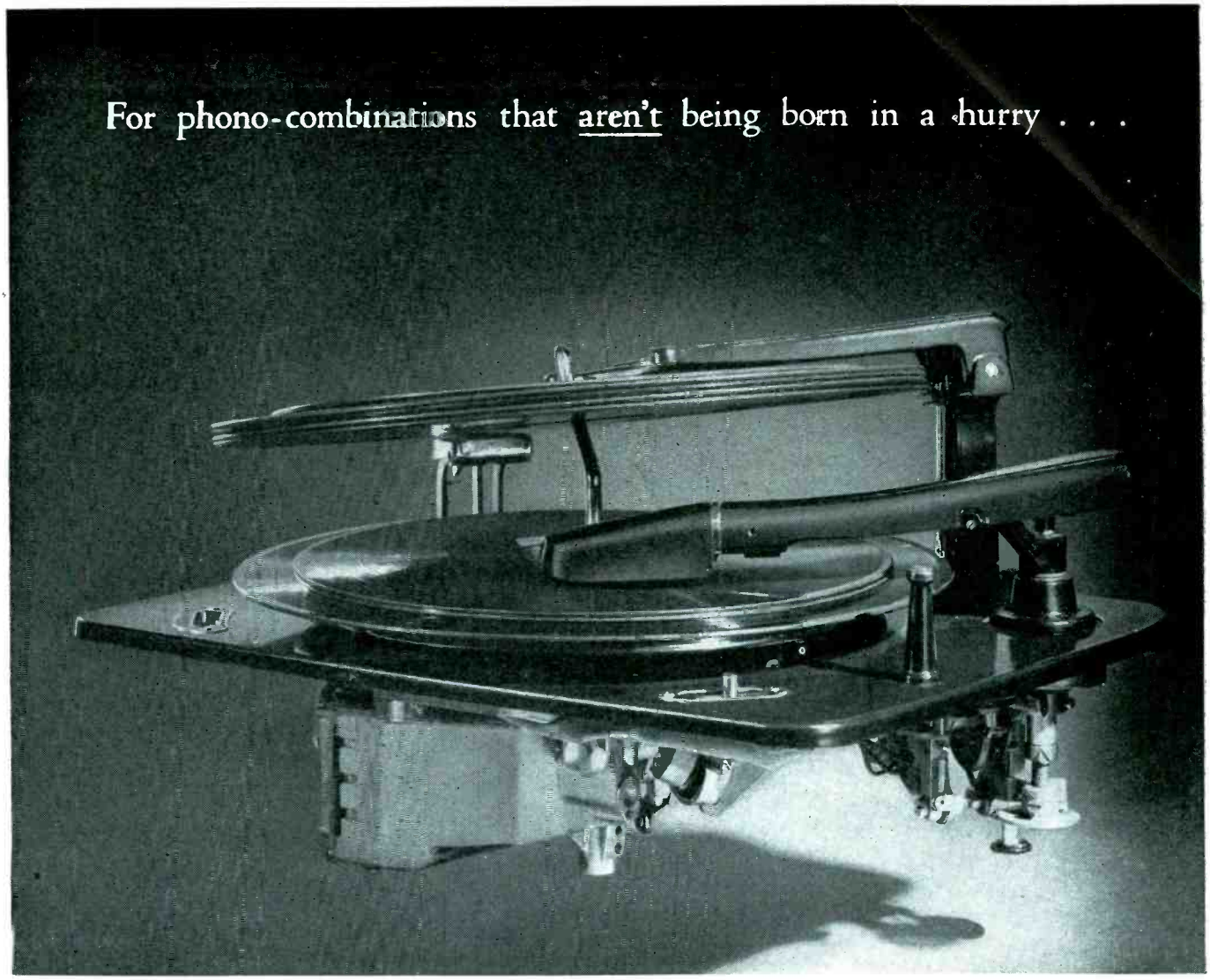
includes a circuit to ring a bell and flash a light when the particular vehicle is called. The light remains on to warn an absent operator on his return that he has been called.

Moving-Coil Pickup (30)

COOPER MFG. CO., 17 Hanway St., London, W. 1., England. A new lightweight moving-coil pickup requires a pressure of 0.5 ounce on the record and has a response essentially flat from 30 to 12,000 cycles. Replacement of the sapphire stylus has been facilitated by use of a special tool. The device is robust enough not to be easily damaged by dropping on the record.

Sound System Pads (31)

GENERAL ELECTRIC CO., Syracuse, N. Y. Wire-wound L-pads and T-pads for sound systems, covering impedance ranges from 8 to 600 ohms, have just been announced. The T-pads may be used as variable attenuators in stable line impedance circuits, while the L-pads



If you manufacture the kind of combination that takes its precious time coming off the drawing board – and off the assembly line – Garrard is your record changer.

For the most part, Garrard changers have been finding their way into those custom-built assemblies where every component is hand-picked, without a sidewise glance at cost. Your finest combinations are made that way, and there is every reason why you can and should select Garrard.

It's as simple as this: with Garrard in your combination, you can feature the changer as you feature cabinetry and tone quality. You can point up the watch-like construction; the exclusive governor-controlled, speed-regulated motor; the non-slip spindle . . . and more. Most important . . . Garrard has the "look" of belonging in distinctive sets.

Send for a sample changer. Garrard Sales Corporation, 315 Broadway, New York 7, New York.

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1. Exclusive speed-regulated, governor-controlled motor
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3. True tangent, jewelled-pivot tone arm
4. Exclusive non-slip spindle
5. Automatic stop
6. Heavy fly-wheel action built into turntable
7. Only one operating control required
8. Full swivel tone arm for changing needles
9. Kind to fragile records; no knives or trick spindles

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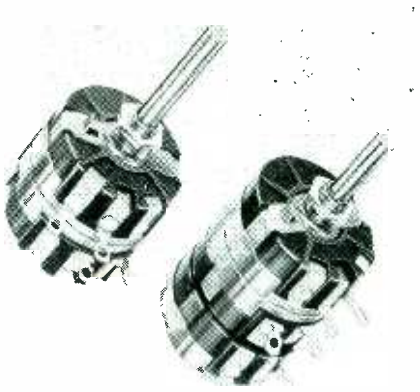
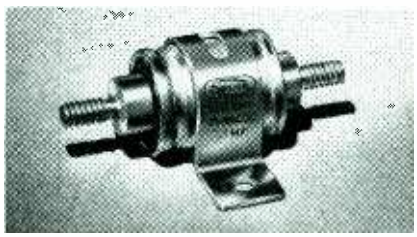


have application as individual volume controls for multiple speakers or as attenuation controls for constant impedance at either the source or load. Rated at a maximum power dissipation of 2.5 watts, the units have a continuous range of from 0.5 to 30 decibels attenuation in 90 degrees of rotation, the last ten percent affording infinite attenuation.

High Current Capacitors (32)

SOLAR MFG. CO., 285 Madison Ave., New York 17, N. Y. Small filter capacitors capable of continuous use at currents up to 100 amperes with line voltages up to 250 volts

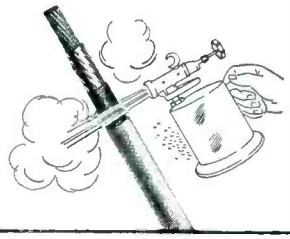


a-c are suitable for 3-terminal network filters to attenuate radio interference from motors and other rotating equipment. Capacitance values up to 0.75 microfarad are available.

Electronic Timer (33)

SPECIAL PRODUCTS CO., Silver Spring, Md. The Speco-Rhein electronic timer is useful for time delay action in timing short intervals and for continuously repeating a definite cycle of time. The new unit is compact in size, and is housed in a cast aluminum case for wall mounting. The standard unit provides timing ranges from 1/10 second to 60 seconds, although other

1 WON'T BURN OR SUPPORT FLAME



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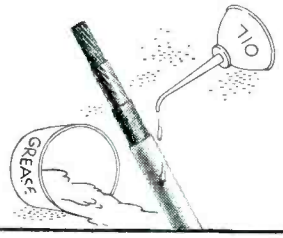
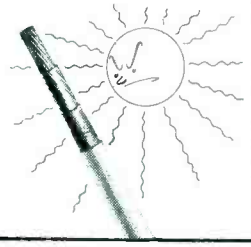


4 RESISTS HEAT AND OXIDATION



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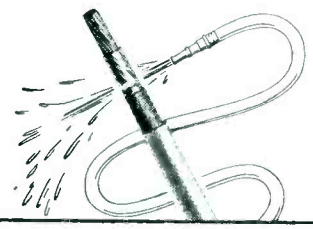
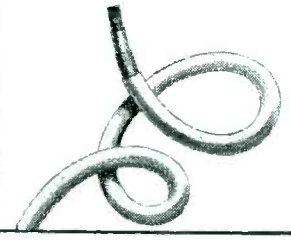


6 REMAINS FLEXIBLE



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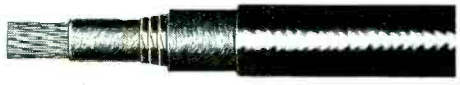
ROCKBESTOS FIREWALL HOOKUP WIRE

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 3,000 volt, also in twisted pair, tripled, shielded and multi-conductor constructions.

ROCKBESTOS THERMOSTAT CONTROL WIRE

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



ROCKBESTOS A.V.C. MOTOR LEAD CABLE

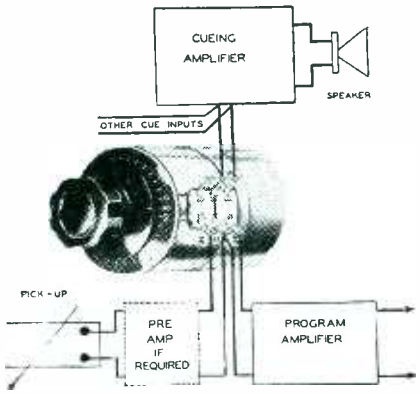
Use this apparatus cable for coil connections, motor and transformer leads exposed to overloads and high ambient temperatures. Insulated with impregnated felted asbestos and varnished cambric, and covered with a heavy asbestos braid, it is heat-proof and resistant to oil, grease, moisture and flame.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

NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.

ranges are available. Interval variations are less than 2 percent in repeat cycle timing and less than 3 percent for as high as 10 percent variation in line voltage. Because of the characteristics of the resistor-capacitor elements the range is spread out in a logarithmic scale, making the dial dimensions wide in the shorter time periods.

Cue-Control Attenuators (34)

THE DAVEN CO., 191 Central Ave., Newark 4, N. J. A new line of attenuators with built-in cueing control transfers program material to



a cueing amplifier at the extreme attenuation position so that a program can be brought in smoothly without manipulation of additional cueing switches.

VHF Power Tube (35)

GENERAL ELECTRIC CO., Syracuse, N. Y. A new vhf power tube, type GL-5513, with a tube output ranging to 2 kw, has been designed for television and f-m applications under class B and class C conditions. The new tube can be operated up to 220 megacycles and it may be adapted to dielectric heating services employing the higher frequen-

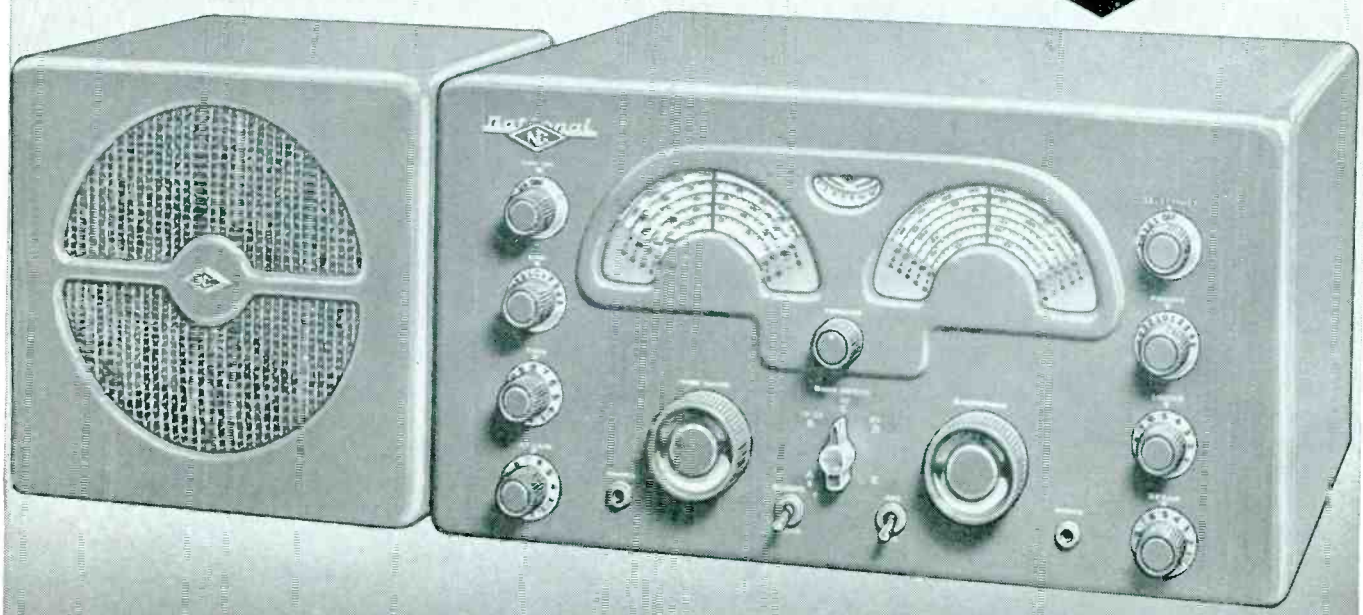
SOON . . . THE NEW NATIONAL NC-173

The NC-173 is the wholly new product of months of post-war research, prompted by war-time advances in radio technique.

