electronics

REFERENCE and DIRECTORY *Issue*

JUNE • 1942

PRICE ONE DOLLAR

McGRAW-HILL PUBLISHING CO., INC.

"hyper-highs"

Pioneering in development of the frequencies of the future

Even as Amperex engineers distinguished themselves by exclusive developments in the design and structure of ultra-high frequency transmitting tubes . . . so are they now intent upon exploring the infinitely higher frequencies.

While these improvements originating in our research and engineering departments are entirely restricted to military operations, they will be released, in due time, for broadcast, industrial and electro-medical application.

AMPEREX ELECTRONIC PRODUCTS

79 WASHINGTON STREET **BROOKLYN, NEW YORK**

A McGRAW-HILL PUBLICATION

electronics

Vol. 15 No. 6

CONTENTS—JUNE, 1942

Reference and Directory Issue

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Founder and Honorary Chairman

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HERE'S A TRACING CLOTH
proofed against
MOISTURE GHOSTS

Perspiration stains and water marks hold no terrors for this improved tracing cloth—*and it holds pencil smudges or erasure scars at a minimum.* Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

The secret of this amazing performance lies in a remarkable new process that defies moisture, and gives PHOENIX an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H pencil lines show clearly, and reproduce strongly! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. The new white color and increased transparency provide excellent drawing contrast and produce strong blueprints.

Let PHOENIX speak for itself on your own drawing board. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

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CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES · DETROIT · MONTREAL

PHOENIX DEFIES MOISTURE GHOSTS

Your hands are never dry. Perspiration stains ordinary tracing cloth, producing opaque spots, or "ghosts," that show on blueprints. Water splashes make even more disagreeable stains.

PHOENIX *Tracing Cloth withstands actual immersion in water for more than 10 minutes at a time without ill effects!* Perspiration will not stain it!

PHOENIX LESSENS SMUDGE GHOSTS

The improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: Cleaner tracings and blueprints.

PHOENIX REDUCES ERASURE GHOSTS

Ordinary tracing cloths become scarred when erased. Erased spots produce ghosts on the blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

K&E

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for pencil *and* ink

whitest instrument dials stay

"How can we keep instrument dials from discoloring?" That's a question to which industry has wanted an answer for years. Today the answer is ready.

Make this test for yourself—Take an ordinary instrument dial and one of the new Westinghouse permanent white dials. Place them overnight in an oven heated to 300° F. Then look at them. That is how they will look after approximately two years of service in the average plant. Other destructive conditions, such as exposure to corrosive fumes of excessive humidity, as may be experienced in many instrument applications, will have a similar effect. The Westinghouse dial will stay white because all Westinghouse instrument dials are faced with a plastic-base material, which resists the effects of time, industrial fumes, heat and moisture.

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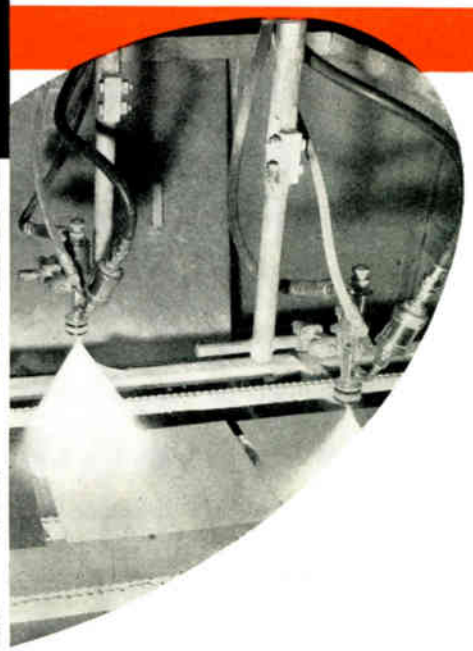
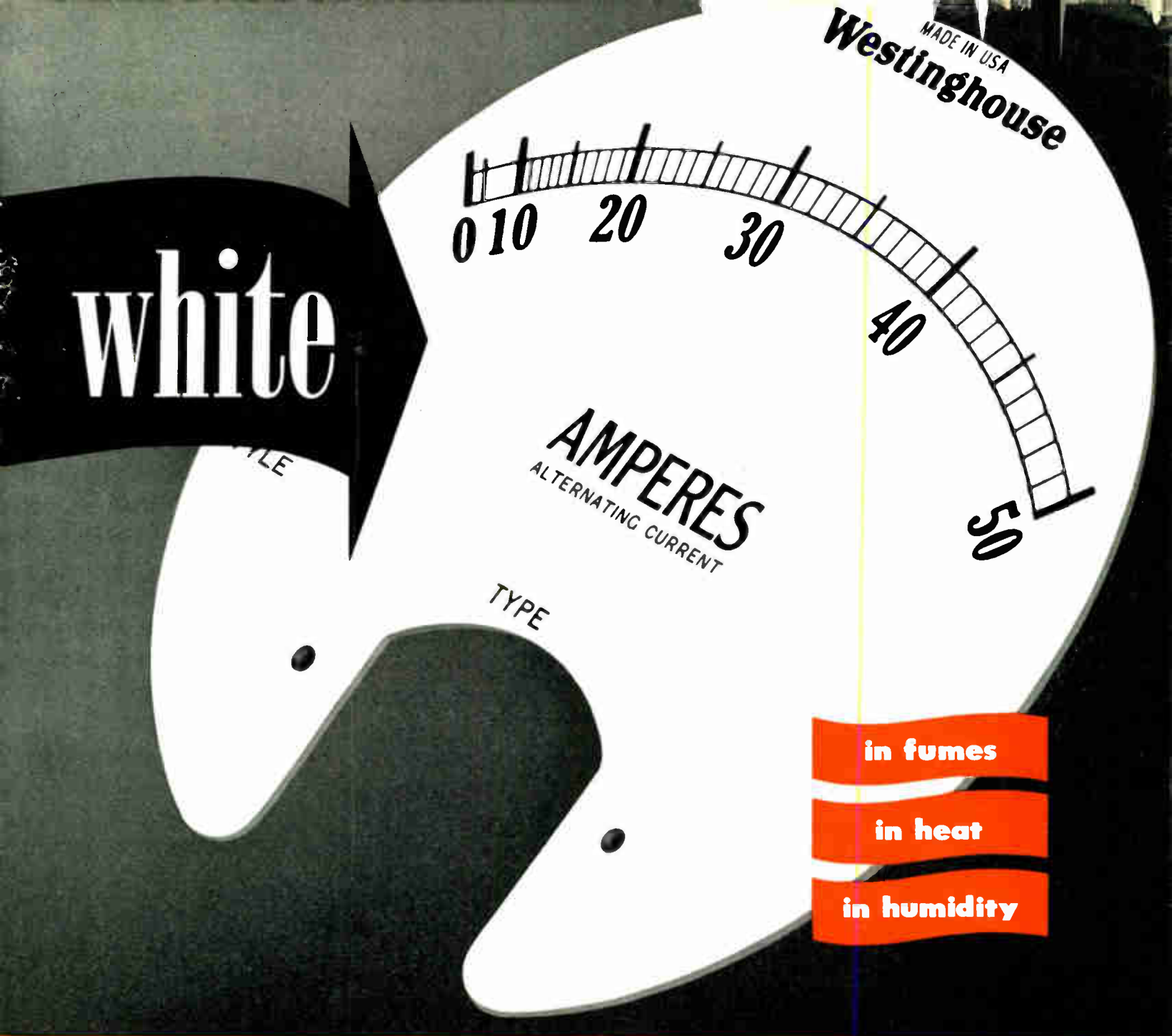
This is only one example of the special steps we take to make our instruments the best you can buy. Detailed information on other features, including nonblunting pivots, nonaging springs, permanent magnets, and tubular pointers, is in our Bulletin 3013. Address Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Department 7-N.

J-40334

Westinghouse





INDUSTRY'S MOST COMPLETE LINE OF QUALITY ELECTRICAL INSTRUMENTS

S-35 is an attractively styled switchboard instrument for projection mounting on medium size panels. Accuracy within 2%.

For flush mounting on small panels Type V-35 is an instrument of attractive design. Accuracy within 2%.

On large switchboards where it is desirable to have large full-face round type instrumentswith high accuracy, the Type S is the answer.

High visibility in a switchboard instrument is one of the features of this KA-25 with flush-mounted case 5½ inches square. Accuracy is 1%.

TA Industrial Analyzer—in one case all the instruments needed for complete a-c data in any industrial plant.

The Type A recorder with low first cost, low maintenance unit gives good service in a variety of applications.

PC-135, a through type current transformer gives 1 through 250 amperes in primary, 5 amperes in secondary.

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Some of the SHALLCROSS Products...

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- Bonding Testers
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- Decade Resistance Boxes
- Megohm Decade Resistance Standards
- Potentiometers—Decade Type
- Decade Resistance Standards (Heavy Duty)
- Megohmmeters
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INSTRUMENTS · RESISTORS · SWITCHES

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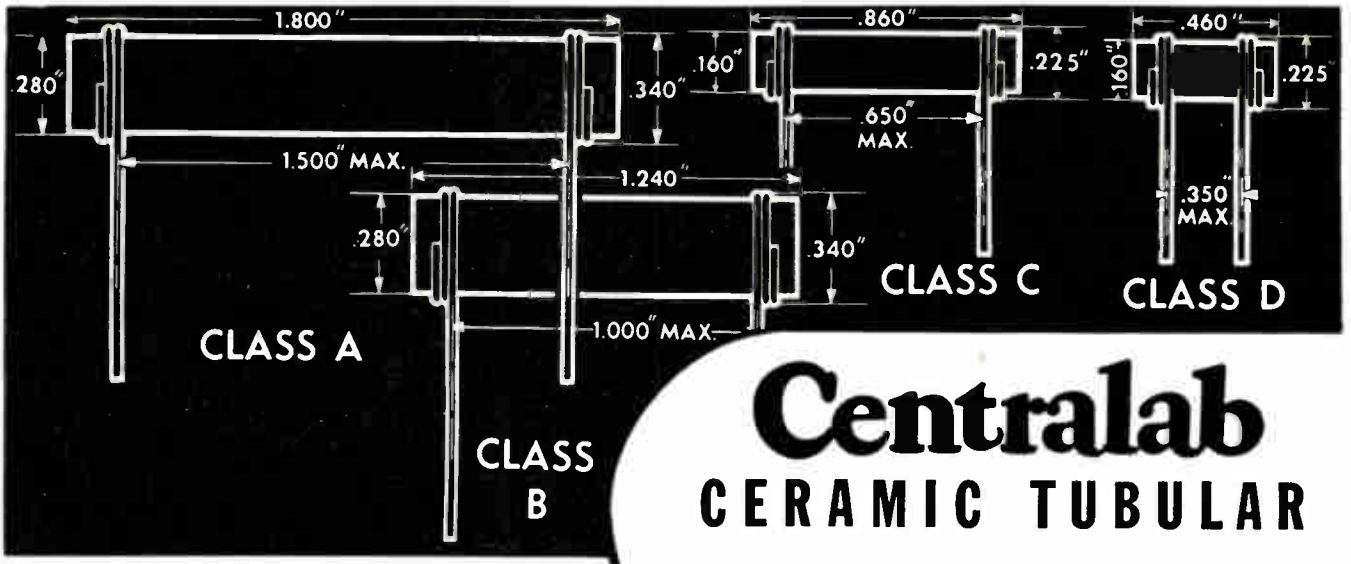


Centralab

CERAMIC TUBULAR FIXED CAPACITORS

Write for Data

Bulletin 597 describes the CENTRALAB CERAMIC TUBULAR Fixed Capacitors with controlled temperature sensitive characteristics.

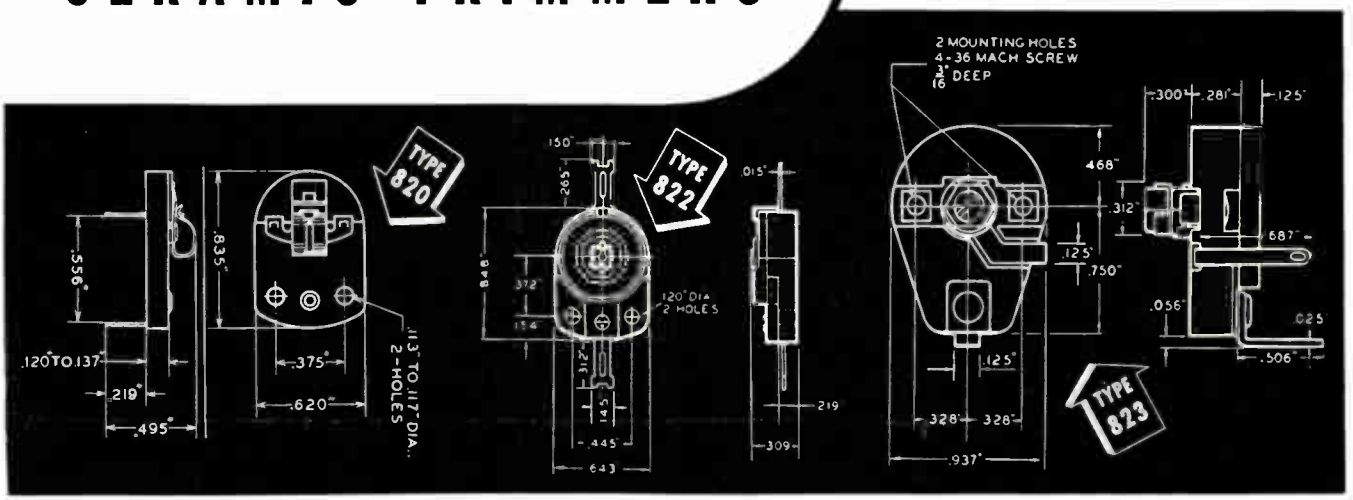
Centralab Ceramic Trimmers feature capacity ranges and stability, the equivalent of air trimmers, plus a saving in space and weight. Write for bulletins that supply full Ceramic Trimmer data.