The new "Double Diode" noise limiter and the new AVC system are effective on both phone and CW. The voltage-regulated oscillator circuits are extremely stable. The frequency range includes the 6-meter amateur band. (0.54 to 31 and 48 to 56 MC.)

The NC-173 offers all the features you expect in a fine receiver. A glance at the illustration below will suggest the versatility of its adjustments and the handiness of its controls, but only a trial will prove its thoroughbred qualities. Study the advanced design of its 13-tube circuit, appraise its modern styling and challenge its performance with the toughest conditions that crowded amateur bands can offer.

Here is a receiver a man can be proud to own. See it at your dealer's within the next 30 days.



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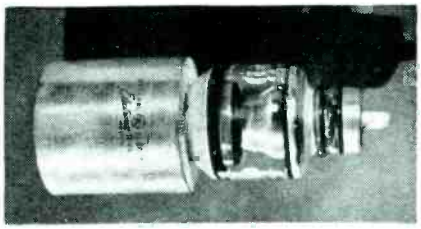
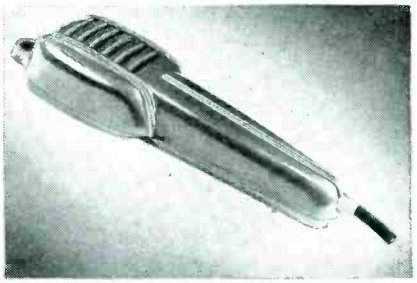


cies. When used as a grounded-grid amplifier in class C telegraphy, the tube has an output of over 2 kw with a power gain of ten. In class B video service under synchronizing peak conditions in a grounded-grid circuit, output exceeds 1 kw, with approximate power gain of 8.

Filament current of 32 amperes and filament voltage of 6.3 volts plus a grid-plate interelectrode capacitance of 8.7 μμf are among the electrical characteristics of the new tube. Maximum plate voltage rating under class C telegraphy conditions is 4,000 volts. For class B video operation the maximum plate voltage rating is 3,000 volts.

Hand Microphone (36)

THE TURNER CO., Cedar Rapids, Iowa. The model 20X crystal microphone withstands high humidity. Frequency response range is 50 to 7,000 cycles. Effective output level is 54 db below 1 volt per dyne per



square centimeter. A high-impedance unit, it can be used with any standard amplifier employing high-impedance input. Where cost is a factor, it is ideal for home recorders, public address, amateurs, paging, and call systems.

Synchronous Motor (37)

R. W. CRAMER CO., Centerbrook, Conn., the SX motor is primarily intended for applications that require a constant speed at a given frequency. It has a torque of 30 inch-ounces at 1 rpm. Power input is 2.7 watts at 115 or 230 volts, 60

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How to describe HOLLISTON Special Purpose Fabrics so that *you* will immediately recognize a use for them in *your* industry? That is the problem; and it has us stumped. Because these amazing fabrics have so many variable characteristics, so many potential uses. For instance, they can be flame-resistant and water-repellent. They can be impervious to mild acids, alkalies and solvents. They can be endowed with surprising dielectric and accoustic properties. They can be any or all of these things. What do they look like? They can be made to simulate almost any material you wish, for they can be fine as silk or coarse as burlap and either limp or stiff. Many HOLLISTON Special Purpose Fabrics are already serving industry daily. Most likely there is a HOLLISTON Fabric that will meet all your requirements. Find out today!

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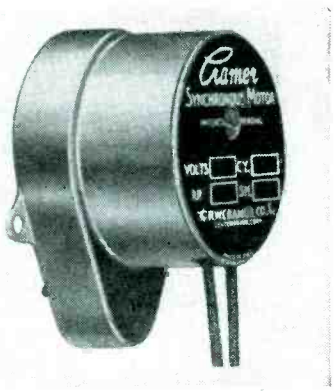
Special Purpose Fabrics

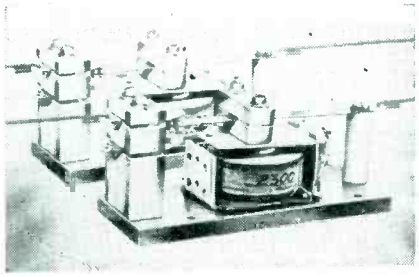
THE HOLLISTON MILLS, INC., NORWOOD, MASSACHUSETTS



cycles. Rotor speed is 240 rpm at 60 cycles. Twenty-eight standard gear trains, ranging in speeds from 60 rpm to one revolution in 24 hours, make the unit adaptable to a variety of applications. Coils are easily removable for changes in voltage rating or field servicing. It is described completely in Bulletin No. 10.

Antenna Changeover (38)

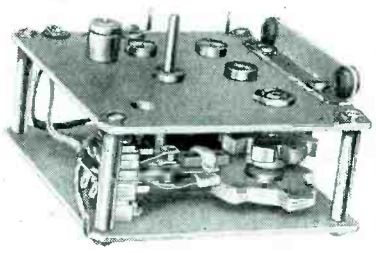
ADVANCE ELECTRIC AND RELAY CO., 1260 W. 2nd St., Los Angeles 26, Calif. Twin relays are available for switching of two-wire open trans-



mission lines. Since they can be placed any distance apart down to two inches they minimize discontinuities in line spacing.

Constant-Speed D-C Motor (39)

AMGLO CORP., 4234 Lincoln Ave., Chicago 18, Ill. An improved model of the constant-speed d-c motor is



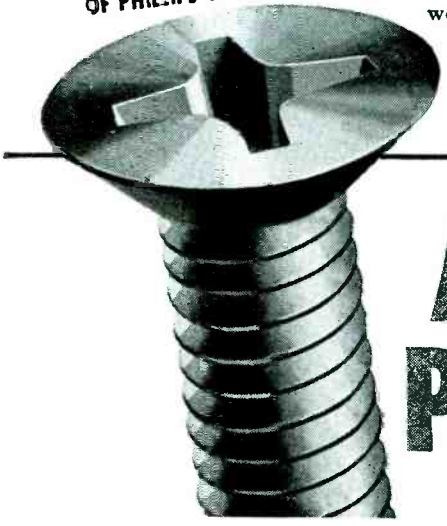
Furniture Builders are "Sitting Pretty"

AND SO ARE THEIR CUSTOMERS...

. . . when Costs are Cut — Appearance and Durability improved — by AMERICAN PHILLIPS SCREWS

IN THE FACTORY: The most modern fastening for all types of furniture is the American Phillips Screw. Easy to handle . . . lightning-fast and automatically straight to drive . . . fumble-proof, slip-proof and damage-proof . . . American Phillips Screws deliver top savings on any fastening job in any type of plant from furniture to railroad cars. Put these engineered screws on *your* costs — *and watch your time-savings shoot up as high as 50%!*

IN THE SALESROOM: One of the hallmarks of fine furniture and other household appointments is the decorative, straight-set, unburred head of the American Phillips Screw. More and more quality-minded buyers look for this distinctive feature—*both* for the sake of appearance, and as a *visible assurance* of sturdy construction and long service—their money's worth and then some! *Your* product should have this cost-cutting, sales-building advantage.

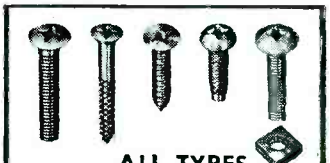


4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

Chicago 11: 589 E. Illinois St. *Detroit 2:* 502 Stephenson Bldg.

AMERICAN PHILLIPS *Screws*

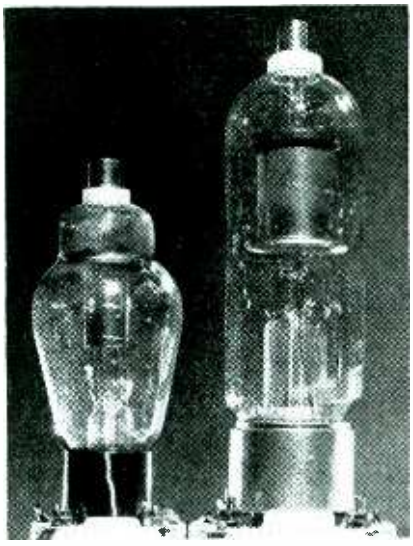


ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

adapted to many uses formerly beyond the scope of the d-c field, particularly in industrial and commercial applications where synchronous units are required. The new model utilizes the principle of polarized magnetic drive of a vibrating reed, the nucleus of speed control under d-c power. Due to simplified design, the new motor is small enough to be held in the palm of the hand, though available for use at 3, 6, 12, 24, 32, or 110 volts.

Mercury-Vapor Rectifiers (40)

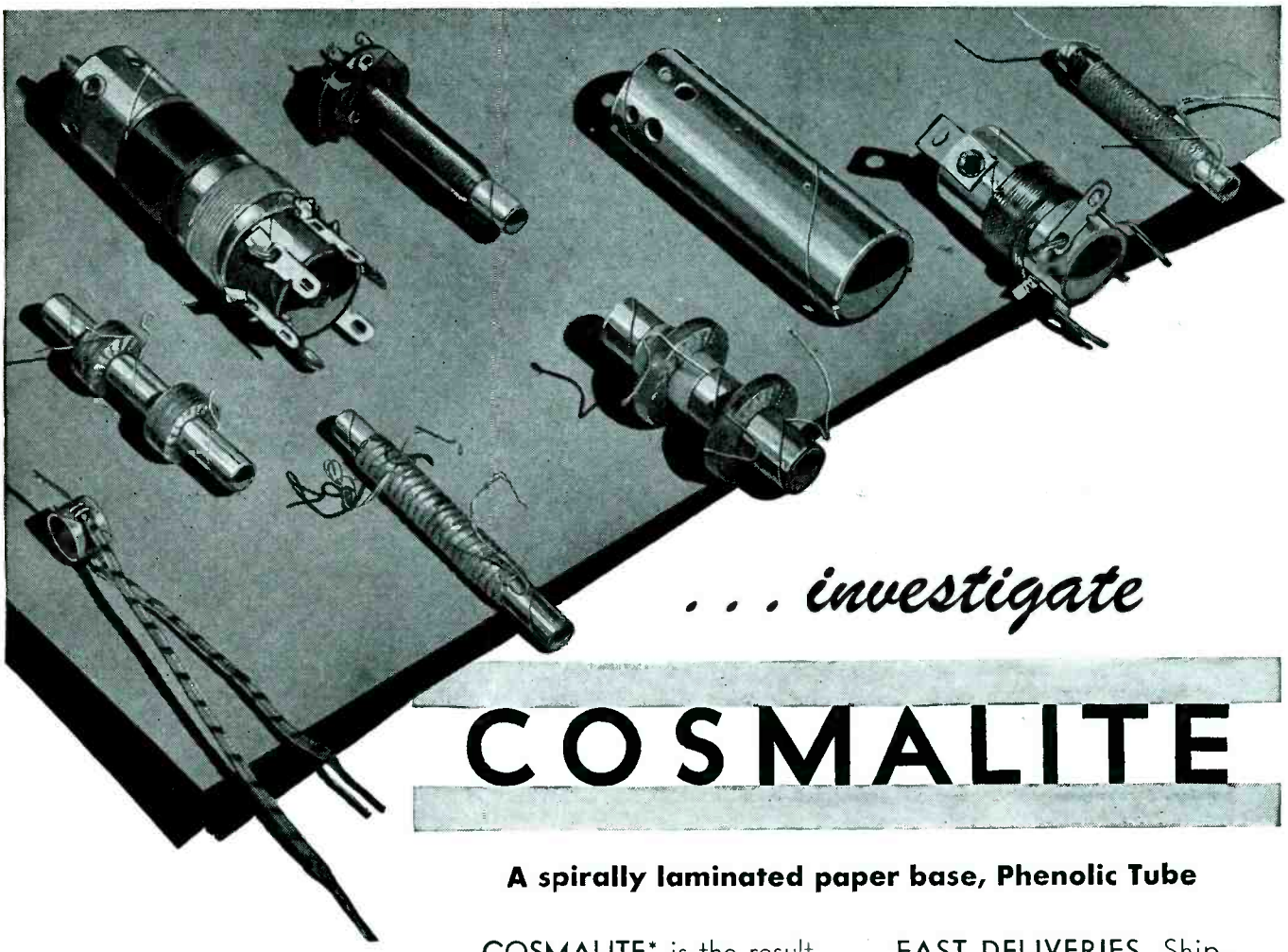
EITEL MCCULLOUGH, INC., 1018 San Mateo Ave., San Bruno, Calif. Eimac type 866A and 872A mercury-vapor rectifiers are directly interchangeable with types 866A/866 and 872A/872 of other manufacture. Type 866A operates with



2.5 filament volts, peak inverse voltages as high as 10,000 volts, and a maximum average plate current of 0.25 ampere. The 872 has a 5-volt filament and carries a maximum peak inverse voltage rating of 10,000 volts and a maximum average current rating of 1.25 amperes.

Rotary Beam Turntable (41)

PREMAX PRODUCTS DIVISION of Chisolm-Ryder Co., Inc., Niagara Falls, N. Y. The Rotomount hand-operated mounting for rotary beam antenna arrays is formed of heavy sheet steel, spot-welded. The moving platform is supported on a 7-inch ball thrust bearing. A 3-inch opening through the center of table and shaft provides space for leads. Cable



. . . *investigate*

COSMALITE

A spirally laminated paper base, Phenolic Tube

Made in Two Types

#96 COSMALITE is for coil forms in all standard broadcast receiving sets. Wall thicknesses from .010 up. Punching if desired.

SLF COSMALITE for Permeability Tuners available in wall thicknesses from .0065 to .0095.

COSMALITE* is the result of approximately seven years of research. You obtain the further advantage of **definitely lower costs!**

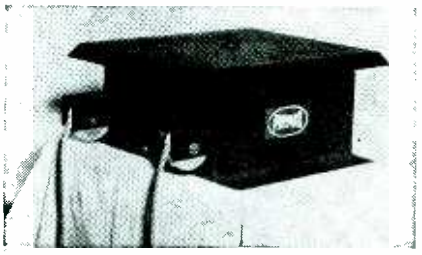
FAST DELIVERIES. Shipments are being made within four weeks.
Inquiries given specialized attention.