Centralab

CERAMIC TRIMMERS

Always specify Centralab — whether for ceramic products . . . Fixed Resistors . . . or Volume Controls . . .

CENTRALAB
DIV. OF GLOBE-UNION INC.
MILWAUKEE WISCONSIN



One thing above all others makes Formica the valuable material it is in so many industries — electrical, mechanical, aviation, chemical, and that is: once a Formica part is installed it remains unchanged almost regardless of conditions. It really stays put!

When you build a part of Formica you can challenge the elements to do their worst and they won't accomplish much.

Changes in temperature do not alter its dimensions appreciably. Humidity or lack of it leaves it untouched. Electrical currents can't push through it because it is an excellent insulator for high or low frequency currents. No atmospheric condition, anywhere in the world, can cause it to corrode, or roughen and destroy its surface, because it is inert chemically . . . The Formica data book tells this story in terms of precise engineering tests. Send for it.

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THE FORMICA INSULATION COMPANY

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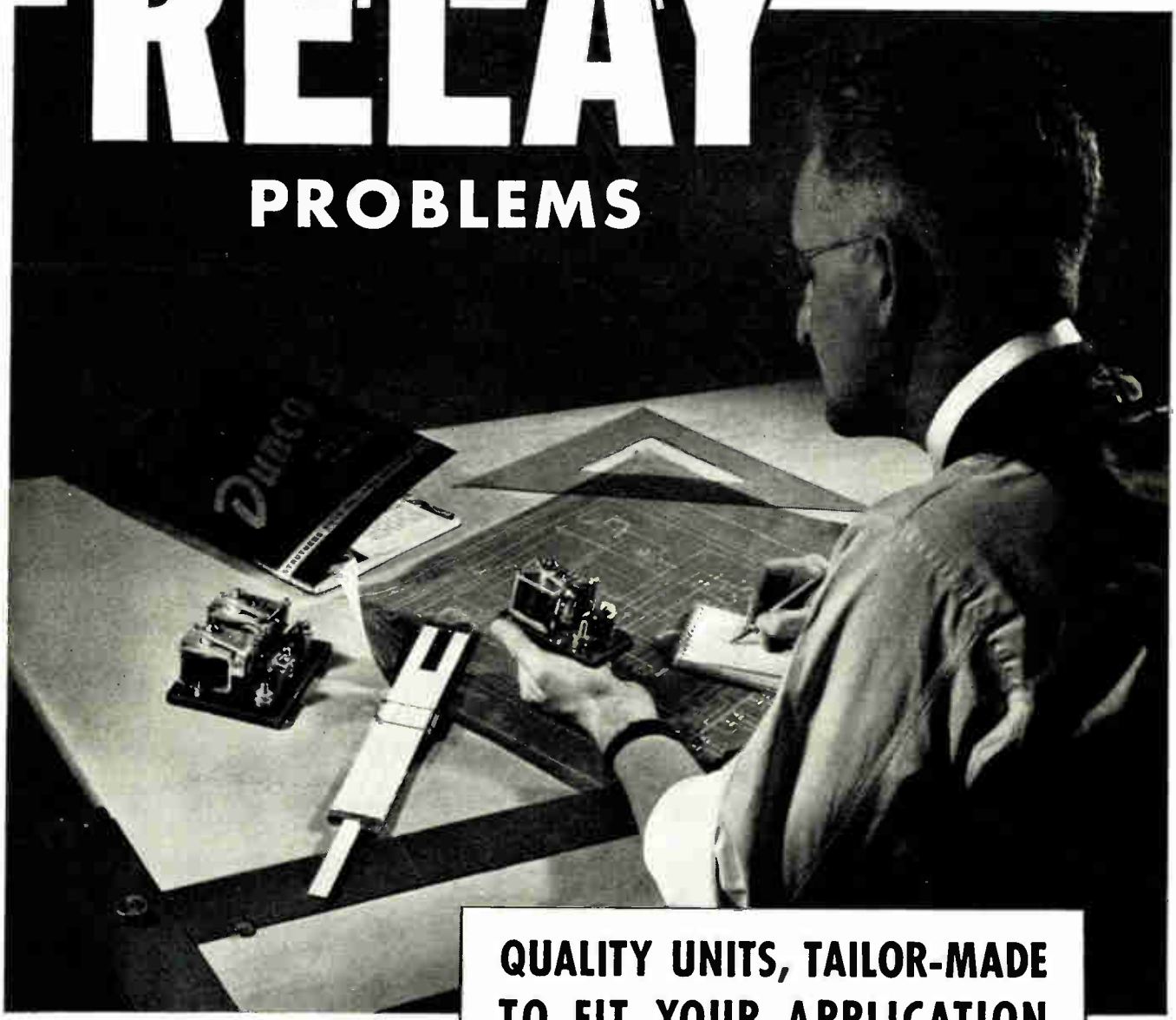


QUALITY UNITS, TAILOR-MADE TO FIT YOUR APPLICATION

Don't engineer "around" Relays and Timers! Don't waste time and effort trying to utilize units that *almost* meet your requirements! Come to Dunco where one of the nation's largest relay businesses has been built solely on the ability to supply exactly the right relay or timing device for the job—tailor-made to fit your specifications like a glove. Dunco engineers will gladly cooperate in solving your relay problems.

DON'T MISS THIS!...

The NEW DUNCO CATALOG AND RELAY DATA BOOK

We sincerely believe this is the finest, most helpful, and most complete volume of its kind ever issued. Contains 48 pages, profusely illustrated with photos, diagrams and charts. Write for your copy today.

STRUTHERS DUNN, INC., 1326 CHERRY ST., PHILADELPHIA, PA.

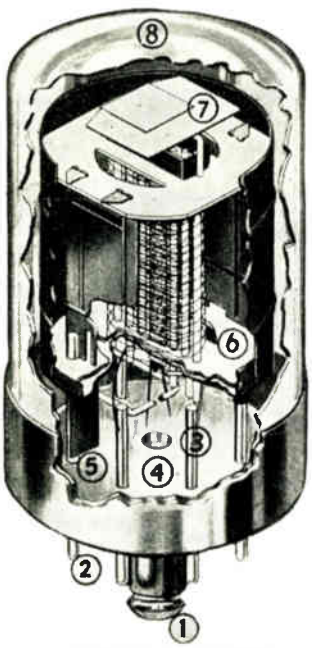
FOR ACTIVE MILITARY SERVICE!

As battle lines lengthen, as American military might fans out over the globe, radio becomes an increasingly vital artery of our communications system.

So naturally, radio tubes must be stronger, more solidly built, better able to "take it" than ever before.

Look at the cross-section of the Sylvania Lock-In, shown in the accompanying diagram. Note its nine outstanding features. Then you'll understand why our armed forces are relying, in growing measure, upon the unflagging dependability of this great tube.

NINE GUARANTORS OF STOUT PERFORMANCE



SYLVANIA LOCK-IN TUBE

1. **LOCK-IN LOCATING LUG** — also acts as shield between pins
2. **NO SOLDERED CONNECTIONS**—all welded for greater durability
3. **SHORT, DIRECT CONNECTIONS** — fewer welded joints—less loss
4. **ALL-GLASS BASE**—low loss and better spacing of lead wires
5. **NO GLASS FLARE** — unobstructed base for internal shielding
6. **IMPROVED MOUNT SUPPORT** — ruggedly mounted on all sides
7. **GETTER LOCATED ON TOP**—shorts eliminated by separation of getter material from leads
8. **NO TOP CAP CONNECTION** — overhead wires eliminated
9. **REDUCED OVER-ALL HEIGHT** — space saving

SYLVANIA
RADIO TUBE DIVISION

HYGRADE SYLVANIA CORPORATION

New York City **EMPORIUM, PA.** Salem, Mass.

Also makers of HYGRADE Incandescent Lamps, Fluorescent Lamps and Fixtures

AIMING

FIRING

SIGHTING

BOMBING

RELAYS by GUARDIAN

★ Swing the turrets! Aim! Fire! And, aircraft guns respond to controls by Guardian. Sight! Bomb! It's the order of the day. Guardian stands ready for any assignment that will help to preserve the "American Way" of life.

Certified by all branches of the war department . . . Guardian invites inquiries for samples of Government Approved Controls for the jobs you are doing today . . . for those new designs that must excel tomorrow. Write—wire—phone.

★ GUN SWITCH HANDLES
★ REMOTE FIRING EQUIPMENT
★ TURRET CONTROLS
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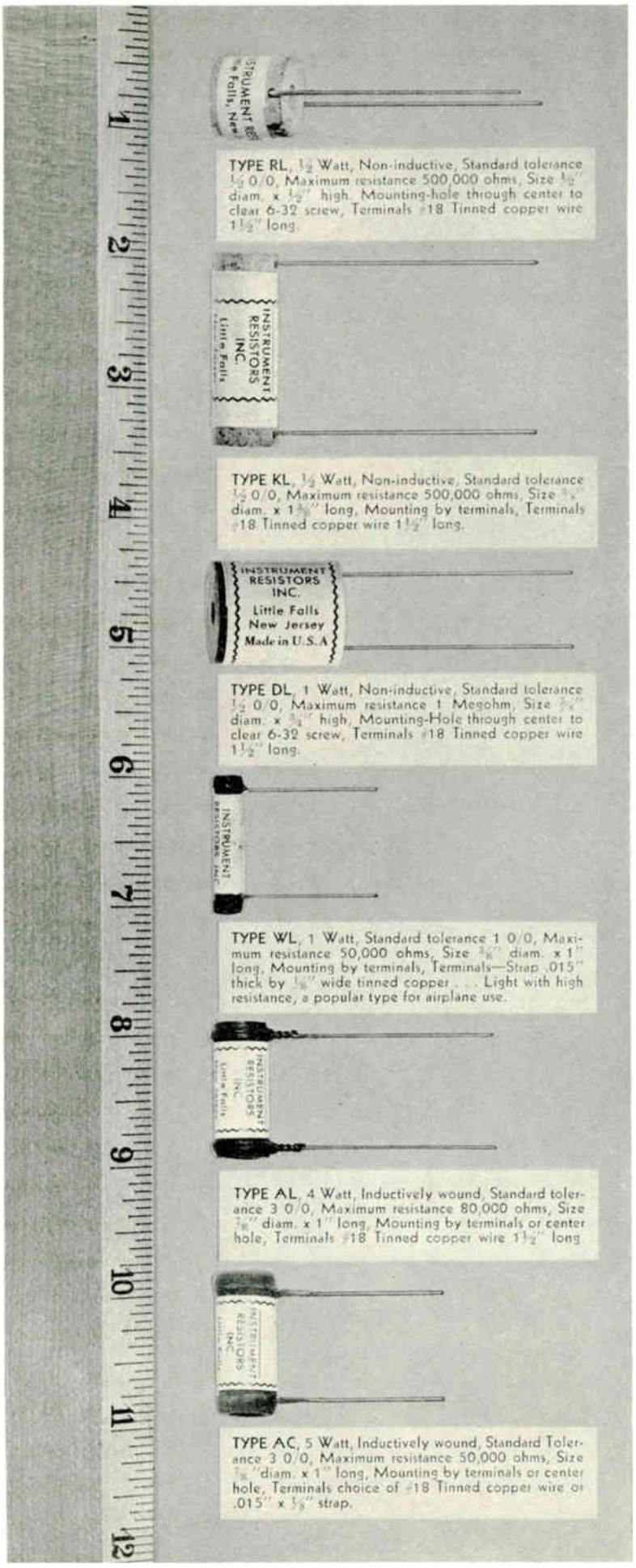
★ NAVIGATION CONTROLS
★ AIRCRAFT CONTROLS
★ BOMB RELEASES
★ SOLENOID CONTACTORS

GUARDIAN ELECTRIC

1625 WEST WALNUT STREET — CHICAGO, ILLINOIS

LARGEST LINE OF RELAYS SERVING AMERICAN DEFENSE INDUSTRY



TYPE RL, 1/2 Watt, Non-inductive, Standard tolerance 1/2 0/0, Maximum resistance 500,000 ohms, Size 1/8" diam. x 1/2" high. Mounting-hole through center to clear 6-32 screw, Terminals #18 Tinned copper wire 1 1/2" long.

TYPE KL, 1/2 Watt, Non-inductive, Standard tolerance 1/2 0/0, Maximum resistance 500,000 ohms, Size 3/16" diam. x 1 3/8" long, Mounting by terminals, Terminals #18 Tinned copper wire 1 1/2" long.

TYPE DL, 1 Watt, Non-inductive, Standard tolerance 1/2 0/0, Maximum resistance 1 Megohm, Size 3/16" diam. x 3/4" high, Mounting-Hole through center to clear 6-32 screw, Terminals #18 Tinned copper wire 1 1/2" long.

TYPE WL, 1 Watt, Standard tolerance 1 0/0, Maximum resistance 50,000 ohms, Size 3/8" diam. x 1" long, Mounting by terminals, Terminals—Strap .015" thick by 1/8" wide tinned copper . . . Light with high resistance, a popular type for airplane use.

TYPE AL, 4 Watt, Inductively wound, Standard tolerance 3 0/0, Maximum resistance 80,000 ohms, Size 7/8" diam. x 1" long, Mounting by terminals or center hole, Terminals #18 Tinned copper wire 1 1/2" long.

TYPE AC, 5 Watt, Inductively wound, Standard Tolerance 3 0/0, Maximum resistance 50,000 ohms, Size 7/8" diam. x 1" long, Mounting by terminals or center hole, Terminals choice of #18 Tinned copper wire or .015" x 1/8" strap.

Specializing in

WIRE WOUND RESISTORS

If space and weight are factors in your design, check the maximum resistances of these wire-wound resistors against their dimensions which are indicated by the rule. Specializing in wire-wound resistors, the type with which it is possible to obtain high resistance in minimum space with minimum weight, we have standardized these and other units in order to give you the price advantage of mass production.

As specialists, moreover, we have the experience and equipment to meet your resistor needs whether or not any of our standard units can be used.

Write today for file catalog with prices . . . and if your resistor problem is unusual, by all means, get our advice and quotations.

●

INSTRUMENT RESISTORS CO.

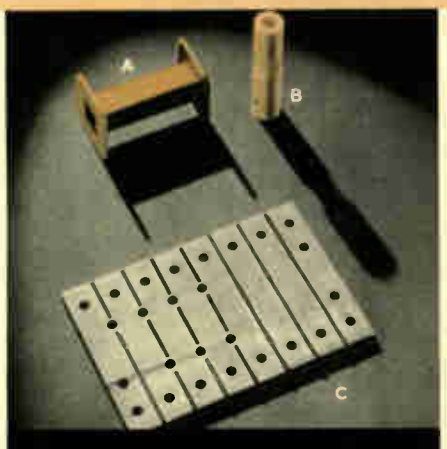
25 Amity Street

LITTLE FALLS . . . N. J.

MICA CARD, Type HN, Standard tolerance 2%. 30 Watt, Maximum resistance 50,000 ohms, Size 1 1/2" wide x 3 1/4" long x 3/32" thick, Mounting Insulated eyelet to clear 6-32 screw, Terminals Tinned copper lug. Ideal for limited space-lying close to panel or wall.

Photo by U. S. Army Signal Corps

How a Shot in the Dark Finds Its Mark



A—Square tube coil form sanded to size; flanges milled, sawed and broached.

B—Insulating tube, sawed, drilled, reamed, and milled.

C—Sawed, milled and drilled terminal panel.

THE destruction of enemy planes at night is dependent upon electrical teamwork. Efficient work of battery units and the reliability of the communications between them require a dependable insulation.

Synthane's combination of physical and electrical properties makes it as useful in war as in peacetime production. Among them are excellent electrical insulating characteristics, light weight, structural strength, ease of machining and resistance to corrosion from solvents, water, many acids and salts.

As an aid to essential industries, some of which are using Synthane for the first time, and as a help to peacetime planners, the information on the back of this advertisement may prove helpful. We'll be glad to supply additional information if you'll write us.

Plan your future with plastics.

SYNTHANE CORPORATION, OAKS, PENNA.

SYNTHANE TECHNICAL PLASTICS

SHEETS · RODS · TUBES · FABRICATED PARTS

SYNTHANE

Bakelite — laminated

SILENT STABILIZED GEAR MATERIAL

STANDARDS OF QUALITY FOR

SYNTHANE BAKELITE-LAMINATED SHEETS

BLACK figures are actual test values; BROWN figures are RELATIVE values for use in comparing grades—100 indicates the most favorable relative value.

GRADE	(1) Tensile Strength	(1) Transverse Strength	(1) Compressive Strength	(2) Dielectric Strength Short-Time Test	(2) Dielectric Strength Step-by-Step Test	(3) Power Factor	(3) Dielectric Constant	(3) Dielectric Loss Factor	(4) % Water Absorption	Impact Strength	Recommended Temperatures for Punching * †
	Pounds per Square Inch			Volts per Mil. (.001")		At 1,000,000 Cycles					
X	12,500 100	21,000 100	35,000 90	700 100	500 100	.050 55	5.5 80	.27 45	4.0 80	40	Cold to 1/32" Hot to 3/32"
XX	8,000 65	16,000 75	34,000 90	700 100	500 100	.040 70	5.0 90	.20 60	1.3 70	30	Cold to 1/32" Hot to 3/32"
XXX	7,000 55	15,000 70	32,000 85	650 95	450 90	.032 85	4.8 95	.15 80	1.0 90	20	Hot to 1/16" (Simple shapes, compound dies only)
XP	8,000 65	15,000 70	22,000 60	700 100	500 100	.045 60	5.0 90	.22 55	3.0 30	40	Cold to 1/16" Warm to 1/8"
XXP	8,000 65	16,000 75	25,000 65	700 100	500 100	.040 70	5.0 90	.20 60	1.3 70	30	Cold to 1/32" Warm to 1/8"
XXXP	7,000 55	15,000 70	25,000 65	650 95	450 90	.027 100	4.5 100	.12 100	1.0 90	20	Warm to 1/32" Hot to 3/32"
C	9,500 75	20,000 95	38,000 100	200 30	120 35	.10 35	7.0 65	.70 15	1.7 55	100	Cold to 1/16" Hot to 3/16"
CE	8,000 65	17,000 80	36,000 95	500 70	300 60	.055 50	5.5 80	.30 40	1.2 75	80	Cold to 1/32" Hot to 3/32"
L	9,000 70	20,000 95	35,000 90	200 30	120 35	.10 35	7.0 65	.70 15	1.4 65	70	Cold to 1/16" Hot to 3/16"
LE	8,500 65	19,000 90	37,000 95	500 70	300 60	.045 60	5.0 90	.22 55	.90 100	60	Cold to 1/32" Hot to 3/32"

ALL VALUES ABOVE REPRESENT MINIMUM AVERAGES FOR STANDARD GRADES.

METHODS FOR TESTING SYNTHANE

1. Tests were made at room temperature, approximately 25 deg. C., following the American Society for Testing Materials Method D-229-39. All thicknesses up to 1 inch, inclusive.

2. Tests were made under oil on 1/8" thickness, according to American Society for Testing Materials Method D-149-40-T.

3. Tests were made at a frequency of 1,000,000 $\left(\frac{6}{10}\right)$ cycles, according to American Society for Testing Materials Method D-150-41-T. All thicknesses up to 1 inch, inclusive.

4. Tests were made on pieces 3" x 1" x 1/8" thick, according to the American Society for Testing Materials Method D-229-39 after immersion in water for 24 hours at approximately 25 deg. C. plus or minus 2 deg. C. (For grades C, CE, L, LE, 1/16" thickness was used.)

SYNTHANE

Bakelite— laminated

SYNTHANE CORPORATION

OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

MACHINEABILITY OF SYNTHANE SHEETS

*Temperature Standards for Punching.

Cold is room temperature, not under 60° F.

Warm is 120° F. to 150° F.

Hot is 175° F. to 250° F.

†All grades of Synthane may be easily sawed, drilled, turned, milled, etc. See Synthane folder on machining.

YOU CAN HEAR VICTORY... in the vibrant speeches of the President contrasted to the "intuitive" whining of *der führer*... in the defiant roar of American industry geared to all-out production... in the swift, sure transmission of vital radio messages to which Cornell-Dubilier contributes capacitors that are as infallible as thirty-two years' and two World Wars' experience can make them.

Today manufacturers must have high priority orders to enjoy C-D's finer performance. But when the war is won, C-D capacitors will again be available to all industry, and C-D's extra dependability, which makes it the most widely used capacitor in the world today, will assure more hours of capacitor use per dollar for industry tomorrow.

Cornell Dubilier Electric Corporation, South Plainfield, New Jersey; New England Division: New Bedford, Mass.

MICA TRANSMITTER CAPACITORS

Copied, imitated...but never duplicated.

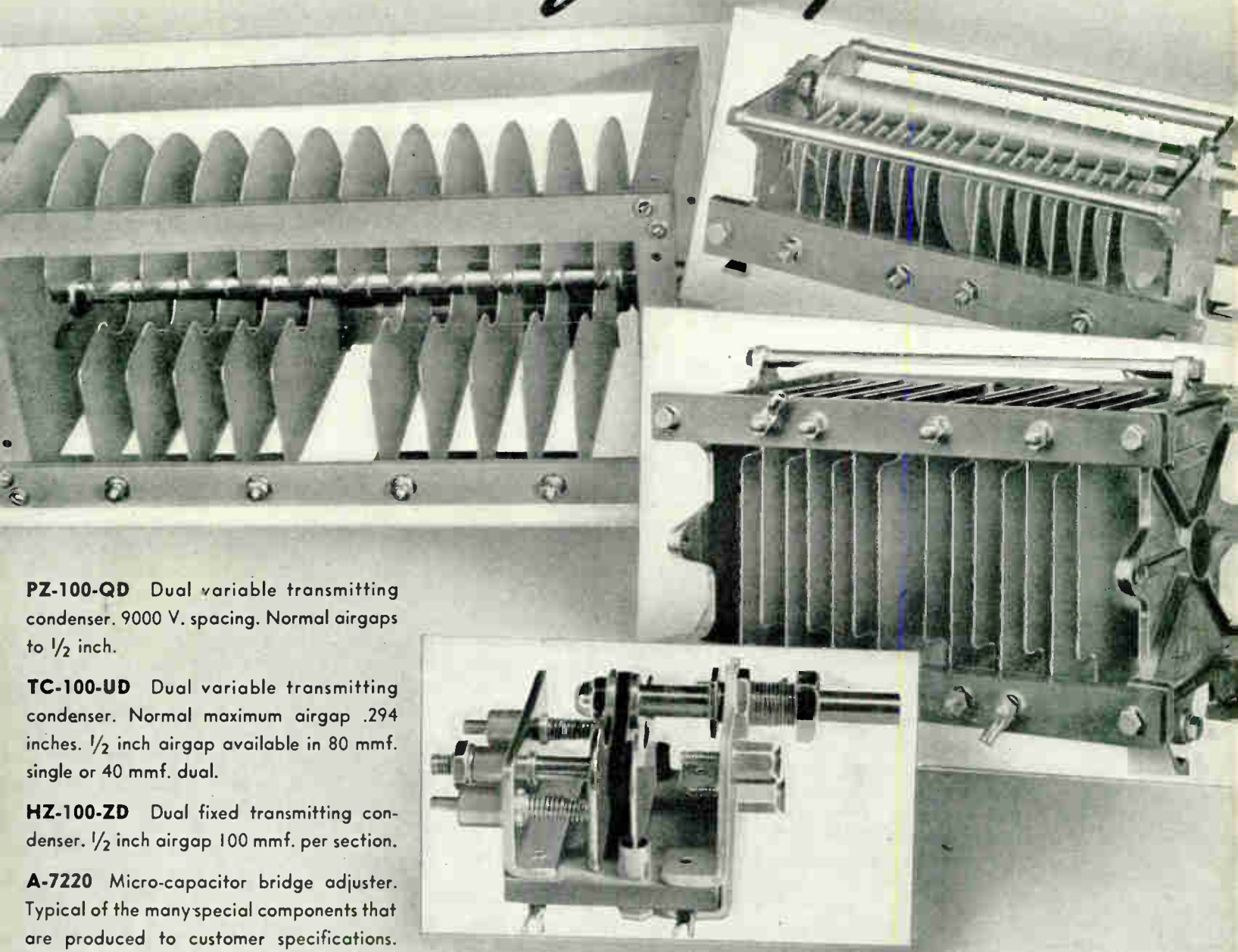
Type 6 Mica Transmitter Capacitors in moulded cases are designed for a wide variety of radio frequency applications, where size and weight must be kept at a minimum. They are specially suited for use as grid, plate, coupling, tank and by-pass units. The type 6 is one of the smallest types employing the Dubilier patented series-stack construction, permitting their use on higher r.f. voltages.

Cornell Dubilier Capacitors

MICA • PAPER • DYKANOL • WET & DRY ELECTROLYTIC CAPACITORS

MORE IN USE TODAY THAN ANY OTHER MAKE

Standard of Comparison



PZ-100-QD Dual variable transmitting condenser. 9000 V. spacing. Normal airgaps to 1/2 inch.

TC-100-UD Dual variable transmitting condenser. Normal maximum airgap .294 inches. 1/2 inch airgap available in 80 mmf. single or 40 mmf. dual.

HZ-100-ZD Dual fixed transmitting condenser. 1/2 inch airgap 100 mmf. per section.