See our Exhibit #421
at the
I. R. E.
Radio Engineering Show.
Consult us for details.

Our spirally wound kraft and fish paper Coil Forms and Condenser Tubes also possess excellent insulation properties.

*Trade mark registered.

The CLEVELAND CONTAINER Co.
6201 BARBERTON AVENUE CLEVELAND 2, OHIO
PRODUCTION PLANTS also at Plymouth, Wisc., Ogdensburg, N. Y., Chicago, Ill., Detroit, Mich., Jamesburg, N. J.
PLASTICS DIVISIONS at Plymouth, Wisc., Ogdensburg, N. Y. • ABRASIVE DIVISION at Cleveland, Ohio
New York Sales Office—1186 Broadway, Room 223
IN CANADA—The Cleveland Container Canada Ltd., Prescott, Ontario



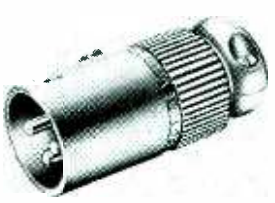
pulleys are dural, and the flexible steel cable furnished is so mounted that it can not come off the pulleys.

Signal Divider (42)

KEITHLEY INSTRUMENTS, 1508 Crawford Road, Cleveland 6, Ohio. The model 101 signal divider is an attenuator designed to provide the low-level input signals used in testing performance of high-gain amplifiers. Since most laboratory oscillators can be controlled from 0.1 volt to 15 volts, the divider extends the range down to about 10 microvolts. Frequency range is 0 to 200,000 cps and input admittance is approximately 11,000 ohms. Further details are available in bulletins issued by the manufacturer.

Steel-Shell Mike Connectors (43)

CANNON ELECTRIC, 3209 Humboldt St., Los Angeles 31, Calif. Two steel-shell plugs which will mate with the standard type XL zinc receptacles carry the additional designation SC. Overall length is slightly smaller than corresponding



When fine wire problems **get in your hair**

ANYTIME you have a problem about fine wire—don't let it get in your hair—call on North American Philips.

Because Philips is Fine Wire Headquarters.

This fine wire leadership stems out of the long experience Philips has had in close, fine precision manufacture . . . over a half century of it . . . and the knowledge and skill that comes from such long experience.

In addition, Philips makes the precision diamond dies that make possible such delicate fine wire. So when you ask Fine Wire Headquarters to solve your problems you benefit from all this accumulated experience.

But don't think that split-hair fine wire is all Philips has to offer. At Fine Wire Headquarters you can get nearly all metals—in plain, plated, enameled or clad fine wire.

With the electronics field growing bigger and bigger, the trend is to smaller components and finer wire. To meet these demands for fine, close tolerance wires, now is the time for you to bring us your fine wire problems...write, wire or call Philips . . . for ELMET Tungsten and Molybdenum and NORELCO fine wires.

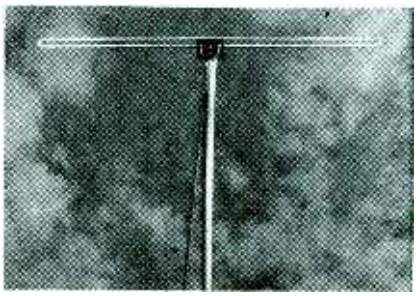
NORTH AMERICAN PHILIPS COMPANY, INC.

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

zinc-plug types. The socket insert assembly carries the latch-lock device. The construction of the shell makes it adaptable to other uses than sound, providing the amperage requirements of the circuits do not exceed the 15-ampere rating of the three contacts, and the minimum flashover voltage is not more than 1,500 volts (250 v working voltage) under normal conditions. Bulletin XL-SC2 will be sent free upon request.

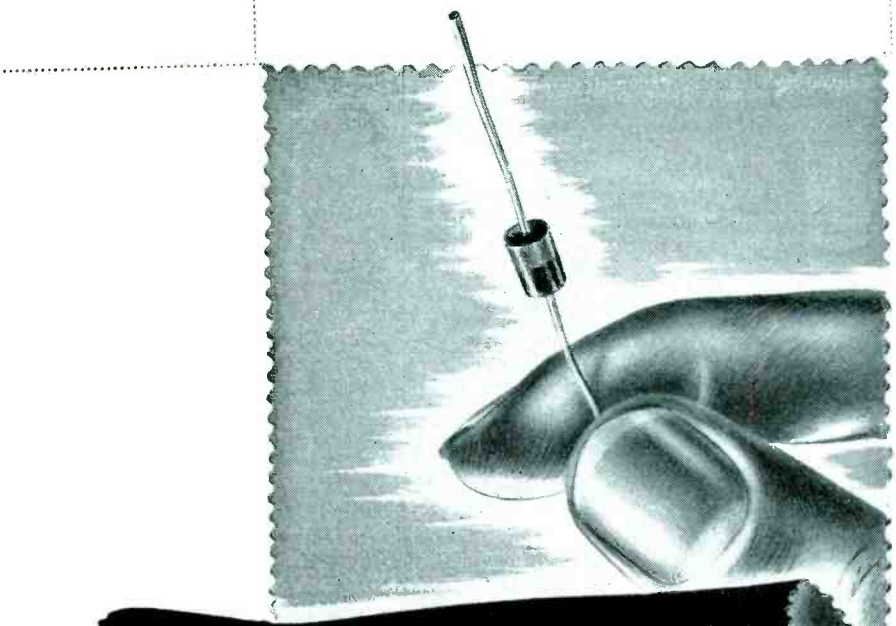
F-M Antenna (44)

STROMBERG-CARLSON CO., Rochester 3, N. Y. The DynaTenna, designed for use on both the 44 to 50 and the 88 to 108 mc f-m broadcast band, is adjustable and can be peaked to the particular frequency of any individual station for maximum response. The U-tube sections of the antenna are designed on the principle of the slide trombone, are easily adjusted and locked in place, and are calibrated in frequency graduations on both sides. The upper side functions as a quarter-wave folded dipole to cover the lower frequencies in the 44 to 50 mc band. The lower side operates as a half-wave folded dipole in the higher frequencies of the 88 to 108 mc band. A flexible construction permits erection for vertical as well as horizontal polarization. The antenna is supplied with 60 feet of low-loss, 300-ohm, plastic-covered lead-in wire recently standardized by the industry.



VTVM Kit (45)

FREDERIC D. SCHOTTLAND, 82-62 Grenfell Ave., Kew Gardens, N. Y. Only screwdriver and soldering copper are named as requisites to assemble and wire a complete vacuum-tube voltmeter that is sold in kit form. Full range is 0.2 to



try this for Size!

where Space is a limiting factor

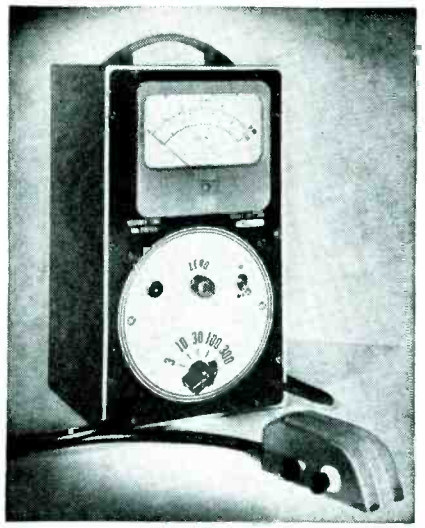
CONSIDER GENERAL ELECTRIC SELENIUM RECTIFIERS

Important savings in space and weight are realized when you design General Electric Selenium Rectifiers into electronic equipment. They'll give you more direct current per cubic inch, more per pound, than alternate types. General Electric offers a wide selection of capacities and sizes, from the mighty midget pictured above which delivers 4 volts at 0.1 milliampere to single stacks rated at 110 volts, 4 amperes.

Whatever your requirements, General Electric Selenium Rectifiers pack a lot of punch where space is at a premium. They withstand extreme variations in ambient temperature, humidity, and atmospheric pressure. You can depend upon them for long, faithful service in series, parallel, or series-parallel arrangement.

For a booklet of facts and figures, write direct to Section A-18-331, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

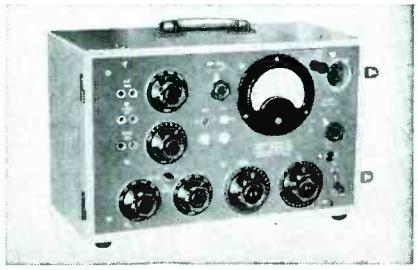
GENERAL ELECTRIC



300 volts, 20 cycles to 200 megacycles. Input capacitance is less than 7 μμf at all frequencies.

Transmission Measuring Set (46)

TECH LABORATORIES, INC., 337 Central Ave., Jersey City 7, N. J. A completely selfcontained, a-c operated measuring set combines the



functions of an accurate vacuum-tube voltmeter, fixed-frequency audio oscillator with four settings, and precision attenuator. Designed for broadcasters, it measures gain up to 80 db and losses down to 60 db. The precision attenuator is flat to 20 kilocycles.

Literature

(47)
Wiring Aid. Star Expansion Bolt Co., 147 Cedar St., New York 6, N. Y. A miniature socket wiring plug and miniature tube pin straightener used in production of small electronic equipment have been pictured in a small brochure.

(48)
Servo Unit. W. C. Robinette Co., 802 Fair Oaks Ave., South Pasa-

TURN TO PLAX FOR PLASTICS

Plax supplies materials below in forms as checked. They are available in a full color range.	SHEET	ROD	TUBE	FIBER	BLOWN WARE	MACHINED PARTS
Cellulose Acetate	✓	✓	✓	✓	✓	✓
Cellulose Acetate Butyrate	✓	✓	✓	✓	✓	✓
Ethyl Cellulose	✓	✓	✓	✓	✓	
Methacrylate		✓	✓	✓		✓
Polyethylene	✓	✓	✓	✓	✓	✓
Polystyrene	✓	✓	✓	✓	✓	✓

Vinyls, Cerex, Styraloy, Plexene, and certain special copolymers are also available from Plax, as are special extruded shapes in most materials.

Plax is a leading source of plastics in sheet, rod, tube, and fiber blown forms — also machined parts. This ability of Plax to supply a wide variety of plastics in a wide variety of forms simplifies your task of obtaining the best type of material for your product. Plax offers you many unique plastics developments, such as the tough and flexible Polyflex* Sheet, Laminated Polyflex, and Polyflex fiber forms of polystyrene.

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*T.M. Reg. U.S. Pat. Off.

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How to Machine Plax Polystyrene Products.
How to Use Coolants with Plax Polystyrene Products.
How to Cement Plax Polystyrene Products.
How to Polish Plax Polystyrene Products.
Notes on Design and Assembly of Plax Polystyrene Products.
Die-cut Parts from Plax Polystyrene.
How to Form Plax Polystyrene Rod.

AND THIS PRODUCT INFORMATION

Data Sheets on Plax Cellulose Acetate, Cellulose Acetate Butyrate, Methacrylate, Polyethylene, Polystyrene and Ethyl Cellulose Products.
Article on Plax's Blown Products.
New special plastic shapes by Plax.

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133 WALNUT STREET ★ HARTFORD 5, CONNECTICUT

dena, Calif. The Motron servo unit model 61A is a packaged continuous balance control system of great sensitivity that can be applied to automatic control or regulation of equipment. An illustrated sheet H-26 can be had from the company.

(49)
Insulators. Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis. A new catalog includes 28 pages of information on standards, design criteria, body characteristics and common shapes of various cearmic insulators. Included is data on metallized ceramics and printed circuits.

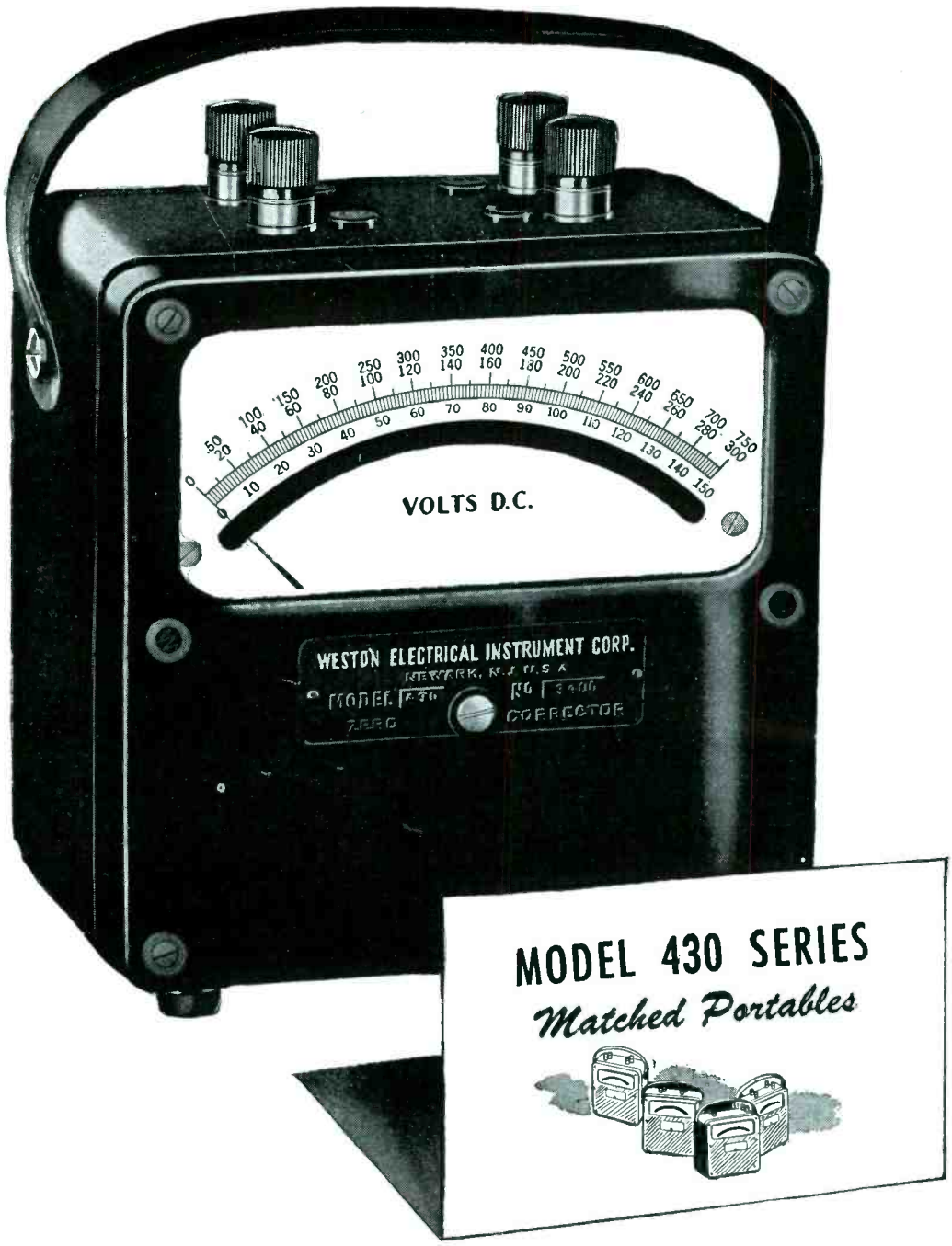
(50)
Tube Socket Guide. E. F. Johnson Co., Waseca, Minn. The 1946 edition of the tube socket guide is in effect a detailed catalog of the company's sockets and connectors together with applications and illustrations.