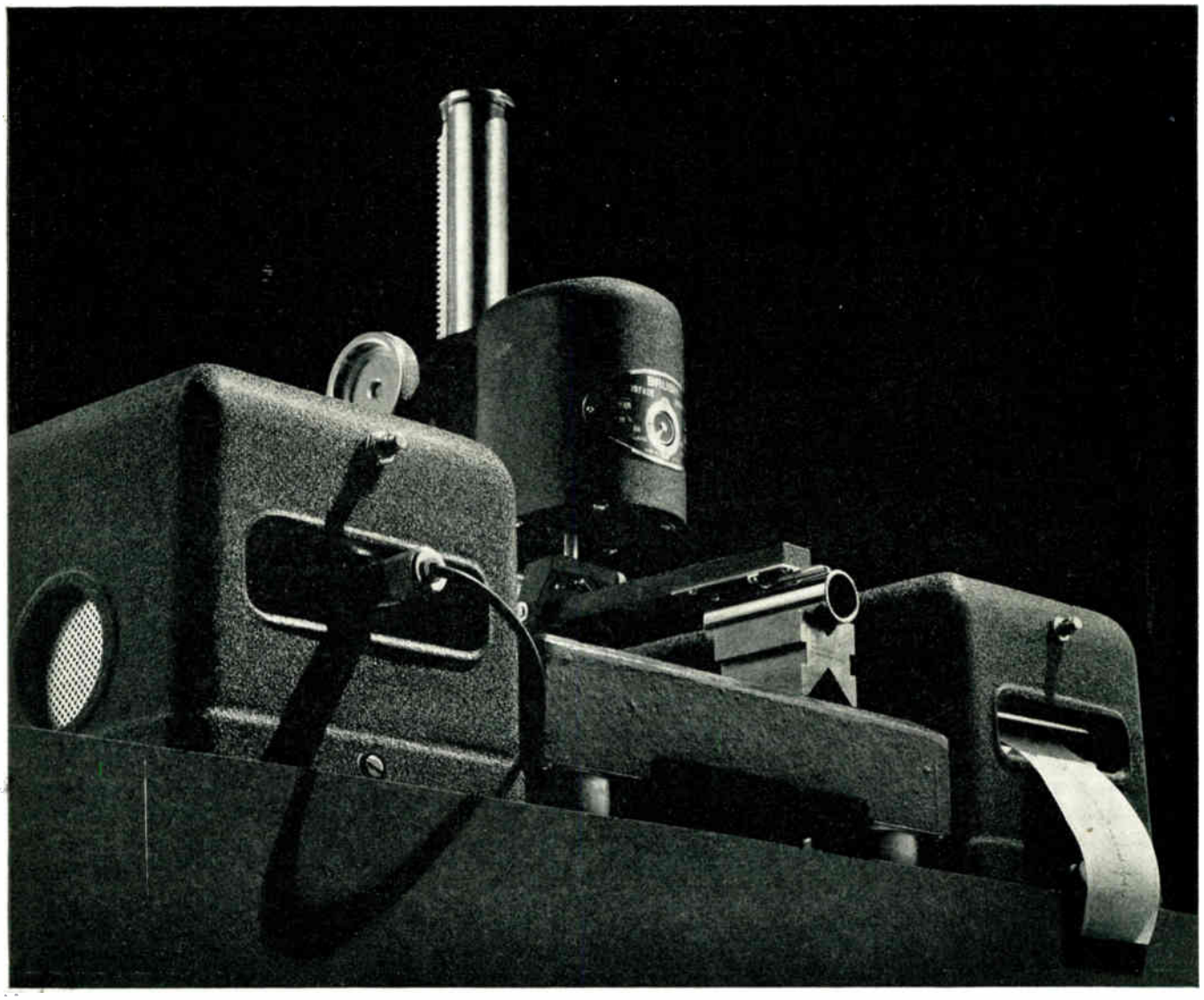
A-7220 Micro-capacitor bridge adjuster. Typical of the many special components that are produced to customer specifications.

CARDWELL CONDENSERS

Specified and used generously in practically every type of communications equipment from the lowest power transmitters to the highly complex controls of frequency checking devices, CARDWELLS have never failed to justify their selection.

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION

83 PROSPECT STREET BROOKLYN, N. Y.



Precision STARTS WITH LITTLE THINGS • • • AS LITTLE AS .000001"

Surface smoothness (height, depth, pitch of each irregularity) is accurately measured to a millionth of an inch . . . precision at its finest . . . by the Brush Surface Analyzer.

The movement of the diamond stylus is amplified up to 100,000 times and immediately recorded on a moving paper chart for permanent reference.

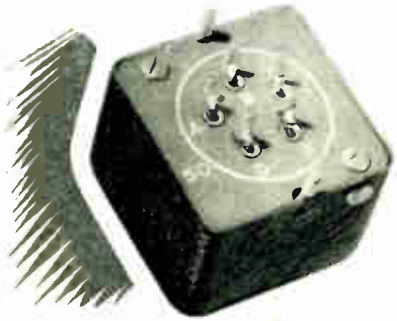
Readily operated anywhere by plugging into a 110 volt, 60 cycle, A. C. line.

BRUSH CRYSTAL PRODUCTS

THE BRUSH DEVELOPMENT CO.

3311 PERKINS AVENUE • • CLEVELAND, OHIO

FACILITIES FOR
PROMPT QUANTITY PRODUCTION



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400 CYCLES
Inductance held to ½ of 1%

TRANSFORMERS:
Power up to 2 KVA. Modulation . . Audio

CHOKES

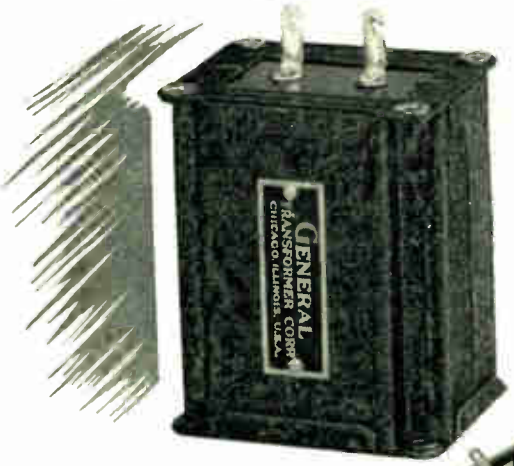
COILS: Paper Layer or Bobbin Type

AUDIO and NOISE FILTERS

POWER SUPPLY UNITS

ASSEMBLIES: Which Include Transformers for Transmitters and Receivers

To Signal Corps, Air Corps, Navy Specifications . . . .



COMPLETELY ENCLOSED
SHIELDED TRANSFORMER

TRANSFORMERS UP
TO 2 KVA. IN CAST
IRON HOUSINGS

POWER TRANSFORMER
Hermetically sealed to pass salt water immersion tests

CHOKE
30 henries

SEND DRAWINGS AND SPECIFICATIONS FOR SPEEDY QUOTATIONS TO

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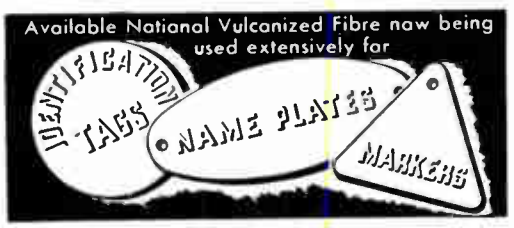
air raid wardens lives are safer

thanks to available National Vulcanized Fibre

NATIONAL VULCANIZED FIBRE is doing yeoman service in civilian defense. One outstanding use is in Protective Helmets. It is ideally suited for this application because of its lightness in weight (one-half that of aluminum) but more importantly, because it is tough! It has the remarkable property of absorbing impact blows and distributing their forces over so wide an area that injury is prevented. Protective Helmets made of National Vulcanized Fibre withstand without fracture the impact of an eight-pound ball dropped six feet! And they stubbornly resist wear and abrasion. National Vulcanized Fibre is daily replacing hard-to-get metals and plastics. Our engineering and research facilities are available to you on any problem. Wire, phone or write us.



NATIONAL VULCANIZED FIBRE COMPANY

WILMINGTON DELAWARE

Offices in Principal Cities

You can use this Handbook profitably. Write for free copy today.

★ ★ ★ *Broadening American Enterprise through Dependable Plastics* ★ ★ ★

IT'S A LONG JUMP FROM

BOUDOIR TO FOX HOLE!

SHOCK-

factor in

"... withstood wear and tear of civilian use ..."

"... retained its lustrous finish ..."

"the Signal Corps required extra durability ..."

The molding of telephone handsets may seem far removed from your manufacturing operations. Yet it may be of direct importance, as an example of the problems you may encounter in using plastics for war production.

What happened when the handset used in homes and offices had to be adapted to service in the Signal Corps? Molded from phenolic plastics, the standard handset was sufficiently strong to withstand the wear and tear of everyday civilian use, and it retained its lustrous finish despite constant handling.

But the Signal Corps required

BAKELITE

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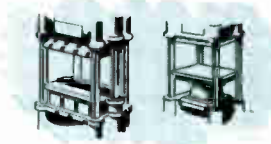
PLASTICS HEADQUARTERS

3 Ways "BAKELITE" PLASTICS

1 LITERATURE ON "DO'S" AND "DON'T'S" OF PLASTICS... Helpful technical booklets containing data on types and forms of BAKELITE plastics, and the most efficient methods of fabrication. This literature will help you to choose the right plastic for each job, save time and avoid errors.

RESISTANCE is now the prime selecting plastics for strategic service!

"specifications . . . called for another type of material . . ."



". . . high impact plastic required higher pressures . . ."

"study . . . avoided errors that might have slowed production . . ."

extra durability, to meet much more exacting service requirements. Specifications were changed, calling for another type of phenolic molding material providing much greater resistance to shock. Use of this high-impact plastic made it necessary to build stronger molds, to withstand considerably higher molding pressures. This, in turn, brought about important modifications in molding technique.

This careful study of problems relating to plastics materials, design, and fabricating techniques avoided manufacturing errors that might have slowed production and wasted valuable material. As a result, production is maintained at a high level, and the molded handset provides satisfactory field performance.

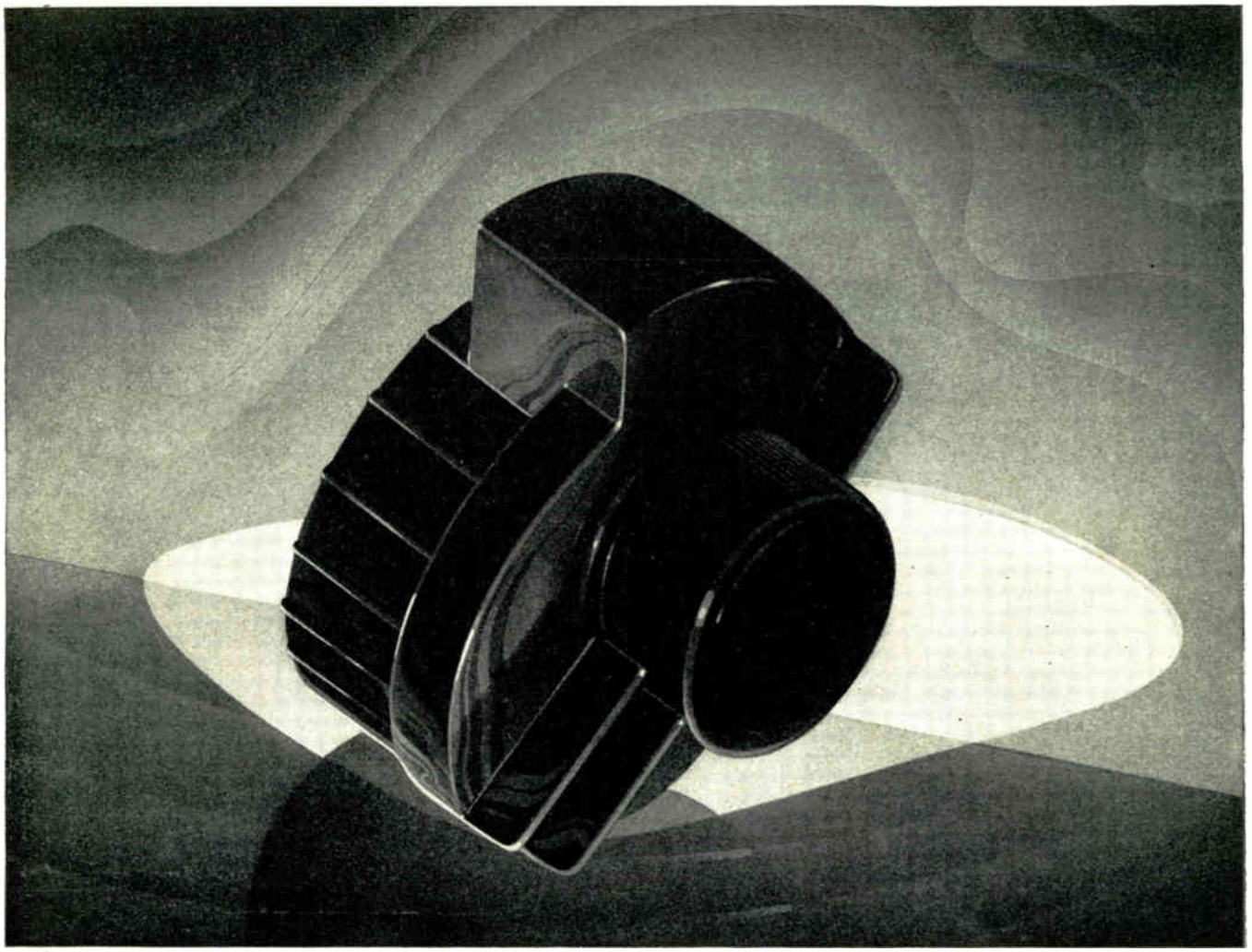
"prevented waste of valuable plastics materials"

BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York, N. Y.

HEADQUARTERS Can Help You Speed Production and Conserve Strategic Materials

2 GEARING OUR LABORATORIES TO YOURS . . . Bakelite Laboratories offer a two-fold service. They are ready to help you utilize present plastics in war production. They will also develop new formulas to help solve the problems of highly specialized requirements.

3 FIELD WORK ON "FRONTLINE" JOBS . . . Located at important industrial centers throughout the nation, Bakelite Field Engineers are ready to give prompt service to manufacturers engaged in war production. Fully qualified, they can frequently solve production problems on the spot.



Here is something new for the "Son of Heaven"

SOMETHING new under the sun? *Yes, sir!*—lots of new products to speed up the drive against the Japs . . .