(51)
Tube Data. Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y. An 8-page booklet containing tube data reference tables describes the complete line of transmitting, rectifying and industrial tubes manufactured by the company.

(52)
Portable Rectifier. W. Green Electric Co., Inc., 130 Cedar St., New York, N. Y. The model 725S1C portable rectifier with output of 25 amperes from 0 to 6 volts is completely described in literature available from the manufacturer.

(53)
Ball Bearings. New Hampshire Ball Bearings, Inc., 2 Main St., Peterborough, N. H. Bulletin 47 describes a new line of small ball bearings suitable for instrument and small mechanisms use.

(54)
Bulletins. Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y. Data sheets on several of the company's new products have just come off the press. Bulletin EC-24 describes the use of



Universal favorites for electrical testing and maintenance . . . compact and extremely rugged, high-visibility mirror scales and knife edge pointers, accuracy and dependability in the WESTON tradition . . . all at relatively low initial cost. Available for all AC and DC requirements. See your nearest WESTON representative or write direct . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston *Instruments*

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NEW ORLEANS • NEW YORK • PHILADELPHIA • PHOENIX • PITTSBURGH • ROCHESTER • SAN FRANCISCO
SEATTLE • ST. LOUIS • SYRACUSE • IN CANADA, NORTHERN ELECTRIC CO., LTD., POWERLITE DEVICES, LTD.

the hydrogen thyratron type 4C35. Bulletin EC-23 gives further information on the type R4330 electronic flash tube. Germanium and silicon crystals are covered in bulletins EB-6 and EC-22B.

(55)
Marine Radiotelephone. Radiomarine Corp. of America, 75 Varick St., New York 13, N. Y. A new two-color folder details the features of a 75-watt radiotelephone transmitter-receiver combination, model ET-8012-D. The transmitter has ten crystal-controlled channels and a nine-tube receiver is used for two-way communication.

(56)
Phototube. Radio Corp. of America, Harrison, N. J. A high-vacuum, blue-sensitive phototube, type 1P42, recently announced, is completely analyzed in a leaflet now available. The tube has been designed particularly for control purposes in applications where space limitation is of prime consideration, the maximum diameter of the tube being ¼ inch.

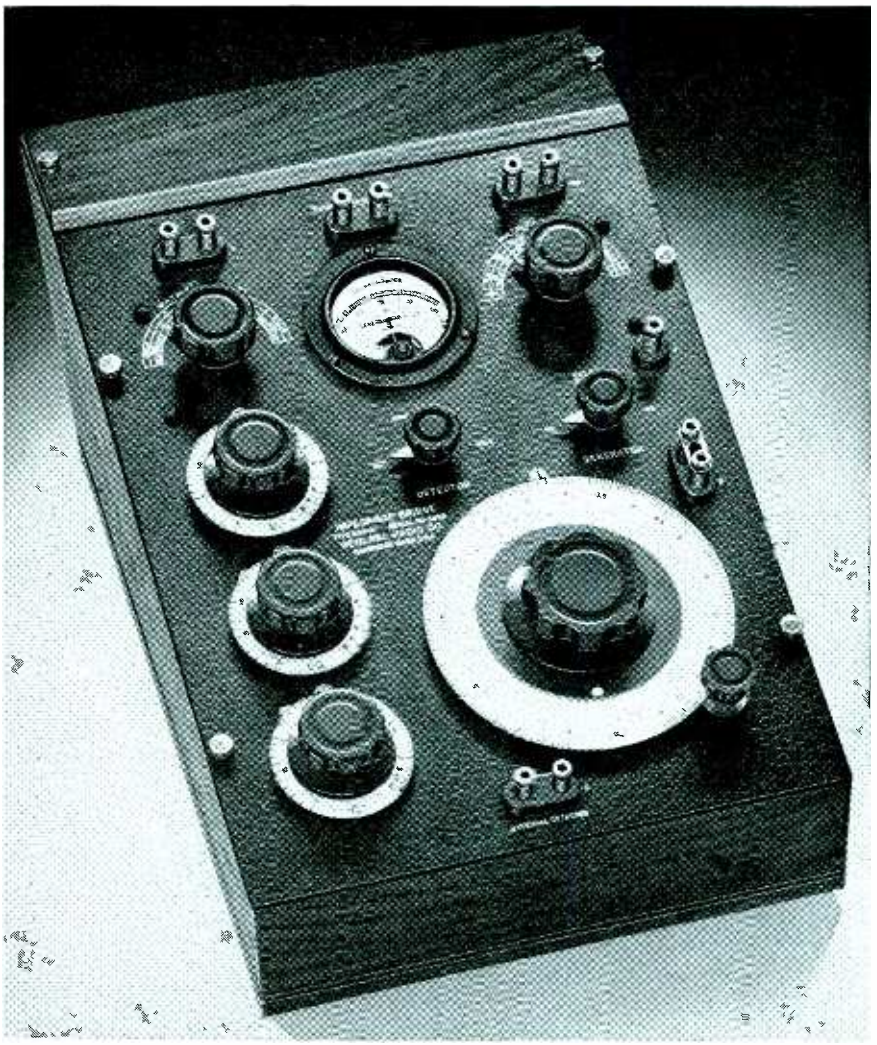
(57)
Vibration Pickup. The MB Mfg. Co., New Haven, Conn. A four-page, two-color leaflet pictures all aspects of an interesting magnetic pickup used for industrial vibration analysis.

(58)
Audio Components. Burnell and Co., 10-12 Van Cortlandt Ave., East, Bronx 58, N. Y. High-Q toroidal coils, equalizers and attenuation filters are described in a four-page two-color catalog recently issued.

(59)
Resistor Bulletin Resistors, Inc., 2241 South Indiana Ave., Chicago 16, Ill. A new catalog bulletin of resistor data on the full line of the company's resistors and windings is now available. Write for bulletin 87.

(60)
Graphic Pyrometer, Leeds and Northrup Co., 4934 Stenton Ave.,

FOR ROUTINE MEASUREMENTS of



- **INDUCTANCE**
- **CAPACITANCE**
- **RESISTANCE**

TYPE 650-A
Impedance Bridge
$220

NO laboratory, in which any electrical equipment is used, is complete without this bridge. Completely self-contained, portable, and accurate enough for most routine measurements, the popular Type 650-A Impedance Bridge is always set up and ready to use. With it you can measure these basic quantities over these very wide ranges—**INDUCTANCE:** 1 microhenry to 100 henrys; **CAPACITANCE:** 1 micromicrofarad to 100 microfarads; **RESISTANCE:** 1 milliohm to 1 megohm. In addition it measures **DISSIPATION FACTOR** (R/X) from .002 to 1, and **STORAGE FACTOR** (X/R or Q) from .02 to 1,000.

The bridge includes built-in standards, batteries, a 1,000-cycle tone source for a-c measurements, a zero-center galvanometer null indicator for dc and terminals for a headset for 1,000-cycle null detection.

Provision is made for use of an external generator for measurements over a wide range from a few cycles to 10 kilocycles.

Direct-reading dials add greatly to the ease and rapidity with which measurements can be made with this universal bridge.

WRITE FOR COMPLETE INFORMATION

GENERAL RADIO COMPANY Cambridge 39 Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38

Philadelphia 44, Pa. Catalog ND46(1) illustrates the Speedomax type G recorder primarily designed for pyrometers. Single or multiple temperatures can be recorded on the same sheet.

(61)
Transmitter Parts. E. F. Johnson Co., Waseca, Minn. The capacitanced general products catalog No. 969 covers variable transmitting capacitors, inductors, tube sockets, and other items as well as new lines such as multiwire connectors, dial lights, and tip plugs.

(62)
Synthetic Rubber Insulation. Simplex Wire and Cable Co., 79 Sidney St., Cambridge 39, Mass. A 12-page slick-paper report to industry on synthetic rubber insulations used by the company.

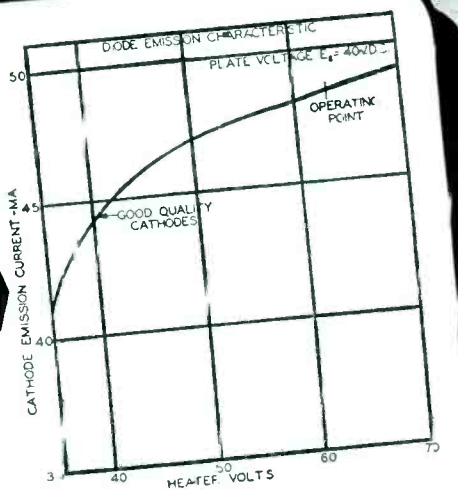
(63)
Components Catalog. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass., has just issued a new 20-page tabbed-section catalog with specification sheets giving data on all its products except crystals. Copies are available from Dept. 4.

(64)
Receiving Tubes. Radio Corp. of America, Harrison, N. J. A new 16-page booklet titled "Receiving tubes for television, f-m and standard broadcasting" (form 1275-C) charts characteristics and socket connections. Tubes are classified in various convenient ways and the booklet sells for 10c.

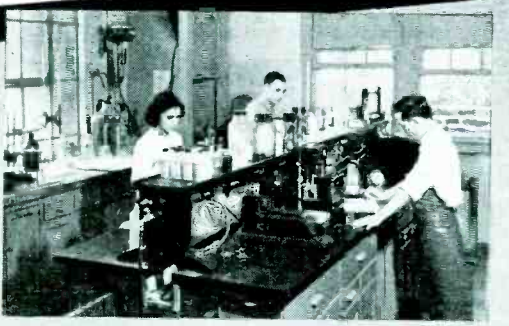
(65)
Radio and Industrial Tubes. Radio Corp. of America, Harrison, N. J. A 16-page booklet entitled "Power and gas tubes for radio and for industry" (form PG-101) has been compiled so as to present the subject information with clarity and simplicity. Copies can be obtained at 10c. each.

(66)
Recording Materials. Eastman Kodak Co., 343 State St., Rochester 4, N. Y. A new 44-page booklet describing photographic recording

THE STORY BEHIND SUPERIOR'S ABILITY TO PRODUCE CATHODES THAT PERFORM LIKE THIS



The metal tubing used for cathodes must meet the most rigid chemical, metallurgical, dimensional and cleanliness standards. Maximum cathode performance is assured through Superior's unusual facilities for the study of the materials, processes and controls.



CHEMICAL

Laboratory analyses are made for the many minute but important elements in cathode materials. Raw stock and finished tubing alike are analyzed and the results checked against rigid purchase specifications.

METALLURGICAL

Frequent examinations of polished and etched cross-sections are made to insure that tubing and strip has suitable grain structure, and is free from flaws and injurious inclusions.

CLEANLINESS

The Electronics Division is housed in a new building free from contaminating elements. The drawing lubricants, cleaning baths, and surface conditions are checked constantly as a part of rigid quality control.

QUALITY CONTROL

Our unusually close control of tolerances insures dimensional accuracy, low shrinkage, and greater uniformity in electron tube production and performance. Tireless checking and inspecting, together with statistical data, results in improved electrical tube characteristics and performance in television and radio receivers.

Through the courtesy of the
INTERNATIONAL NICKEL COMPANY
there will be a display in their booth #78
of **NICKEL ALLOY TUBES**
Manufactured by the
SUPERIOR TUBE COMPANY
at the **RADIO ENGINEERING SHOW**
In **GRAND CENTRAL PALACE**
March 3 through 6, 1947

THE BIGGER NAME IN SMALL TUBING **Superior**

SUPERIOR TUBE COMPANY
ELECTRONICS DIVISION

Post Office Drawer 191 • Norristown, Pa.
Telephone, Norristown 2070

materials for use with cathode-ray tube oscillographs, galvanometer oscillographs, and similar instruments is obtainable on request. Equipment and technique are discussed, and a table of relative speeds of films and papers is provided.

(67)

Precision Testing Equipment. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. Catalog K, Fifth Edition, has recently been mailed out. It describes the complete line of frequency standards, signal generators, monitors, and components. Included is a new price list.