New parts like this (for the time being their use cannot be revealed) are made possible by the use of INSUROK Precision Plastics. This part is but one of many new war-designed products developed by *Richardson Plasticians.*

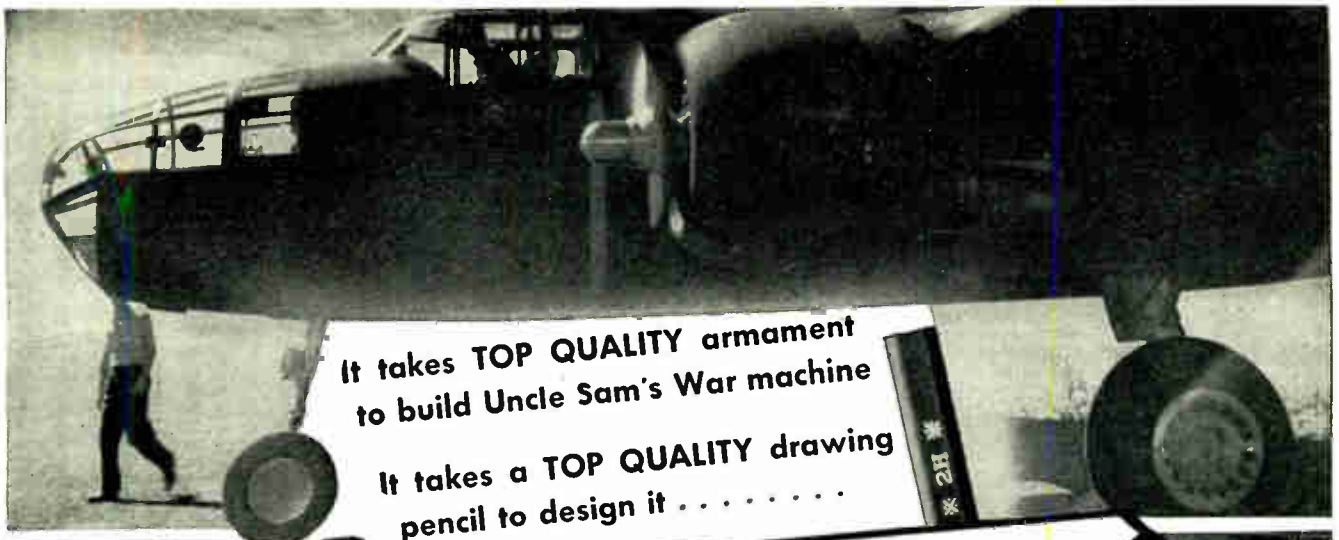
Because Laminated INSUROK can be machined to close tolerances with existing equipment, it facilitates sub-contracting—saves other critical materials for other important uses. Molded INSUROK, too, is serving with the air, land and sea forces because of its versatility and ability to meet the problems of the hour better, faster.

The Richardson Company, Melrose Park, Ill.; Lockland, Ohio; New Brunswick, N. J.; Indianapolis, Ind. Sales Offices: 75 West St., New York City; G. M. Building, Detroit.

INSUROK *and the experience of Richardson Plasticians are helping war products producers by:*

1. Increasing output per machine-hour.
2. Shortening time from blueprint to production.
3. Facilitating sub-contracting.
4. Saving other critical materials for other important jobs.
5. Providing greater latitude for designers.
6. Doing things that "can't be done."
7. Aiding in improved machine and product performance.

INSUROK



It takes TOP QUALITY armament
to build Uncle Sam's War machine

It takes a TOP QUALITY drawing
pencil to design it . . . . . .

The choice of pencil craftsmen everywhere

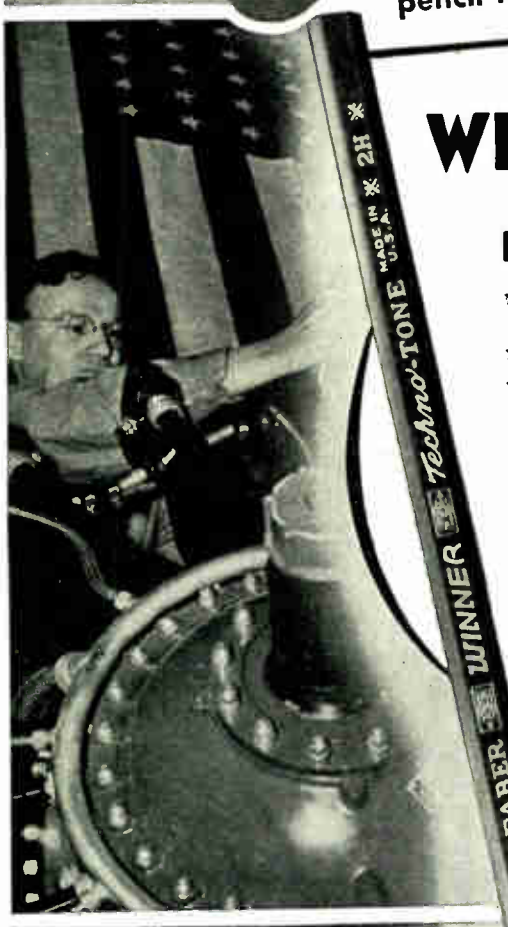
WINNER *Techno*-TONE

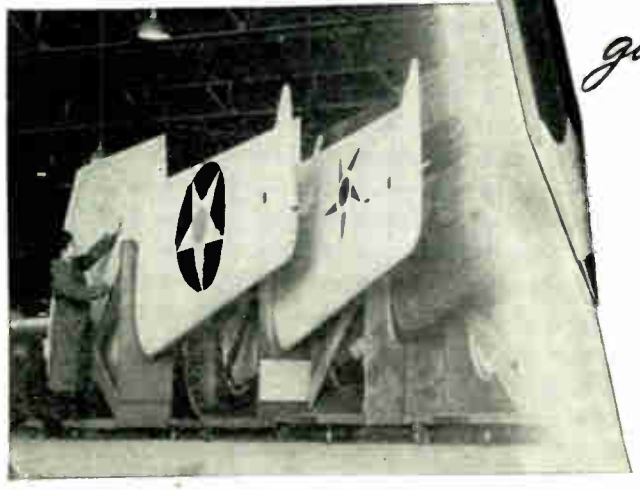
DRAWING PENCIL

- ★ Bearing the A. W. Faber name, famous for 181 years
- ★ America's highest-priced drawing pencil
- ★ America's *standard* of drawing pencil excellence

Besides the 4 Freedoms we are fighting for, there are 4 other freedoms vital to that vast army of pencil men, who conceive and design Uncle Sam's mammoth equipment for all-out War:

1. Freedom from Scratching
2. Freedom from Smudging
3. Freedom from Flaking
4. Freedom from Gritty Hard Spots





A.W. FABER WINNER *Techno*-TONE MADE IN U.S.A. 2H

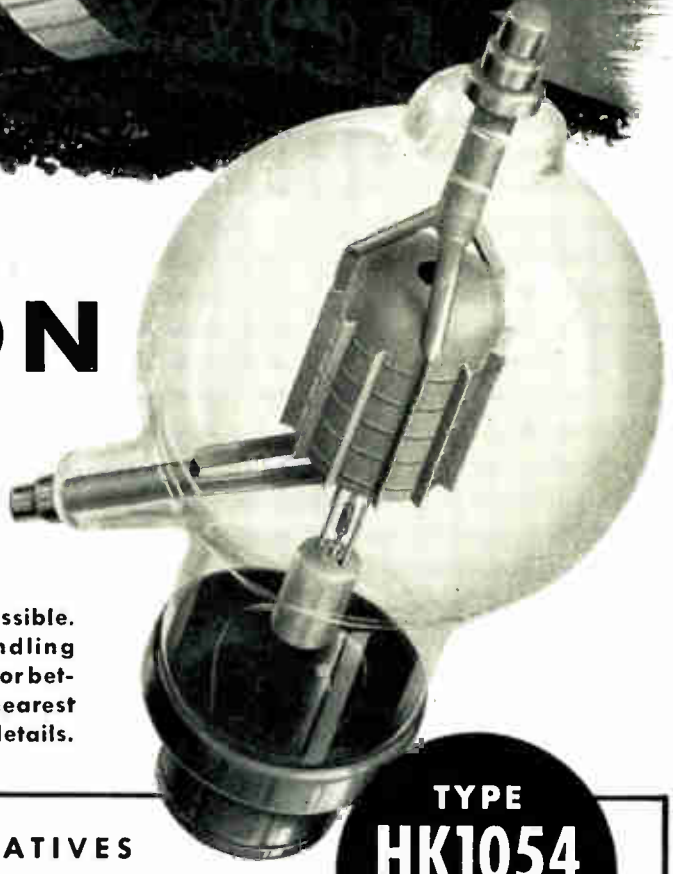
WINNER *Techno*-TONE *guarantees them all!*

Although the better part of two centuries is back of the FABER name, we don't ask you to take our word for the excellence of WINNER Techno-TONE. We will gladly send you two FREE samples of any degree you desire. Simply write on your letterhead, stating your position.

A·W·FABER·*Inc.* NEWARK, N.J.

EXTRA PROTECTION

The Army tank shown above is provided with *extra protection* against almost any War hazard. In the same manner, every GAMMATRON tube is designed and built to give *extra protection* against circuit hazards which would cause ordinary tubes to fail. Full tantalum construction, improved GAMMATRON pumping methods make failure due to internal release of gas impossible. Sturdy mechanical construction prevents handling breakage and provides low internal inductance for better UHF performance. Get in touch with your nearest GAMMATRON sales representative for further details.



TYPE HK1054

MAX. POWER OUTPUT 3000 WATTS

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Anaconda's Central West plants still have unfilled capacity on magnet wire and coil production . . . *for war work*. In addition to these facilities, they have experienced personnel to help solve problems you might have with this phase of manufacture.

Here is an opportunity to release your time so that it can be devoted to other important problems. Our sales offices, located in all principal cities, are near you. Call today. A representative will be glad to discuss your problem.

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from mine to consumer
This familiar trade-mark symbolizes the best efforts of modern research and production.

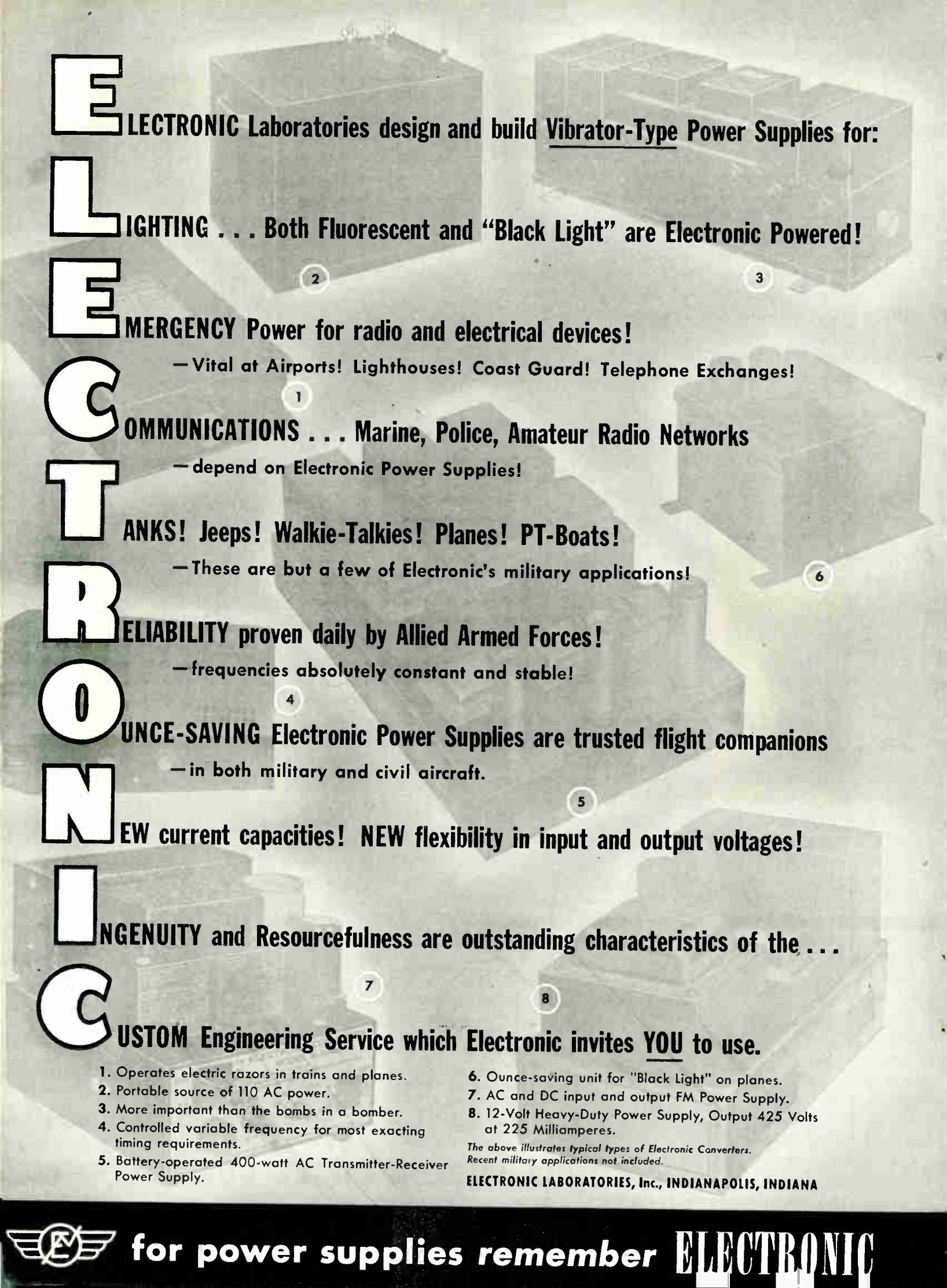
These Improved Insulations Are Now Available
Nylon—Vitrotex—and Formvar

The commercial development of Nylon and Vitrotex insulations is in part the result of Anaconda research . . . research that continues with redoubled effort producing new products for war work. Of course, when peace comes, the benefits of this research will be ready for industry everywhere.

42268

magnet wire and coils

ANACONDA WIRE & CABLE COMPANY



ELECTRONIC Laboratories design and build Vibrator-Type Power Supplies for:

LIGHTING . . . Both Fluorescent and "Black Light" are Electronic Powered!

EMERGENCY Power for radio and electrical devices!
—Vital at Airports! Lighthouses! Coast Guard! Telephone Exchanges!

COMMUNICATIONS . . . Marine, Police, Amateur Radio Networks
—depend on Electronic Power Supplies!

TANKS! Jeeps! Walkie-Talkies! Planes! PT-Boats!
—These are but a few of Electronic's military applications!

RELIABILITY proven daily by Allied Armed Forces!
—frequencies absolutely constant and stable!

OUNCE-SAVING Electronic Power Supplies are trusted flight companions
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NEW current capacities! NEW flexibility in input and output voltages!

INGENUITY and Resourcefulness are outstanding characteristics of the . . .

CUSTOM Engineering Service which Electronic invites YOU to use.

1. Operates electric razors in trains and planes.
2. Portable source of 110 AC power.
3. More important than the bombs in a bomber.
4. Controlled variable frequency for most exacting timing requirements.
5. Battery-operated 400-watt AC Transmitter-Receiver Power Supply.
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The above illustrates typical types of Electronic Converters. Recent military applications not included.

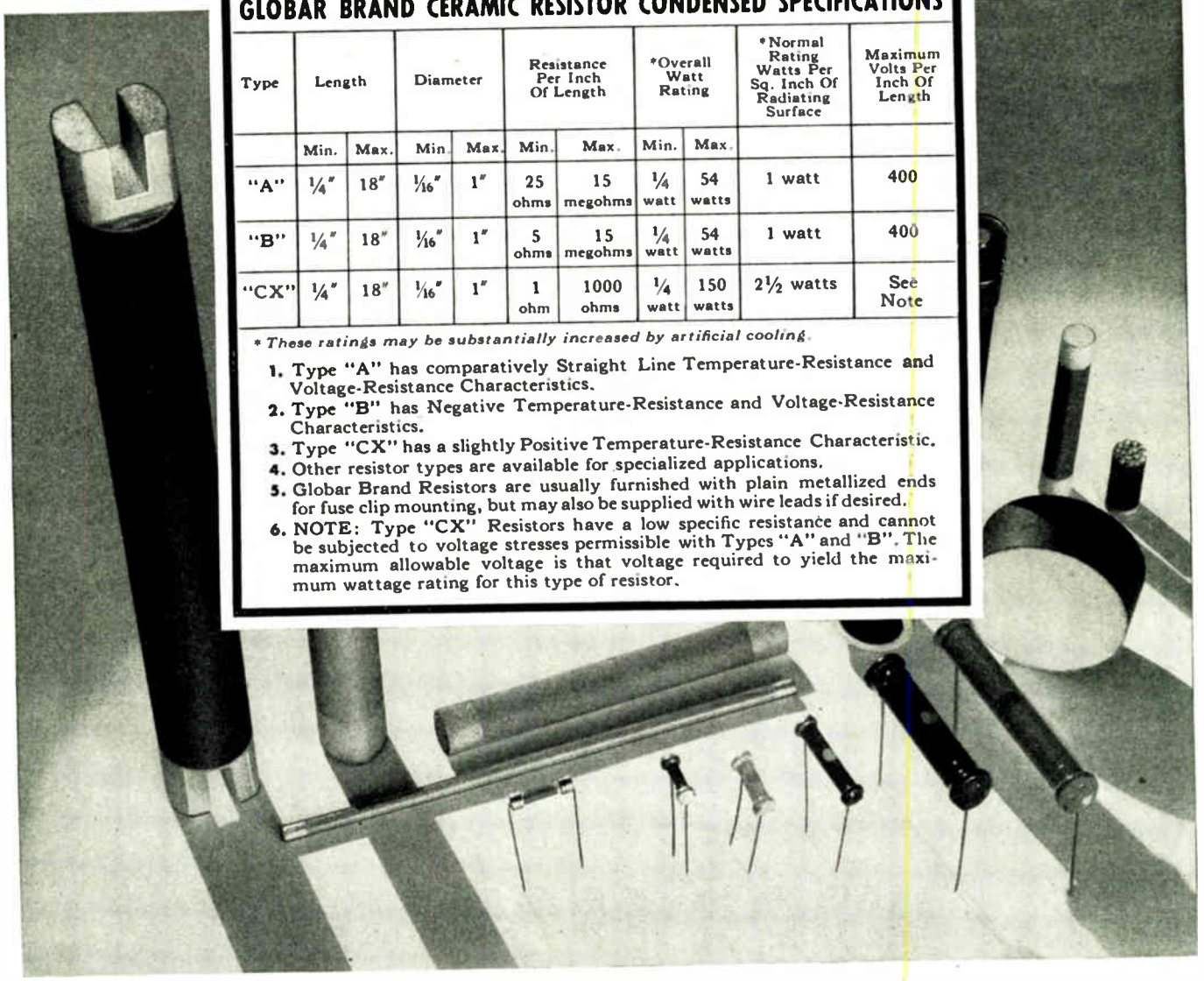
ELECTRONIC LABORATORIES, Inc., INDIANAPOLIS, INDIANA

for power supplies *remember* ELECTRONIC

If your design calls for a resistor

INVESTIGATE "GLOBAR" CERAMIC RESISTORS

GLOBAR Ceramic Resistors are non-inductive and have excellent radio frequency characteristics. They are rugged, have liberal overload capacity and are not affected by humid atmospheres. Standard terminals consist of metallized ends; permitting neat, orderly assembly in fuse clips or other types of mountings. Globar Resistors are available in many shapes and sizes in the types whose characteristics are briefly outlined below. To conserve your time and to assist you in selecting the resistor best suited to your purpose our long experience in specialized resistor manufacture is at your service. Send us full details of your requirements and your problem will have our immediate consideration.



GLOBAR BRAND CERAMIC RESISTOR CONDENSED SPECIFICATIONS

Type	Length		Diameter		Resistance Per Inch Of Length		*Overall Watt Rating		*Normal Rating Watts Per Sq. Inch Of Radiating Surface	Maximum Volts Per Inch Of Length
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
"A"	¼"	18"	1/16"	1"	25 ohms	15 megohms	¼ watt	54 watts	1 watt	400
"B"	¼"	18"	1/16"	1"	5 ohms	15 megohms	¼ watt	54 watts	1 watt	400
"CX"	¼"	18"	1/16"	1"	1 ohm	1000 ohms	¼ watt	150 watts	2½ watts	See Note

** These ratings may be substantially increased by artificial cooling.*

1. Type "A" has comparatively Straight Line Temperature-Resistance and Voltage-Resistance Characteristics.
2. Type "B" has Negative Temperature-Resistance and Voltage-Resistance Characteristics.
3. Type "CX" has a slightly Positive Temperature-Resistance Characteristic.
4. Other resistor types are available for specialized applications.
5. Globar Brand Resistors are usually furnished with plain metallized ends for fuse clip mounting, but may also be supplied with wire leads if desired.
6. NOTE: Type "CX" Resistors have a low specific resistance and cannot be subjected to voltage stresses permissible with Types "A" and "B". The maximum allowable voltage is that voltage required to yield the maximum wattage rating for this type of resistor.

Globar BRAND CERAMIC RESISTORS

Globar Division **THE CARBORUNDUM COMPANY** *Niagara Falls, N. Y.*

REG. U. S. PAT. OFF.

(Carborundum and Globar are registered trade-marks of and indicate manufacture by The Carborundum Company)

WARD LEONARD CONTROLS
We are proud that Ward Leonard Controls developed during the past fifty years, now contribute their part in increasing safety, comfort and efficiency of men in service.

CONTROLS FOR HEATED FLYING SUITS

The flyer turns the knob on the little Ward Leonard Rheostat and just the right degree of comforting heat surges through his flying suit. It is not an ordinary commercial control but one that has the ruggedness and dependability required by air service in spite of its minute dimensions and extremely light weight. This is but one of the many special control devices that Ward Leonard is producing in quantities to serve national defense.

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control (WL) *devices since 1892.*

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH STREET, MOUNT VERNON, NEW YORK

STEATITE

TEN QUESTIONS...AND ANSWERS

IMPORTANT INFORMATION TO ANYONE CONCERNED WITH DESIGN OR PRODUCTION OF ARMY OR NAVY RADIO EQUIPMENT

Q. *What is Steatite?*

A. Steatite is the term applied to a certain type of low-loss ceramic. It also applies to the principal raw material from which such a ceramic is made.

Q. *What are the uses of Steatite?*

A. Its low-loss characteristics make it almost necessary for radio-frequency circuits. Tube socket bases, switch parts, coil forms, standoff insulators, bowl insulators, rod antenna insulators, etc., are pieces in regular use.

Q. *Is there a shortage of Steatite?*

A. The raw materials of Steatite are available in great abundance. In fact, the Lapp supplier of Steatite talc reports his business substantially reduced, due to reduction in output of non-war ceramics. Facilities for the production of finished pieces of certain types are not sufficient to fill the requirements of the armed forces.

Q. *In what sort of pieces does this shortage exist?*

A. Small close-tolerance pieces (tube socket bases, switch parts, coil forms, etc.) require a precision manufacturing technique for which facilities are not easily amplified.

Q. *What is Lapp's part in the supplying of Steatite?*

A. Lapp facilities are available for the production of a large volume of Steatite, in certain types of pieces.

Q. *What sort of pieces is Lapp equipped to make?*

A. Steatite in larger pieces—that do not demand close tolerances—pieces that can be made by extrusion, formed by turning, throwing, plunging or casting, are producible by regular Lapp processes. These include standoff insulators, rod antenna insulators, bowl entrance insulators, bulk-head insulators, streamline entrance insulators, etc. For production of such pieces in Steatite, Lapp facilities are almost unlimited.

Q. *What are Lapp qualifications for Steatite production?*

A. Lapp engineers have four years' experience in the peculiarities of Steatite production. Shrinkage, glazing and firing problems have been solved. Complete testing facilities in the Lapp laboratory include a radio frequency generator (with range up to 3,000 Kc and 40,000 volts) for making heat runs, corona tests and flashover determinations. By maintaining a close check on radio frequency characteristics—dielectric constant, power factor, puncture strength, etc.—Lapp can assure performance characteristics of finished pieces.

Q. *What can't Lapp make?*

A. Lapp has limited facilities for pressing, and is not equipped to make small close-tolerance pieces.

Q. *What of hardware?*

A. For pieces requiring sanding and cementing into hardware, Lapp methods are perfectly suited. (This, like the production of a large volume of heavy Steatite pieces, fits right into normal Lapp insulator production methods.)

Q. *What should you do when you need Steatite pieces?*

A. Such pieces as can capably be produced by Lapp should be ordered from Lapp. Other Steatite Manufacturers, thus released from this part of the load, will be free to increase production on those pieces which they alone can manufacture efficiently. Such a program will reduce the over-all shortage of Steatite, and will accelerate the war effort.

Lapp

LAPP INSULATOR COMPANY, INCORPORATED • LEROY, N. Y.

The dawn of Peace

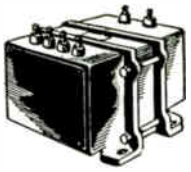
WILL REVEAL NEW TRANSFORMER HORIZONS

War-born improvements in design and construction will bring you even better AMERTRAN Products . . .

AmerTran is in the thick of the fight now, on war production . . . and under the stress we are developing improvements that we cannot now reveal. But some day the complete story will be told . . . and the better transformers we are shipping to those with priorities today, for wartime production, will be available for all to use. Improved designs and manufacturing methods, born under the spur of necessity—will bring you even better AmerTran products than those you know now . . . will still further confirm the leadership that AmerTran has gained and held during the past 41 years in the communications field, in electronic and radio applications. While the war lasts—plan ahead! Plan for the peace boom with AmerTran improved transformers.

AmerTran modulation transformers and reactors, oil-immersed type, for large broadcast transmitters.

AmerTran RS plate transformers and reactors, oil-immersed type, for all large installations.



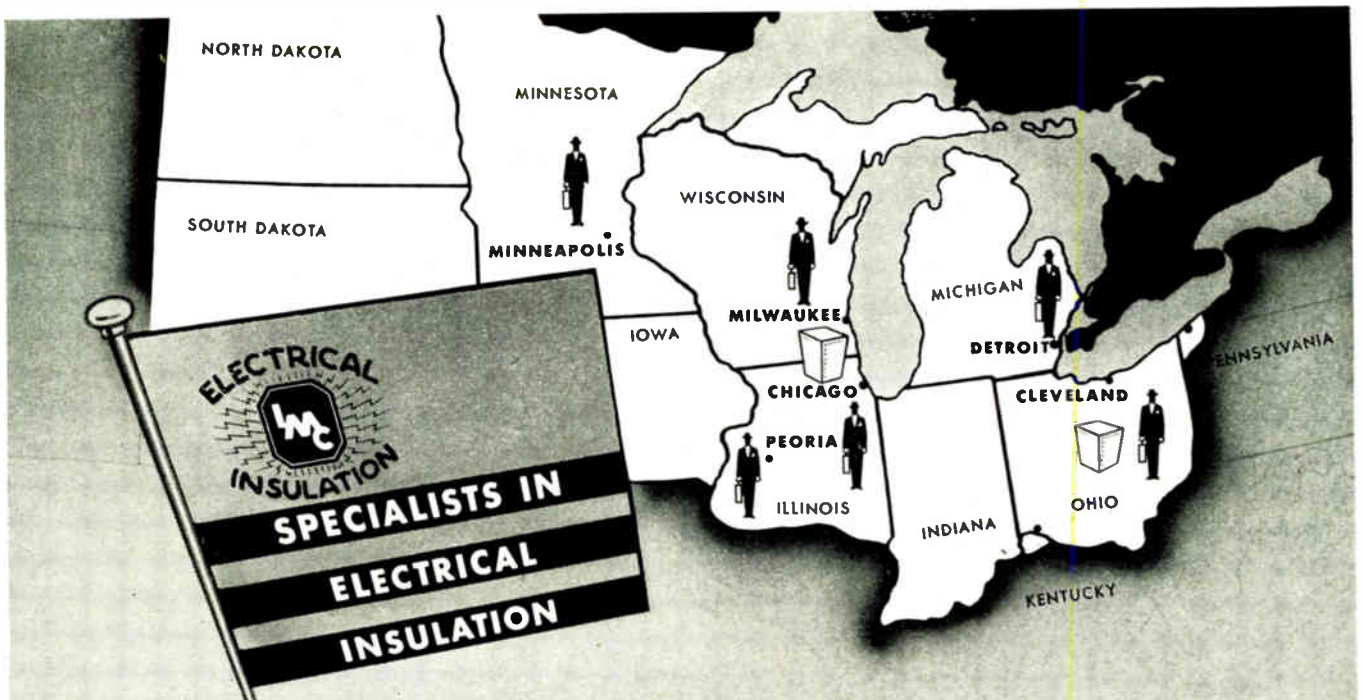
AmerTran W plate transformers and reactors for all small and medium installations.