(68)

Low-Loss Leadin. General Electric Co., Syracuse, N. Y. A single-sheet catalog bulletin tots up the characteristics of two types of 300-ohm parallel twin-conductor cable for television and f-m and the somewhat similar 100-ohm r-f cable.

(69)

Vacuum Tube Voltmeter. Reiner Electronics Co., Inc., 152 West 25th St., New York 1, N. Y. A single sheet tells about the Model 451 vacuum-tube voltmeter and the Model 101 amplifier that can be used to increase its sensitivity a hundredfold.

(70)

Volume Control Index. Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 2, N. Y. The volume control cross-index guide is a collection of cards printed on both sides with the complete cross-index of corresponding type numbers of four leading volume-control manufacturers, arranged numerically. The guide is free from distributors or by writing the company.

Tube Registry

Tube Types Registered by RMA (Starting Oct. 1946)

Type 5558

Half-wave mercury rectifier, heater type, heating time 5 min.; tempera-

GRACOIL

"One Good Turn – or a Million"

★ Here, in expanded plant facilities, GRACOIL Coils and Transformers are expertly designed and built to exact specifications. Plan your next product with GRACOILS.

THE GRAMER COMPANY

Established in 1935

Electrical Coils and Transformers

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We'll take POSJ * POT * SV * SJ * 2, 3 and 4 conductor. S,-2 and 3 conductor and heater cord.

We'll make it into CORD SETS with Electrix, Allied Glade, Carling or Gilbert plugs.

We'll put on Eyelets, - Lugs, - Connectors - Ground Jacks, - Loops, - Markers, - Etc.

We'll attach Diamond, - Soreng, - Woodwin Female Plugs or Cutler-Hammer, Carling heater attachments, or feed thru switches.

We'll make up any special types of cord set or cable you require. Samples and Prices on request.

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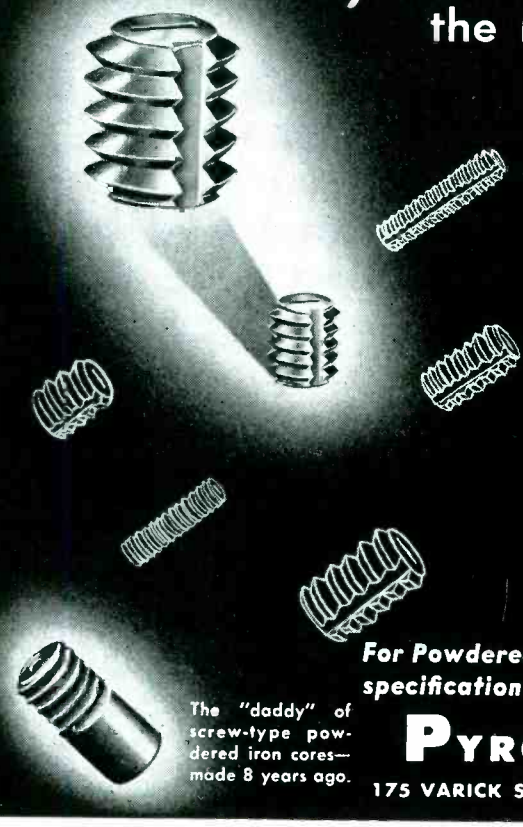
eight years ago

. . . . PyroFerric PIONEERED the manufacture of SCREW-TYPE POWDERED IRON CORES



. . . today Fyroferric is manufacturing a full line of standard sized Powdered Iron Screw-type Cores of varying lengths, with standard threads, as well as its complete line of powdered iron cores, with and without inserts.

For Powdered Iron Cores to meet your specification address your inquiry to

The "daddy" of screw-type powdered iron cores—made 8 years ago.

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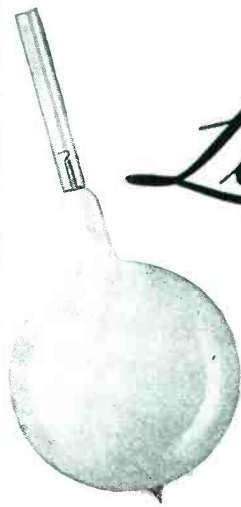

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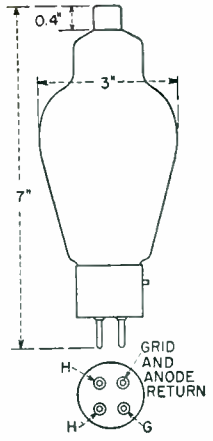
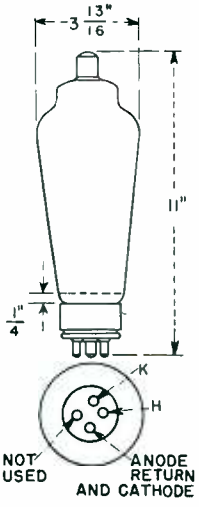


E_f = 5 v
I_f = 4.5 to 4.9 amp
E_{drop} = 16 v
E_b = 1,000 v
E_{c2} = 0
$E_{control}$ = − 6.5 v
E_{ins} = 1,000 v (max)
E_{fwd} = 1,000 v (max)
E_c = − 500 v
I_b = 200 amp (0.1 sec surge)
I_c = 0.25 amp
C_{in} = 10 μμf
gC_p = 2.5 μμf

10 microseconds; deionization time, 1 millisecond; basing 4BL.

Type 5561

Half-wave mercury rectifier, heater type; heating time 5 min; tempera-

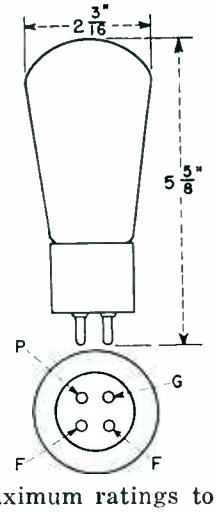


E_f = 5 v
I_f = 10 to 10.75 amp
E_{drop} = 15 v
E_{ins} = 10,000 v (max)
I_b = 80 amp (0.1 sec surge)

ture range, −25 to +50 C; frequency 150 cycles.

Type 5556

Triode power amplifier/oscillator,



E_f = 4.5 v
I_f = 1.1 amp
E_b = 350 v
I_b = 19 ma
E_c = − 20 v
μ = 8.5
g_m = 1,330
C_{in} = 2.3 μμf
C_{out} = 3.1 μμf
gC_p = 7.7 μμf
I_b = 40 ma (max)
W_p = 7.5 watts

filament type, maximum ratings to 6 mc, basing 4AX.

electronic counter circuits, 2 on electron tubes, 12 on nuclear machines such as cyclotrons, 6 on ionization gages and G-M tubes, and 30 on miscellaneous electron tube circuits that were considered in connection with the atomic energy projects. Representative abstracts of some of these electronic papers follow.

PB 49548, ALLEN, J. S., Characteristics of metal type electron-multiplier tube, (Manhattan Engineer District LA Rept 65, Series C; MDDC Rept 275) Mar 1944, 12 p. Price: Microfilm—$1.00—Photostat—$1.00

Scientific paper released for general information Sept. 12, 1946. An electron multiplier tube of the electrostatically focused type enclosed in a metal shell has been developed. The metal construction permits the use of copper gaskets and the outgassing of the tube by external heating. When a narrow beam of Po alpha-particles hits the first electrode the tube will count every alpha falling upon the sensitive surface. Approximately 5×10^6 electrons reach the final collector for each alpha incident upon the first electrode. The tube may be used as a pulsed detector by varying the potential of one of the electrodes with respect to the others.

Both static and dynamic tests were made. A square wave of 150-volts amplitude will turn the tube on and off. A radium source surrounded by 5 cm of Pb was placed near the multiplier tube. The counting rate was about 10^{-4} times the number of photons striking the first electrode. Graphs and a circuit diagram are included.

PB 52819, CHADWICK, S. R., Alpha counters as used in radioassay of Plutonium, (Manhattan Engineer District LADC Rept 272; MDDC Rept 454) Jan 1946, 53 p. Price: Microfilm—$2.00—Photostat—$4.00

Scientific paper released for general information. A description of the amplifiers, scalers, and power supplies used with the air and nitrogen chambers is given. Circuit diagrams and shop drawings of the chambers are included in the appendix.

PB 52802, FRISCH, O. R., Note on a use of delay lines in counter pulse amplifiers, (Manhattan Engineer District, LA Rept 107; MDDC Rept 238) Jul 1944, 5 p. Price: Microfilm—$1.00—Photostat—$1.00

Scientific paper released for general information August 22, 1946. A delay line is used to bring a pulse disturbance quickly back to zero, thus permitting more rapid counting than usual and helping to eliminate low-frequency interference.

PB 52717, GHIORSE, A. and others, The multi-channel pulse analyzer, (MDDC Rept 23) n.d. 27 p. Price: Microfilm—$1.00—Photostat—$2.00

The pulse analyzer consists of an ionization chamber and electronic units which make it possible to record the energy distribution of alpha disintegrations in a radio-active sample. In particular it is used to measure the amounts and determine the nature of alpha disintegrations in a mixture of isotopes. Description and circuit diagrams of the equipment are included in this paper released for general information through Manhattan Engineer District June 14, 1946.

PB 52719, HIGINBOTHAM, W., Higinbotham scale of 64, mark 5, model 3 (MDDC Rept 26) Dec 1945, 2 p. Price: Microfilm—$1.00—Photostat—$1.00

This scaling instrument is built for use with a self-quenching Geiger-Mueller tube. The scale of 64 is of the Eccles-Jordan type as modified by Higinbotham. The scaler will operate on evenly spaced pulses to a speed of at least 150,000 counts per second. A circuit diagram accompanies the description, which is released for general information through the Manhattan Engineer District.

PB 52739, JAFFEY, A. H. and others, A manual on the measurement of radioactivity (MDDC Rept 388) Aug 1944, 49 p. Price: Microfilm—$1.00—Photostat—$4.00

Scientific paper released for general information, October 16, 1946. This manual was written as an introduction to radioactivity measurements for chemists and others who were unfamiliar with this field. Its aim is to provide fairly explicit operating instructions together with the minimum background necessary for intelligent use of the instruments and interpretation of results. It is restricted to instruments and techniques for the development of processes for the chemical engineering scale separation of

plutonium from uranium and fission product activities. The manual has three sections: (1) Alpha counting; (2) measurement of beta and gamma radiation; and (3) statistics and counting. Diagrams and graphs are included. A foreword written in 1946 indicates which of the material is now obsolete and what new methods and instruments are in general use. It also contains a list of references.

PB 49561, KATCOFF, SEYMOUR, Sweeping of radioactive gases from a homogenous pile, (Manhattan Engineer District LADC Rept 215; MDDC Rept 293) Apr 1946, 23 p. Price: Microfilm—$1.00—Photostat—$2.00

Scientific paper released for general information September 11, 1946. The radioactive fission-product gases produced in a homogeneous pile were blown by a stream of air through a long tube along whose axis was a negatively charged wire. The various gases deposited their solid radioactive daughters upon the wire in a manner proportional to their half-lives. By cutting the wire into sections and analyzing each one for several fission products, the following results were obtained: (1) An approximate half-life of 33 seconds for Kr^{90}; (2) an accurate half-life of 1.7 seconds for Xe^{142}; and (3) the fraction of each of the fission-product chains containing a gaseous member that was swept out of the water boiler, (Tables VI and VII). Schematic diagrams and tables are included.

PB 52433, LAVATELLI, L. S., Snouting and focusing the cyclotron beam, (Manhattan Engineer District LADC Rept 128; MDDC Rept 350) Feb 1946, 22 p. Price: Microfilm—$1.00—Photostat—$2.00

Scientific paper released for general information September 26, 1946. The steps necessary to get an external beam down a snout section and the equations for focusing a beam magnetically are given. These equations together with the initial beam configurations and other constraints are solved simultaneously approximately to yield suitable design for a focusing chamber. The chamber enabled a beam of about three microamperes to be focused on an area of one square inch at a point 20 feet distant from the target chamber of the cyclotron. Diagrams and photographs are included.

PB 42178, NIER, A. O. and others, Mass spectrometer for leak detection (MDDC Rept 5) Apr 1946, 18 p. Price: Microfilm—$1.00—Photostat—$2.00

A simple low resolution mass spectrometer is described which has ben used successfully in detecting small leaks in high vacuum equipment. One part of He in 200,000 parts of air can be detected. Photographs, diagrams, and graphs are appended. This contribution from the Kellex Corporation is released through the Manhattan Engineer District for presentation before the American Physical Society.

PB 49579, WATTS, R. J., Safety circuit with D-C amplifier, (Manhattan Engineer District LAMS Rept 161, Series B; MDDC Rept 316) Nov 1944, 15 p. Price: Microfilm—$1.00—Photostat—$1.00

Scientific paper released for general information September 11, 1946. A method is described to record the rise in intensity of any hard beta, gamma, or neutron radiation and cut it off at any predetermined level. A range in intensity of a factor of one million may be covered easily. The equipment is designed so that if any part fails it will fail safely, i.e., in such a manner as to cut off the radiation. The electronic circuits are readily adaptable to many uses and have been used to monitor a cyclotron. Any current of 10^{-11} amperes or higher from a high-impedance source will operate the mechanism. Drawings and circuit diagrams are appended.

British Computer

Construction of an automatic computing engine (ACE) as the British counterpart of the American electronic numercial integrator and computer (ENIAC) has been announced by the British Department of Industrial and Scientific

NEWS OF THE INDUSTRY (continued)

NBC and Frank P. Schreiber of station WGN, were elected to the Board, replacing O. B. Hanson of NBC and E. A. Hayes of Hughes Tool Co.

THE WARD PRODUCTS CORP., Cleveland, Ohio, has been purchased by The Gabriel Co. of Cleveland, and will continue operation as a division of the latter company.

DUNLEE CORPORATION, Chicago, Ill. has been organized for the design and manufacture of x-ray tubes, with H. A. Dodge as president, D. W. Dunk, formerly with Eureka X-Ray Tube Corp., as vice-president of manufacturing, and Z. J. Atlee, formerly with General Electric X-Ray Corp., as vice-president of engineering.