AmerTran transformers are manufactured to meet your exact electrical and mechanical requirements.

AMERICAN TRANSFORMER COMPANY, 178 Emmet St., Newark, N. J.

Manufactured Since 1901 at Newark, N. J.

AMERTRAN



IMC ENGINEERS spotted in this territory to give correct application assistance

Macallen Mica Products—Vartex Varnished Cloth and Tapes—Varslot Combination Slot Insulation—Varnished Silk and Paper—Fiberglas Electrical Insulation—Dolph Insulating Varnish—Manning Insulating Papers and Press Boards—Slot Wedges—Dieflex Varnished Tubings and Saturated Sleevings—National Hard Fibre and Fishpaper—Phenolite Bakelite—Adhesive Tapes—Asbestos Woven Tapes and Sleevings—Cotton Tapes, Webbings, and Sleevings—and Other Electrical Insulating Materials Used in the Manufacture and Repair of Electric Motors, Transformers, and Other Electrical Apparatus.

HEADQUARTERS FOR INSULATION MATERIALS

Factories and shops located in this area have the advantage of IMC engineering service. IMC insulation engineers get around. They know how to apply insulation products . . . time and material saving methods of application . . . which you may find valuable when put into practice in your plant.

APPLICATION ASSISTANCE ON NEWER MATERIALS

They are especially helpful in the efficient application of some of the newer insulating materials available today. This service is yours for the asking. Write to us and we'll arrange to have the IMC engineer in your district call at once. In the meantime, specify and order IMC products. Phone or write to nearest office. Shipments *can* be made.

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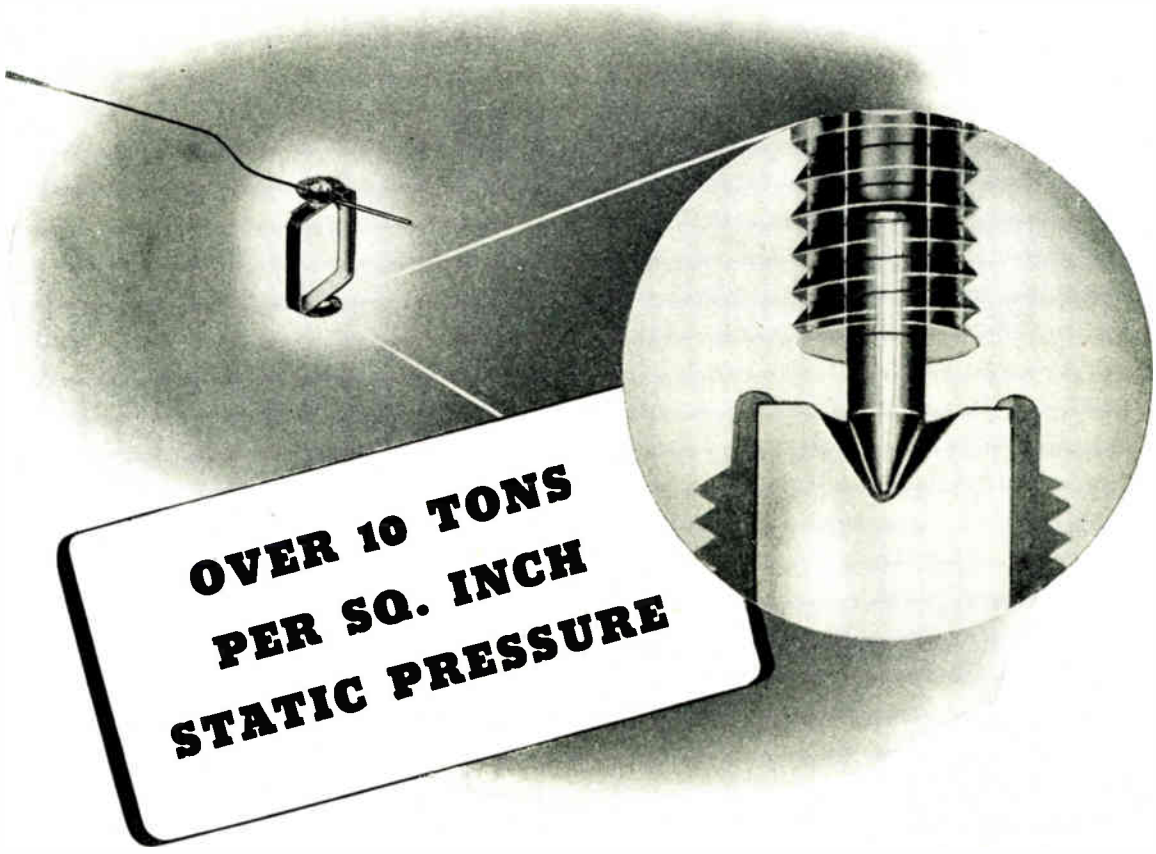


. . . on this tiny Instrument pivot!

Here the pivot for a WESTON instrument is being scrutinized for exact dimensions by the projection microscope, after meeting all other critical metallurgical standards. The bearings, also, exactly meet high WESTON standards because they, too, are processed and tested by methods which have been perfected through a half century of instrument specialization.

"How is it possible for WESTON so successfully to forestall friction in instrument bearings when the combination of design factors is so critical?"

First let's look at these factors. The bearing may measure only 3/32 in. dia. The tiny steel pivot, supporting a moving coil weighing only 1/100 ounce, may have a point several times sharper than the finest needle. The static pressure between them will exceed 20,000 lbs. per square inch; and the starting torque may only be the result of minute energy produced by a few microamperes. Yet that pivot must swing freely perhaps millions of times during the life of an instrument!

Here, again, the answer is to be found in basic WESTON design, and WESTON control of every step in instrument manufacture. Despite their extreme fineness pivot points for example, are formed to a *true sphere* . . . then the pivots are heat treated by an exclusive process to the exact hardness degree that resists crushing or mushrooming under the tremendous pressures involved. The "V" bearing, too, is carefully checked for precise dimensions and flawless surface by a special optical method which insures perfect operation of pivot and bearing.

But supplementing these and other WESTON methods is the skill of instrument craftsmen who have acquired the "know how" through years of instrument specialization . . . to whom the term "friction-free" is ever an ideal capable of achievement. For only through *specialization* can the superior techniques be developed, the "know how" be acquired, the ideal be so closely achieved . . . to insure that *instruments provide the accuracy and dependability so typically* WESTON . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, N. J.

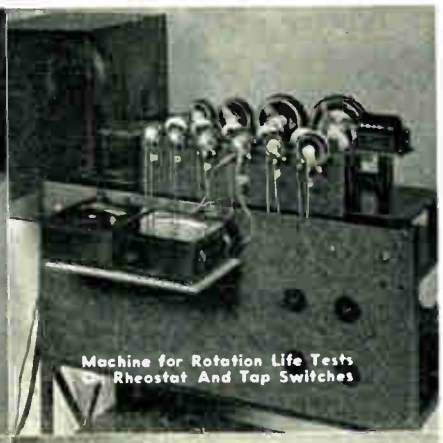
WESTON

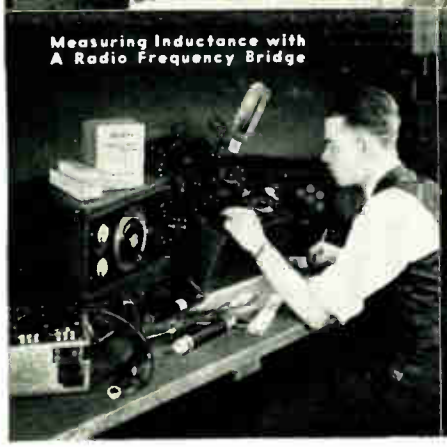
Instruments

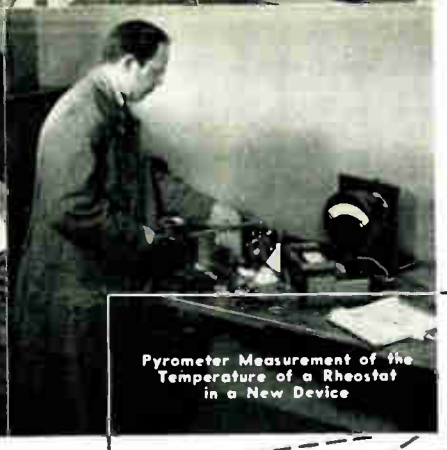
LABORATORY STANDARDS . . . PRECISION DC AND AC PORTABLES . . . DC, AC, AND THERMO SWITCHBOARD AND PANEL INSTRUMENTS . . . INSTRUMENT TRANSFORMERS . . . SENSITIVE RELAYS . . . SPECIALIZED TEST EQUIPMENT . . . LIGHT MEASUREMENT AND CONTROL DEVICES . . . EXPOSURE METERS . . . AIRCRAFT INSTRUMENTS . . . ELECTRIC TACHOMETERS . . . DIAL THERMOMETERS

WHY OHMITE RESISTANCE UNITS MEET TODAY'S CRITICAL REQUIREMENTS


Controlled High Humidity Chamber for all types of Humidity Tests


Machine for Rotation Life Tests of Rheostat And Tap Switches


Measuring Inductance with A Radio Frequency Bridge

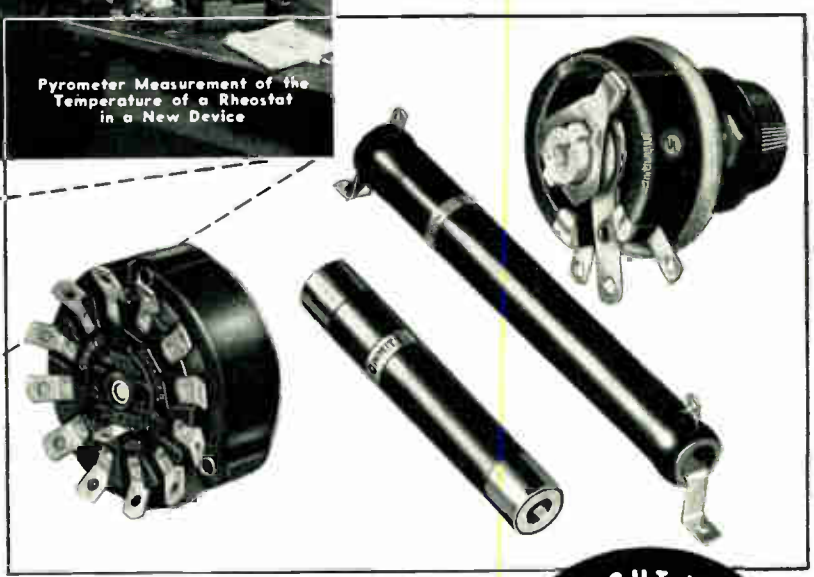

Pyrometer Measurement of the Temperature of a Rheostat in a New Device

Extra quality and *extra* dependability have always been an integral part of Ohmite Resistance Units. Electrical and physical fitness for heavy-duty service in exacting applications are built-in from the very beginning. Research, engineering, testing, production and inspection all work together to make Ohmite Products always a little better.

As a result Ohmite Rheostats, Resistors, Chokes, Tap Switches readily meet today's requirements. They are widely used for military, electronic, scientific and industrial purposes.

The wide range of types and sizes makes it easier to meet each need. Many stock items. Units produced to government specifications or specially engineered for you. Let Ohmite engineers help you.