WESTINGHOUSE ELECTRIC CORP. announces a broad sales and servicing agreement with Tropical Radio Service Corp., wholly-owned subsidiary of United Fruit Co. Westinghouse will manufacture complete marine radar equipment of its own design, of the continuous ppi type with range of from 100 yards to 32 miles, with Tropical as a major channel for installing, licensing, servicing, and selling the units.

MUTUAL BROADCASTING SYSTEM has begun work on $2,500,000 radio and television studios in Hollywood, Calif., in which is to be a unique quarter-million-dollar master control panel serving a-m, f-m, and television.

GENERAL ELECTRIC CO., Syracuse, N. Y., shipped its 100th f-m radio broadcast transmitter to station WPEN-FM in Philadelphia, and is now working to fill the more than 100 additional orders still on hand.

EASTERN AMPLIFIER CORP., New York City, announces assumption of complete control by Leon Alpert. The new management plans to expand the products and sales of the firm in the sound systems field.

HAZELTINE ELECTRONICS CORP., New York City, announces that starting March 1 its Lanac system will be in every day operation by the AAF All-Weather Flying Division on the air route between Clinton County

gress and Exposition, Oakland Civic Auditorium, Oakland, California; over 75 technical papers, lecture courses, and round table discussions.

MARCH 31-APRIL 2: Midwest Power Conference, Palmer House, Chicago, sponsored by Illinois Institute of Technology and directed by Prof. S. E. Winston.

APRIL 14-18: Radio Broadcast Engineering Institute, Atlanta, sponsored by Georgia Association of Broadcasters, Georgia chapter of IRE, and Georgia School of Technology, with Professor M. A. Honnell of Georgia Tech as chairman.

APRIL 21-MAY 2: International Merchant Marine Radio Aids to Navigation; first week devoted to exhibits, papers, and visits to firms in New York City and vicinity; second week on three ships working out of New London, Conn. for demonstrations of equipment; sponsored by U. S. State Department and other government agencies.

APRIL 28-30: RMA Spring Meeting of transmitter and transmitting tube engineers, at Hotel Syracuse, Syracuse, N. Y. Technical sessions and meetings on first two days, with inspection trips on third day.

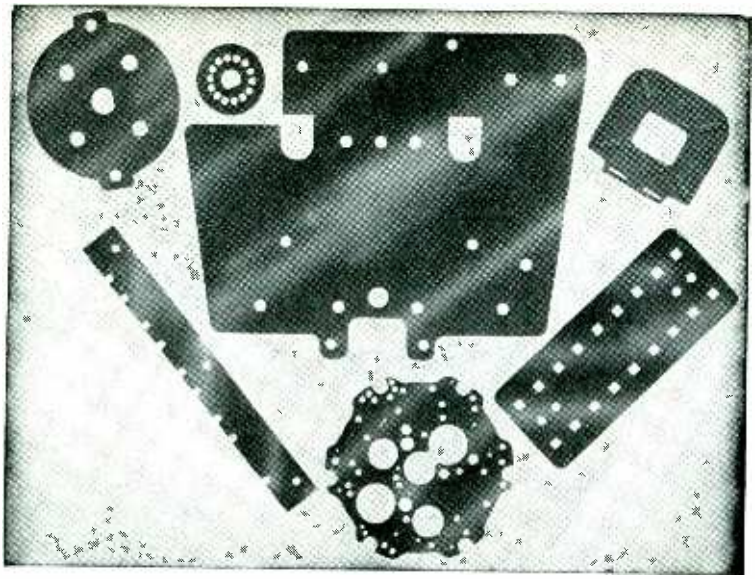
MAY 17: New England Radio Engineering Meeting of North Atlantic Region of IRE; six technical sessions, luncheon, and banquet at Continental Hotel, Cambridge, Mass.

MAY 4-8: National Electrical Wholesalers Association meeting, Traymore Hotel, Atlantic City, N. J.

MAY 13-16: 1947 Conference and Show by Radio Parts and Electronics Equipment Shows, Inc., Chicago.

BUSINESS NEWS

TELEVISION BROADCASTERS ASSOCIATION, INC., New York City, announces reelection of J. R. Poppele as president for a third term. Two new directors, John F. Royal of



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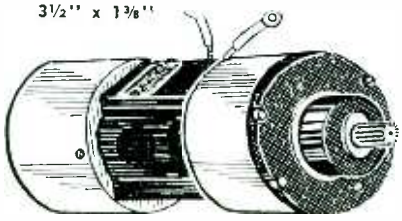
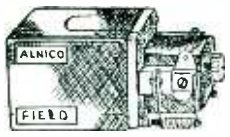
3½" x 1⅜"



Operates on Flashlight batteries, speed depending on the voltage. Fairly strong on 6 volts, full power and speed on 27 volts. Designed to be used in bombsights, automatic pilots, etc. Two types, 145 or 250 RPM. Either speed a bargain at..... **$5.00**

BASIC MOTOR 2 X 1 X 1



ELECTRICALLY SAME AS GEARED MOTOR **$3.00**

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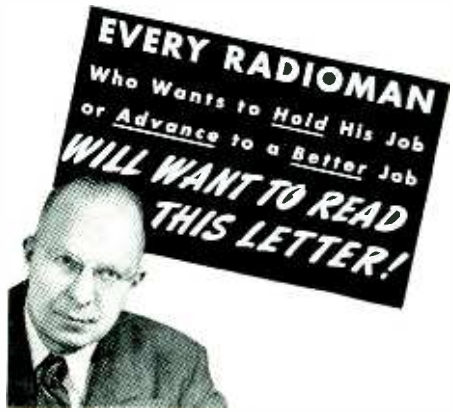
RADIO CORPORATION of AMERICA
HARRISON, N. J.

E. H. Rietzke, *President* of CREI, invites You to Write for this

Free

Significant Analysis of Job Opportunities in Radio Electronics.



The Story Behind This Interesting Letter You Will Want to Read . . .

Our advertising agents, realizing that vital changes are taking place in the radio industry, asked me to give them a factual report of the unprecedented job opportunities created by the almost unbelievable expansion of the radio industry.

My letter to them contains some pertinent viewpoints on the subjects of COMPETITION—INDUSTRY EXPANSION—OPPORTUNITIES. These are first-hand observations based on my own experiences . . . a great deal of time spent in the field and constant contact with leaders in the radio industry.

The immediate reaction of our agency upon reading this letter was that it contained so much inspiration and information that it should be reproduced for thousands of radiomen to read. Therefore, this unusual advertisement to invite you to send for, and read, this letter.

It is doubtful if many radiomen realize the actual things that are happening. That is why I think you will want to read this letter. You are invited to send for your personal copy today.

E. H. Rietzke
President, CREI

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Capitol Radio Engineering Institute 16th and Park Road, N. W., Dept. E-3 Washington 10, D. C.

Gentlemen: Please send me FREE, Mr. E. H. Rietzke's Analysis of Job Opportunities in Radio-Electronics.

NAME .....

POSITION ..... AGE ....

ADDRESS .....

CITY ..... ZONE .... STATE.....

way radiotelephone units as of the first of the year, and applications for some 2,000 additional units are now being processed. Largest grant of this nature was to a fleet of 1,600 cabs operating in San Francisco and Los Angeles. For the entire mobile two-way radiotelephone service, the total number of experimental authorizations is approximately 1,000, involving some 12,000 taxicabs, trucks, private cars, and other vehicles not in such organized services as police, fire, aviation, marine, railroad, public utility, and geophysical.

Broadcast Engineering Conference in Atlanta

A RADIO broadcast engineering institute will be held in Atlanta, Georgia, April 14-18, 1947 under sponsorship of the Georgia Association of Broadcasters, the Georgia chapter of IRE, and the Georgia School of Technology. Professor Martial A. Honnell of Georgia Tech is general chairman. Outstanding experts in the various fields of radio broadcasting will cover the latest technical developments in their respective specialties, and manufacturers will exhibit and demonstrate latest types of radio and television equipment.

Those attending will also have an opportunity to visit the five radio stations in Atlanta, as well as the modern f-m transmitter now operating on an experimental basis at Georgia Tech. The Institute will be patterned after the Ohio State University national conference, which is not being held this year.

MEETINGS TO COME

MARCH 3-6: IRE Winter Meeting, Hotel Commodore, New York City, with Radio Engineering Show at Grand Central Palace.

MARCH 3-7: 1947 Winter Conference of National Electrical Manufacturers Association, at the Edgewater Beach Hotel, Chicago. Committee meetings only.

MARCH 22-27: Western Metal Con-

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SELF-LOCKING ACORN PALNUTS?

• Self-locking Acorn Palnuts are dome shaped, single thread locknuts made of tempered spring steel. They exert a powerful double-locking action that defies loosening under vibration. Low in cost—light in weight—easily, speedily applied—require but 3 bolt threads space to lock effectively.

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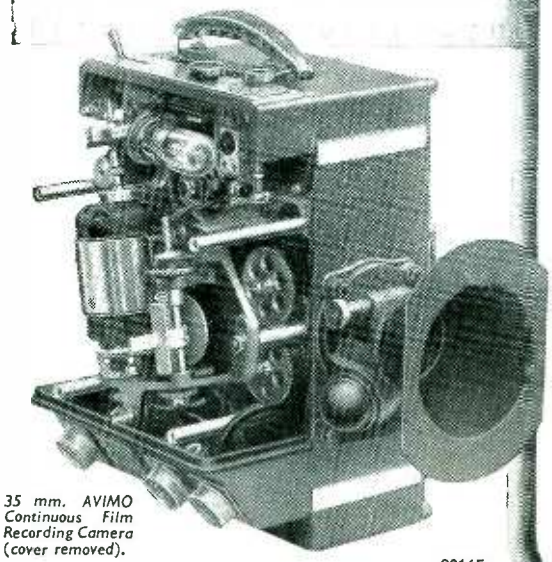
4 Oscillograph traces on 70 mm. paper.



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- Sweep Frequency—Up to 40 megacycles!
- Frequency Meter—Measures from 3 to 800 megacycles!
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The MEGA-SWEEP shows at a glance the response of any network or amplifier. This eliminates the tedious point to point analysis. Its use saves engineering time and stimulates research. Valuable for television production alignment.

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tosh, consultant. Frank Gunther, M. H. Jennings, James Day, and Wilbur Thorp of the REL engineering staff discussed aspects of specific equipment design and use in the field.

During the discussion periods various station operators' problems were presented and the answers volunteered by attending engineers. Mr. Braum, the FCC representative, interpreted regulations and explained the Commission attitude in the absence of specific rulings.

A feature of the demonstration period each day was reception of a special program of live talent broadcast from Major Armstrong's Alpine, N. J. radio station W2XMN. The entertainment originated at the home of Mr. C. R. Runyon, radio pioneer, in Yonkers, N. Y., and was beamed from his high-frequency experimental station to Alpine where it was picked up and rebroadcast.

F-M Polarization

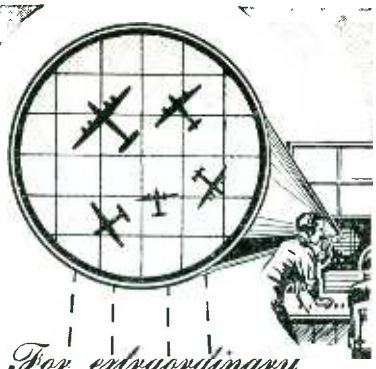
THE FEDERAL Communications Commission has announced that licensees of f-m stations may add circular or elliptical polarization. (ELECTRONICS, p 214, December 1946). Horizontal polarization is still retained as the standard and must be used by all f-m licensees (including those who exercise the option of utilizing circular or elliptical polarization).

Additional transmitter operating power would be authorized to stations employing the new type polarization, but it may not exceed the horizontally polarized component used for allocation purposes; service contours thus remain unchanged.

It is expected that circular or elliptical polarization will decrease the antenna requirements for home and car radio receivers and materially increase the probability that a receiving antenna located at random will provide entirely satisfactory f-m reception.

Taxicab Radio Survey

NEARLY 8,000 taxicabs in the United States, in over 200 different fleets, received FCC authorization for two-



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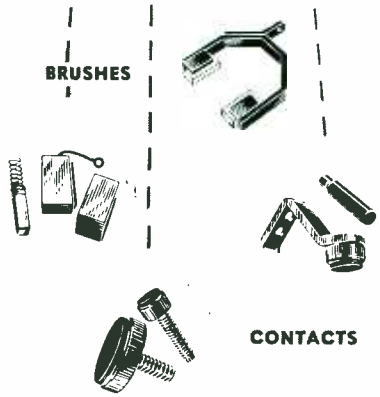

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for high current density ● minimum wear ● low contact drop ● low electrical noise ● self-lubrication

in CONTACTS
for low resistance ● non-welding character

GRAPHALLOY works where others won't! Specify GRAPHALLOY with confidence.

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Have you ever seen the INSIDE of an EXPLOSION?

Now made possible by remarkable new electronic advance, embodied in

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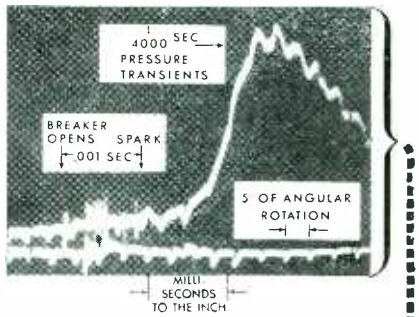

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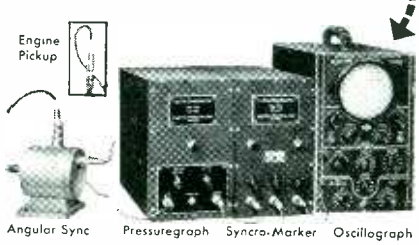
Covers "transients."

Send for description and full engineering data



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medical, and scientific purposes. Stipulations provide that emissions shall be confined to the channel between 2,400 and 2,500 megacycles and no interference shall be caused to authorized communication services from spurious or harmonic radiations. Chief uses for this allocation at present are diathermy, induction and dielectric heating for industrial purposes, and microwave heating with such equipment as Raytheon's radarange.

Clearing Low F-M Band

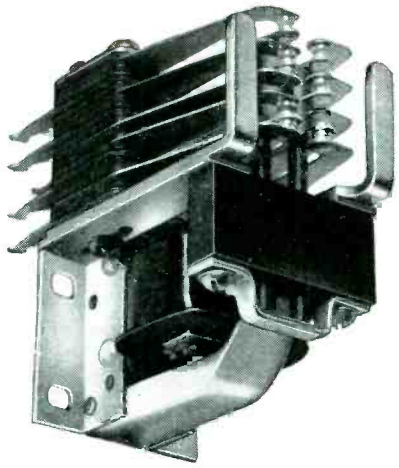
In order to clear the 42-44 mc portion of the low f-m band for use by the nongovernment fixed and mobile services to which these frequencies have been allocated, the FCC has made temporary new assignments above 44 mc for the nine f-m stations that were operating below this frequency. The changes in frequency must be made no later than Feb. 1, 1947. Some affected stations plan to cease operation until their equipment is ready for operation on their regular assignment in the new higher-frequency band.

No date has been fixed by the FCC as yet for transfering of all f-m operation to the new 88-108 mc band. Temporary operation of stations in the lower band is contemplated until sufficient f-m receivers for the higher band are available.

F-M Clinic

THE F-M BROADCAST engineering clinic conducted by Radio Engineering Laboratories in Long Island City starting Jan. 20 drew an attendance of over 100 engineers, some from as far as Liberia and Australia, during four days of lectures, demonstrations, and discussions on technical subjects associated with frequency modulation.

Outside speakers included Major E. H. Armstrong, inventor of the f-m system; Paul A. de Mars, of Raymond E. Wilmotte, Inc., consultant; John Bose, Columbia University; C. M. Braum, FCC; Stewart Bailey, of Jansky and Bailey, consultant; C. Russell Cox, of the Andrew Co., engineer; F. M. McIn-



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Coils for 115 volts, 60 cycles, and 12 volts, 60 cycles, and pure silver contacts $\frac{5}{32}$" diameter (rated 5 amps. 115V AC non-inductive) and $\frac{7}{32}$" diameter (rated 10 amps. 115V AC non-inductive) are standard. Other contacts and coils can be supplied on special order.

Overall width $1\frac{3}{4}$". Relay extends $2\frac{7}{16}$" forward and $\frac{9}{16}$" backward from mounting surface. Overall height $2\frac{3}{4}$" from bottom of armature to top of vertical contact guards. This height will accommodate 4 average contact assemblies, 2 in each pileup. Each additional contact assembly adds approximately $\frac{1}{4}$" to the overall height.

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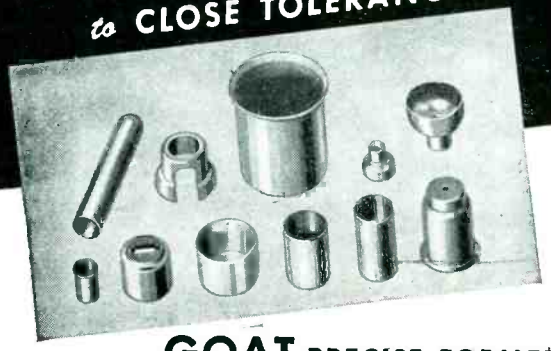

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Research. Estimated cost of the one machine to be built is of the order of 150,000 British pounds, and work on it will take two to three years. The British circuit is expected to have higher memory storage, of 75,000 decimal digits as compared with 200 for ENIAC.

Radar on Airliners

Incorporation of modern radar in eight Stratocruiser luxury airliners being built for American Overseas Airlines by Boeing is claimed to be the first case of preplanned radar installation in commercial aviation. The ships are to be placed in transatlantic service late this year.

Two antennas will be utilized, one in the nose pointing forward to detect storm areas and areas of dangerous icing, and the other a 60-inch diameter unit in the belly to map shorelines from many miles out to sea and to utilize ground radar beacons along the route for navigation. Such beacons at each end of airport runways will also serve with radar on the planes to simplify blind landings and reduce possibilities of collision with high objects in the vicinity of airports.

Ionospheric Research

Radio propagation conditions in the 28-mc band are being investigated by the Central Radio Propagation Laboratory of the National Bureau of Standards with the voluntary participation of 130 radio amateurs located around the globe. It is hoped that the project will make possible surer recognition of the unusual transmission and reception conditions accompanying sporadic E-layer ionization, which makes communication between two points possible at a higher frequency than the predicted maximum.

Frequency for Heating

One frequency on which operation is now permitted without a license is 2,450 megacycles, assigned by the FCC for industrial,

Army Airfield and Andrews Field in Maryland. In earlier tests of the system at Indianapolis, three Lanac-equipped planes were able to land at one-minute intervals through an overcast so bad that all commercial planes in the area were grounded.

BLACKBURN-HAMILTON CO. has been organized as a firm of radio station brokers, with offices in Washington, D. C. and San Francisco, Calif.

BURNDY ENGINEERING CO. has opened a new factory and warehouse in Vernon, Calif., for manufacture of connectors.

New Burndy plant in California

ALLEN B. DU MONT LABORATORIES, INC. has installed a new RCA three-bay superturnstile antenna for its television station WABD in New York City, increasing the effective radiated power from 1.81 kw to 17.8 kw, which gives the maximum coverage allowed by present FCC regulations.

HALLICRAFTERS CO., Chicago, is sponsoring a six-month expedition to equatorial Africa for exploration of the Mountains of the Moon and the Lost Lakes of the Ruwenzori and to conduct scientific research and short-wave radio experiments. Leader is Commander Attilio Gatti. From the expedition's field camp on Ruwenzori, a powerful short-wave radio station will maintain contact with the home station at the new Hallicrafters plant in Chicago, and with amateur radio operators throughout the world.

BENDIX RADIO DIVISION, Baltimore, Md. announces that one of its latest radar airport surveillance devices, known as AN/GPN-2, has been loaned to CAA by the U. S. Navy for use at Pittsburgh airport to provide exhaustive practical testing of radar for airport traffic control. It gives 360-degree coverage up to 10,000 feet altitude within 30 nautical miles of the airport. De-

signed as a mobile supplement to GCA, the equipment requires only one operator and includes two-way radio operable on all aircraft frequencies. Fast time constant circuits reduce the masking effect of ground clutter on the ppi indicator, simplifying tracking of planes close to the ground.

PACIFIC ELECTRONICS ENGINEERING CORP., Los Angeles, Calif., is setting up a demonstration microwave transmission service between Shanghai and Soochow in China as the first step in selling microwave equipment to the Ministry of Communications for eight-channel telephone communication service to serve in place of wire lines. Advantages of radio include freedom from pilferage of wire.

PERSONNEL

WILLIAM F. COTTER becomes chief engineer for Scott Radio Laboratories, Inc., Chicago, succeeding Marvin Hobbs who is engaging in consulting engineering on radio broadcast equipment.

EUGENE FREKKO was appointed chief engineer of the electrolytic division of Cornell-Dubilier Electric Corp., South Plainfield, N. J., succeeding Paul McKnight Deeley who becomes manager of the plant.

JOHN I. ADAMS is director of research for Schweitzer Paper Co., Mt. Holly Springs, Pa. in connection with manufacture of capacitor papers. He was formerly with the paper group at the Pittsfield, Mass. plant of General Electric Co.

CONRAD H. HOEPPNER has resigned as head of the Naval Research Laboratory Telemetry Group to become director of the Glenn L. Martin Co. Electronics Laboratory, Baltimore, Md.

EMIL REISMAN, formerly with International Resistance Co. for over 14 years, is chief engineer of Resistance Products Co., Harrisburg, Pa.

EVERETT W. THATCHER becomes head of the research division of the

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SALARIED POSITIONS $2,500-$25,000. This thoroughly organized confidential service of 37 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 278 Dun Bldg., Buffalo 2, N. Y.

EXECUTIVES $3,000-$25,000. This reliable service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. E. 109 Church Street, New Haven, Conn.

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ENGINEERS presently employed as supervisor of test equipment design section for large manufacturer desires position with smaller progressive organization actively planning production of television receivers. Have successfully organized both prewar and postwar television receiver production test programs. Familiar with preproduction model analysis, test process, establishment and standards, production methods of assembly and test, equipment costs, quality and reject control. Age 35. Position must carry direct responsibility for setting up and initiating production—with commensurate salary. PW-297, Electronics, 330 W. 42nd St., New York 18, N. Y.

RADIO, ELECTRONICS and Communications Engineer:—graduate radio and electrical engineer, B.S. degree, 14 years experience radio, electronic and communication engineering, design, installation, operation, supervision, both management and technical, 1 year aircraft radio, some radar, send receive 25 words per minute, 6 years purchase, supply export documents, speak, read, write French and Spanish, location immaterial, salary open, desire administrative or technical position. PW-308, Electronics, 330 W. 42nd St., New York 18, N. Y.

LABORATORY ASSISTANT Technician, no experience, four years radio repair experience. Salary open to consideration G. I. Bill if advisable. R.C.A. institute evenings. PW-309, Electronics, 330 W. 42nd St., New York 18, N. Y.

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COMPLETE FILE of Proceedings IRE, unbound, from Jan. '32 to Dec. '46 incl. Best offer received by April 15 gets it. FS-310, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

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Opportunities for Broadcast Equipment Sales Engineers

Alert, progressive designer and manufacturer of high quality AM and FM broadcast transmitters, speech equipment and accessories has immediate openings for two experienced sales engineers, preferably at present centrally located in the following territories: (1) Michigan, Indiana, Ohio and Kentucky. (2) Montana, Wyoming, Colorado, North and South Dakota, Nebraska and Kansas. Must be broadcast engineers with at least five years of successful selling experience in this field. Competitive salaries. Write fully.

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Additional Position Vacant ads on page 285—wanted ads on page 288

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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.

More on Hearing

GENTLEMEN:

It has pleased us a great deal that our article titled "Auditory Perception" in the July 1946 issue of ELECTRONICS aroused so much interest and response. With the exception of the opening paragraph in Mr. Lamport's letter (p 264, January 1947), which in view of later temporizing appears overstated, we found his critical comments interesting. The subject is controversial and will always remain so to the extent that it is related to the enjoyment of music, hence to the widely varying concepts, educational backgrounds and opinions that enter into any evaluation of what is desirable in any form of artistic expression.

Mr. Lamport says that we "do not really accept the human ear as the basic perceptor of sound—but rather regard it as an imperfect instrument for which the good radio engineer should compensate." This is not entirely accurate. The effect known as "scale distortion" occurs when the reproduction is not at the same intensity as the original sound.

Distortion may be defined as any change between the original signal and the reproduction. It is our concept that the final subjective experience of the listener is the criterion of correct design. It is the brain that must be satisfied, not the ear.

Mr. Lamport describes a condition which he believes would result in perfect reproduction, "provided the volume was adjusted to the same intensity. If he turns the volume lower, he will hear a different rendition." Obviously there is complete agreement on the phenomena under consideration. The difference is that we believe compensation for the effect is desirable. Mr. Lamport does not agree. He admits that we may be right but says it is his opinion that we are wrong, and indicates that the burden of proof is on us.

We would like to make it clear that we have no axe to grind in this connection. We have devoted a good portion of twenty years to the study of problems related to music reproduction. We have conducted listening tests with thousands of observers. The principles on which our basic suggestion is developed do not represent an innovation, but merely a method of accomplishing a well known effect automatically. It is our experience that most competent and critical observers prefer a slightly rising bass and treble characteristic for music reproduction at low intensity levels. If as a result of extensive personal listening under controlled conditions Mr. Lamport doesn't like this, we have no quarrel with his individual taste.

At the end of his letter he says, "the better the receiver, the louder it can be played with enjoyment until, I expect, the same intensity as the original sound will be the customary one and the problem considered by Goodell and Michel will have disappeared." The first half of this statement is entirely correct. We submit that anyone who operates equipment so as to produce sound intensity comparable to a symphony orchestra in his living room is probably either deaf or trying to break a lease. . . .

. . . we believe no listening tests comparing two reproducing instruments have any validity in determining the desirability of faithful reproduction. The comparison must be made between reproduced and live music . . . The task of the engineer designing reproducing devices should be confined to reproducing for the listener the same subjective experience that he has when observing the original signal.

JOHN D. GOODELL
Chief Engineer
The Minnesota Electronics Corp.
St. Paul, Minnesota

CONSTRUCTION permits have been granted to Winfield Morton by the FCC for temporary provisional f-m radiotelephone links between Santa Fe and Abiquiu, New Mexico, using 250 watts on 39.54 mc. Abiquiu is in an isolated ranch area with 700 population, without telephone contact.

CONTACTS

FOR THE FIELD OF ELECTRONICS

frequency generators are becoming equally as important to civil and mechanical engineers as to electrical engineers. The book is interestingly illustrated and many of the exercises are so arranged that instructors can substitute values of their own to increase the variety of numerical examples available.

Industrial electronic topics covered include induction heating, electrostatic precipitation equipment, rectifiers for electrochemical processes, electronic motor control, fluorescent lighting, industrial measurements and automatic control, electronic timers, and photoelectric controls. The final chapter deals with electrical communication. This book is part of the Prentice-Hall Electrical Engineering Series, of which W. L. Everitt is editor.—J.M.

Plastics Handbook for Product Engineers

By JOHN SASSO, *former Managing Editor of Product Engineering. McGraw-Hill Book Co., Inc., New York,* 1946, 468 *pages,* $6.00.

PHYSICAL and chemical properties of plastics and synthetic rubber are presented in concise form for the product engineer and other users of plastics. Electrical insulation, dielectric stress, flow temperature, and other characteristics of importance to electronic engineers are included. Factors governing failure of plastic products as insulators in electronic equipment receive detailed attention. The use of electrostatic heating as a method of working plastics is presented in the chapter on recent developments and techniques.—F.R.

The Decibel Notation

By V. V. L. RAO. *Chemical Publishing Co., Inc., New York,* 1946, 179 *pages,* $3.75.

THE CONTENT of this printing is the same as that published elsewhere (ELECTRONICS, p 406 Dec 1945). The treatment includes not only elaborate discussions of the decibel, neper, and phon, but also developments of transmission characteristics in acoustic and electric systems, manipulations of logarithms, and characteristics of sound transducers. Much space is devoted to obsolete terms and values.—F.R.

NEW BOOKS

Industrial Carbon

By C. L. MANTELL. *D. Van Nostrand Co., Inc., New York, N. Y.*, 1946, *Second Edition*, 472 *pages*, $7.50.

IN ACHIEVING thorough coverage of applications of carbon aside from its use as fuel, this book devotes one 12-page chapter to the subject of electronic tube anodes. This chapter, prepared by H. W. Abbott, Director of Laboratories for Speer Carbon Co., presents a comparison of the characteristics of graphite, molybdenum and tantalum, the three materials most used as anodes of power tubes, then covers in detail the characteristics and manufacturing techniques employed in making carbon anodes for tubes.—J.M.

Radio Operating Questions and Answers

By ARTHUR R. NILSON AND J. L. HORNUNG. *McGraw-Hill Book Co., Inc., New York*, 1946, *Eighth Edition*, 434 *pages*, $3.50.

THE LATEST edition of this standard technical radio review book contains some revisions to compensate for slight changes in FCC license examinations during the past four years, along with some new questions. All answers to questions are in essay form to facilitate the study required for answering multiple-choice examinations now in use. The one outstanding new feature is the adoption of ASA symbols for circuit diagrams. All diagrams have been revised to conform to the new standards and an appendix presents a complete compilation of these symbols.—J.M.

Electrical Engineering

By FRED H. PUMPHREY. *Prentice-Hall, Inc., New York, N. Y.*, 1946, 369 *pages*, $5.35.

THIS BOOK, intended as a text in electrical engineering for students specializing in other fields, handles the problem of holding interest by restricting early chapters to essential theory and by devoting almost half the number of pages to electronic topics and applications. The author points out in the foreword that amplifiers as applied to gages and oscillators as applied to high-

Naval Electronics Laboratory at Point Loma, California. He served as deputy technical director of the atomic bomb tests at Bikini, and during the war studied enemy electronics activity in France and Germany.

VANNEVAR BUSH, president of Carnegie Institution of Washington and wartime director of OSRD, has been named the 1946 winner of the Hoover Medal, jointly awarded by AIEE, ASCE, AIMME, and ASME. The citation reads, "Engineer, educator, and administrator, who, in critical time of need, was in a most special sense an organizer, guiding spirit, and driving force of the nation's achievements in physical and medical science; to whom, for outstanding public service, is awarded the Hoover Medal for 1946."

KENNETH A. NORTON becomes chief of the recently established Frequency Utilization Research Section of the Central Radio Propagation Laboratory at the National Bureau of Standards. This section will investigate the utility, for specific applications, of various portions of the crowded radio spectrum. Currently the section is studying comparative accuracy of various existing and proposed radio navigation systems for aircraft and ships.

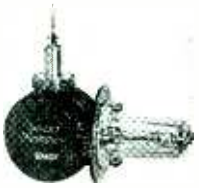
K. A. Norton

G. C. Kuczynski

GEORGE C. KUCZYNSKI has been appointed to the research staff of the Sylvania Electric Metallurgical Laboratory, Bayside, N. Y., where he will do basic research work on electron theory of metals. He received the 1945-46 Baldwin-Southwark Fellowship Award for fundamental work on strain gage wires.

FRANK H. BARNETT is now manager of manufacturing for the Home Radio Division of Westinghouse Electric Corp., Sunbury, Pa.

WAVE GUIDE PARTS



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2J32 is designed for 10 cm. operation. Rated at 300 kw peak pulse power. Complete information supplied. Brand new. The 2J32 is listed at $200.
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Magnets for magnetrons $12.00

KLYSTRON oscilator tubes 2K25/723ab designed for 3 cm. operation. New With complete data. Listed at $38.00.....$ 7.75
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30 mc oscillator-amplifier with 2 6AC7's. Uses 723ab, Waveguide input, xtal detector.
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Thermistor Beads (D-170396), for use with UHF and Micro-Wave Equipment (List $3.00). In separate sealed containers..... .95
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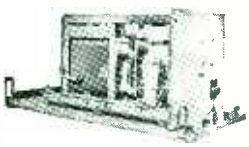

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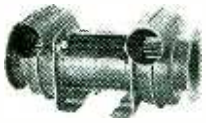

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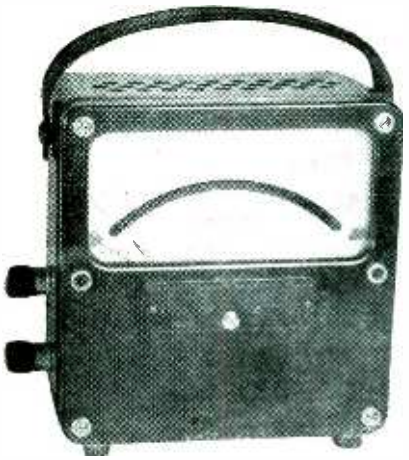

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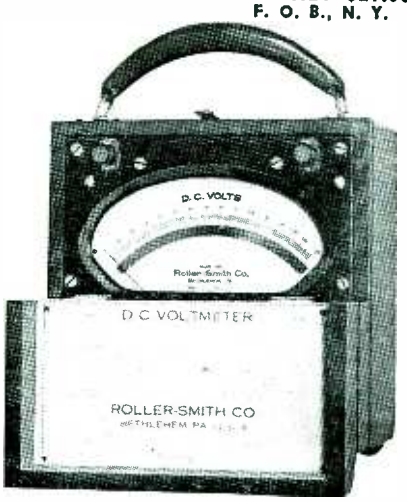

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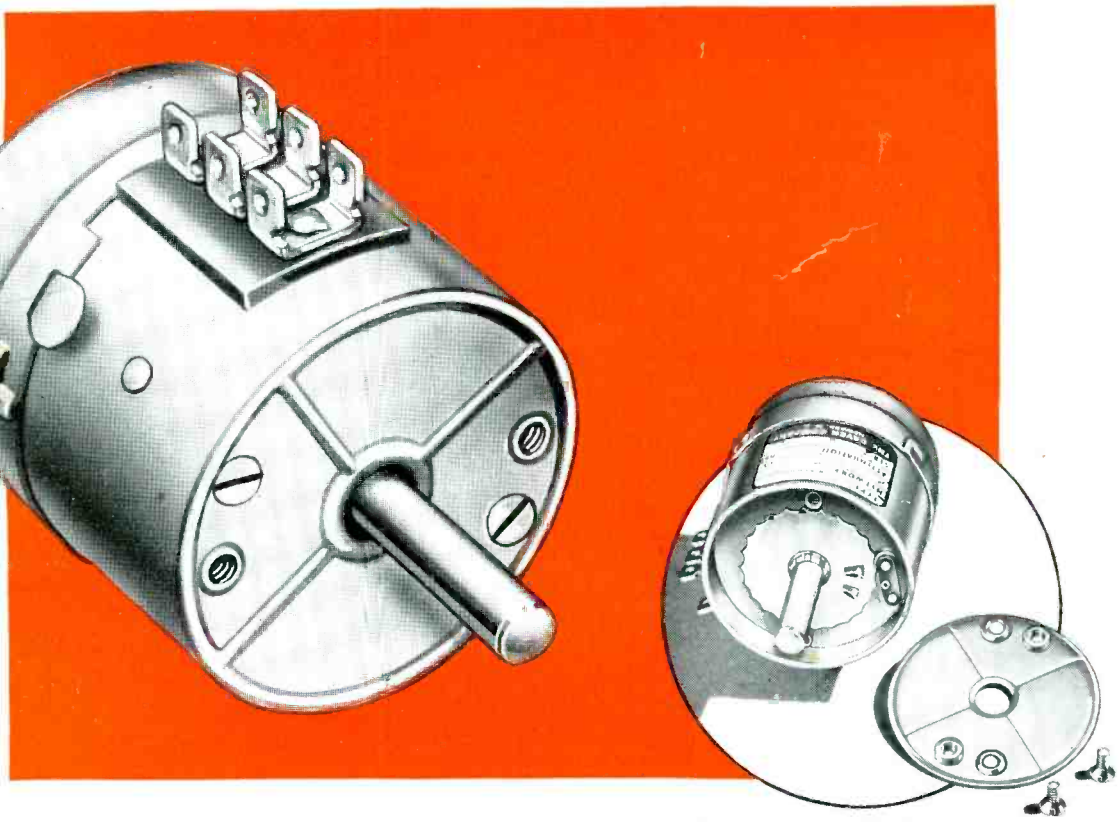

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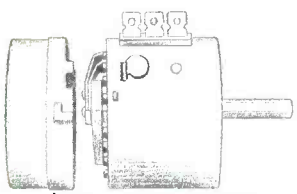

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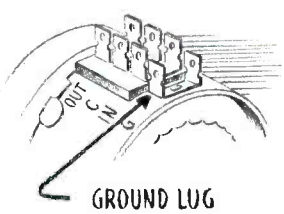
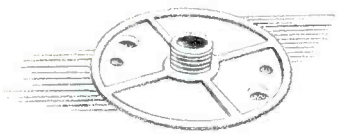


GROUND LUG



SINGLE HOLE MTG.

May we suggest, when purchasing speech input equipment, that you specify DAVEN CONTROLS.

THE DAVEN CO.
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

ANNOUNCING — New RCA Cathode-Ray Tubes

FEATURE NEW DESIGNS — IMPROVED PERFORMANCE

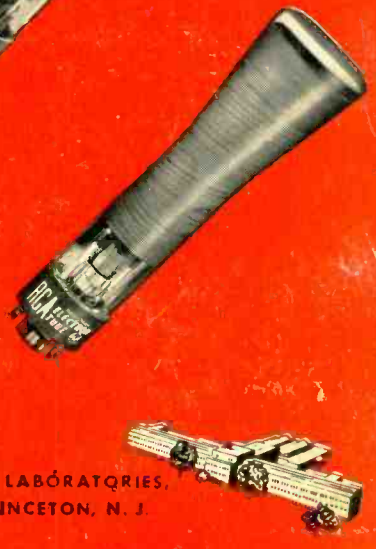
These new RCA cathode-ray tubes comprise a line of popular screen sizes, and incorporate advanced design features that set new performance standards for tubes of their size. They offer designers of oscillograph equipment the following important advantages:

1. Higher deflection sensitivity.
2. Sharper focus both at center and at edges, when beam current is varied over wide range.
3. Higher contrast screens.
4. Zero first-anode-current gun permits use of low-current voltage-divider and smaller filter capacitor.
5. Separate base-pin connection to every deflecting electrode, heater, and cathode permits operation with balanced deflection and with separate connections to heater and cathode.
6. Balanced deflecting-electrode input capacitances minimize cross-talk and dispense with necessity of neutralizing.
7. 3JP7 has an extra anode providing maximum screen brightness with minimum sacrifice of deflection sensitivity.
8. 5U-series and 3KP1 may be used interchangeably with the same power pack and deflection voltages.

The P1, P7, and P11 screens of the new cathode-ray tubes differ in their spectral-energy emission and persistence characteristics. The P1 phosphor is especially useful for general oscillographic work requiring high brightness and medium persistence. The P7 phosphor is a cascade-type of particular interest for radar and similar applications requiring long persistence of the order of several seconds. The P11 phosphor is excellent for photographic work and has sufficiently short persistence to permit its use in moving-film recording at all but the very brightest speeds.

RCA Tube Application Engineers will be pleased to consult with you on the application of these or other RCA tube types. If you desire this service, or complete technical data on the cathode-ray tubes described, write RCA, Commercial Engineering, Section R-40C, Harrison, N. J.

* Not Illustrated



RCA LABORATORIES, PRINCETON, N. J.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

COMPARATIVE SPECIFICATIONS

	2BP1	2BP11	3JP7	3KP1	5UP1	5UP7	5UP11
Heater Volts	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Heater Amps	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Max. Anode #3 Volts	—	—	4000	—	—	—	—
Max. Anode #2 Volts	2500	2500	2000	2500	2500	2500	2500
Max. Anode #1 Volts	1000	1000	1000	1000	1000	1000	1000
Fluorescence	Green	Blue	Gr.-Yel.	Green	Green	Gr.-Yel.	Blue
Persistence	Medium	Short	Long	Medium	Medium	Long	Short
Focus	Electro-static	Electro-static	Electro-static	Electro-static	Electro-static	Electro-static	Electro-static
Deflection	Electro-static	Electro-static	Electro-static	Electro-static	Electro-static	Electro-static	Electro-static
Length (Max.)	7 13/16"	7 13/16"	10 1/4"	11 3/4"	15 1/8"	15 1/8"	15 1/8"
Bulb Dia. (Max.)	2 1/16"	2 1/16"	3 1/16"	3 1/16"	5 11/32"	5 11/32"	5 11/32"
Min. Useful Screen Dia.	1 3/4"	1 3/4"	2 3/4"	2 3/4"	4 1/2"	4 1/2"	4 1/2"
Base	Duodecal	Duodecal	Diheptal	Magnal	Duodecal	Duodecal	Duodecal

RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.