Engineers' and Buyers' Guide

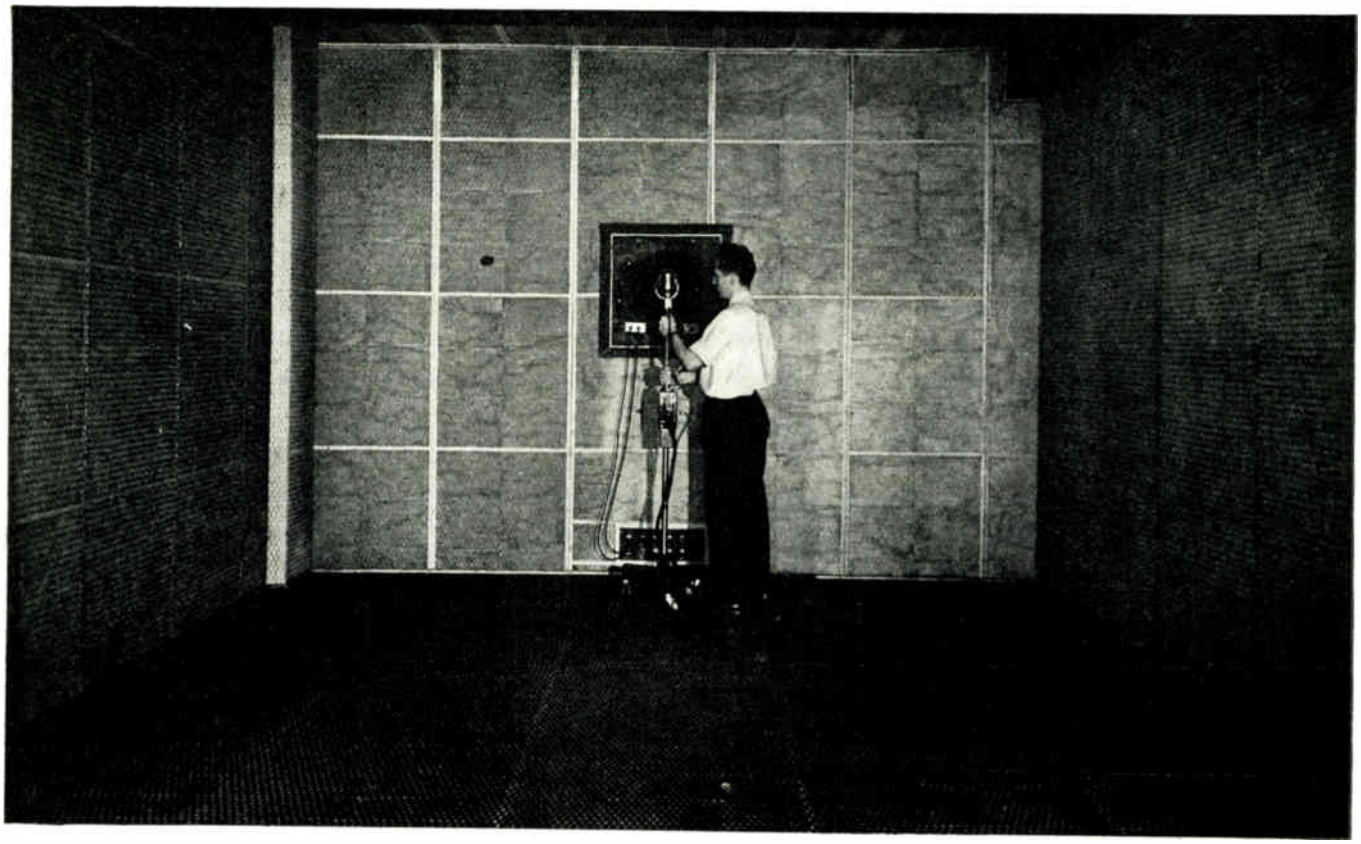


SEND FOR 96-PAGE CATALOG AND ENGINEERING MANUAL No. 40

Write on company letterhead for complete guide in the selection and application of Rheostats, Resistors, Tap Switches, Chokes, Attenuators. Especially helpful today to engineers, production executives and purchasing departments. Contains useful engineering data, reference tables, dimension drawings, illustrations and a manual of resistance measurements.

OHMITE MANUFACTURING CO., 4818 Flournoy St. ★ Chicago, U. S. A.
Foremost Manufacturers of Power Rheostats, Resistors, Tap Switches

BE RIGHT WITH ★ OHMITE Rheostats·Resistors Tap Switches



Main Sound Room at Shure Brothers

THE QUIETEST FIELD OF ACTION

In Total War, Microphones are weapons — for planes, tanks, and ships. These weapons are being built to new and higher standards.

Very important in the development of Microphones, is the accurate measurement of output level and frequency response. In measuring Microphones, the ideal medium is a free field without interference from atmospheric elements, outside noises, or reflections from nearby objects.

To achieve this goal, a special new room has been designed at Shure Brothers with a large area of sound absorbing surfaces. All four walls, floor and ceiling are covered with thick layers of sound insulation and sound absorption materials. The floor is provided with an open grill to offer good support without affecting the sound absorption properties. The room is completely shielded to avoid electrical disturbances. The high fidelity sound field is measured by means of standard Microphones calibrated at the U. S. Bureau of Standards. Electrical equipment for measurement purposes is located outside the room. In this room, the response of Microphones is measured with extreme accuracy.

In addition to close tolerances in output and response, Shure Microphones must survive electrical and mechanical tests which are far more destructive than any conditions they meet in actual service.

Millions of lives may depend on a Microphone. Shure Engineers know this. Shure Microphones are made to do their part.

Send for Booklet No. 172M. *It describes Super-Cardioid performance and the latest Shure Broadcast Microphone, the Super-Cardioid.*

SHURE BROTHERS

Designers and Manufacturers of Microphones and Acoustic Devices

225 West Huron Street, Chicago, Illinois

GENERAL CERAMICS

STEATITE and ULTRA-STEATITE

INSULATORS

RUSH is a badly overworked word in these days of 1942 but it still calls for extra efforts in our plant. That is one reason why we have made a number of new friends in recent months. Other reasons include increased plant facilities; the latest production methods, under constant laboratory control; and, finally, intelligent service backed by broad experience.

GENERAL CERAMICS and STEATITE CORPORATION
Keasbey, New Jersey

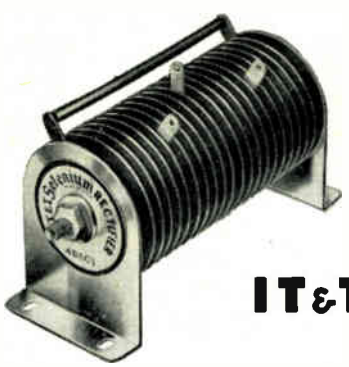
GENERAL CERAMICS COMPANY
INSULATORS

Serving with the Armored Force...

The tanks are coming . . . rolling forts that "go anywhere" and give it as well as they take it. And in the thick of things, wherever direct current is required from an A. C. source, I. T. & T. Selenium Rectifiers are proving *they* can take it, too.

For all practical purposes these rectifiers are unaffected by dust or moisture, shock or vibration. They have no moving parts to wear out or cause failure at crucial moments. Electrically and mechanically stable, they are efficient over the wide temperature and atmospheric ranges met in different fields of combat.

Consulting engineering services available for specific requirements. Address Rectifier Division for descriptive bulletins.



IT&T Selenium RECTIFIERS

International Telephone & Radio Manufacturing Corporation

AN IT&T ASSOCIATE

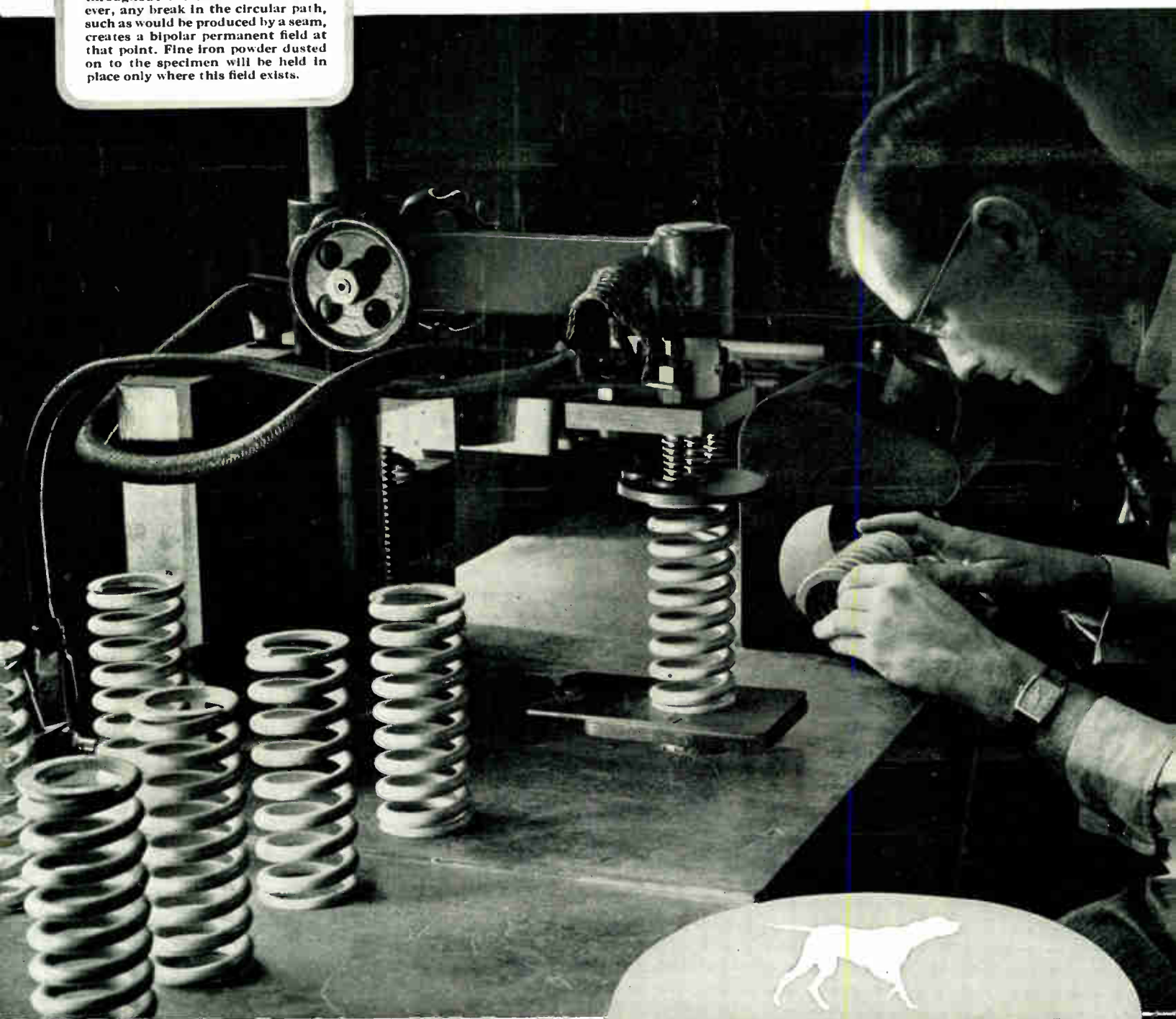
General Offices: 1000 Passaic Ave. East Newark, New Jersey

Here is a LIE DETECTOR *for* SPRINGS

SPRING NEWS

When the heavy DC current passes axially through the cross section of the specimen a circular magnetic field is produced. The action of the current is only instantaneous, so that the magnetic field disappears when the magnetic reluctance is uniform throughout the cross section. However, any break in the circular path, such as would be produced by a seam, creates a bipolar permanent field at that point. Fine iron powder dusted on to the specimen will be held in place only where this field exists.

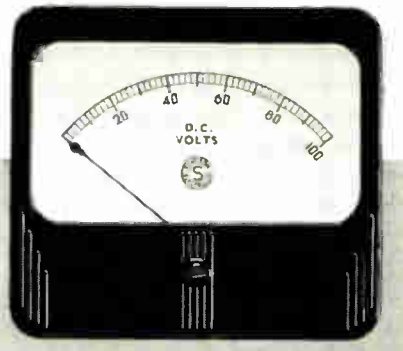
WIRE used in making springs is usually subjected by reliable spring makers to a number of tests . . by Hunter, for example, to a tensile test, twist test, bend test, hardness test—and many others. Yet even these tests do not reveal a category of defects known simply as "seams". The detection of seams involves a scientific method known as Magnaflux inspection. Sketchily, the procedure consists of magnetizing the spring, powdering with iron "dust", and inspection. This method is used to test samples of wire, for "jump" inspection of springs, and occasionally for 100% inspection. A lot of fuss to make over a spring? Not at all. Hunter makes such tests to catch flaws and learn why they occur, to aid in improving materials, to deliver the best springs scientific manufacture can produce for you.



HUNTER

Science in Springs

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.



GETTING DOWN *inside* ~~TO~~ CASES

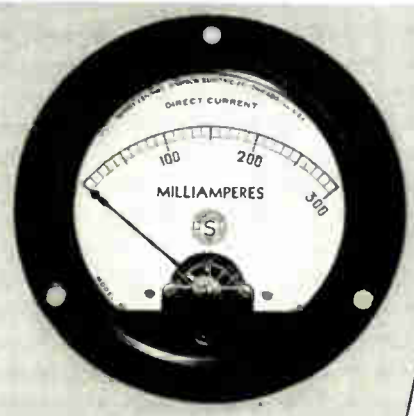
WHILE a good looking instrument case, such as those shown here, may be an outward indication of instrument quality, it is by no means the final evidence.

The real measure of instrument quality lies deep inside — in the instrument movement proper. This is the real "works" — where accuracy and stamina take their beginning. And right here is where you'll find the answer to the outstanding success Simpson Instruments have won in just a few years.

The Simpson movement is the basically-better full bridge type, with soft iron pole pieces. The soft iron pole pieces distribute magnetic flux more evenly — make the movement inherently more accurate to begin with. The two bridges, at top and bottom, lock the moving assembly always in perfect alignment, for lasting accuracy. Springs are carefully selected, tempered and tested—magnets heat treated for permanence — pivots completely Simpson-made, specially processed for strength and hardness—all hand crafted into a balanced, practically frictionless, construction that achieves an extremely high torque to weight ratio.

If your requirements are essential enough to give you the right to buy instruments, they are essential enough to rate the best. Examine the works of any Simpson Instrument, critically, and you will see why, to so many discriminating buyers, best means Simpson.

SIMPSON ELECTRIC COMPANY, 5212 Kinzie St., Chicago, Ill.

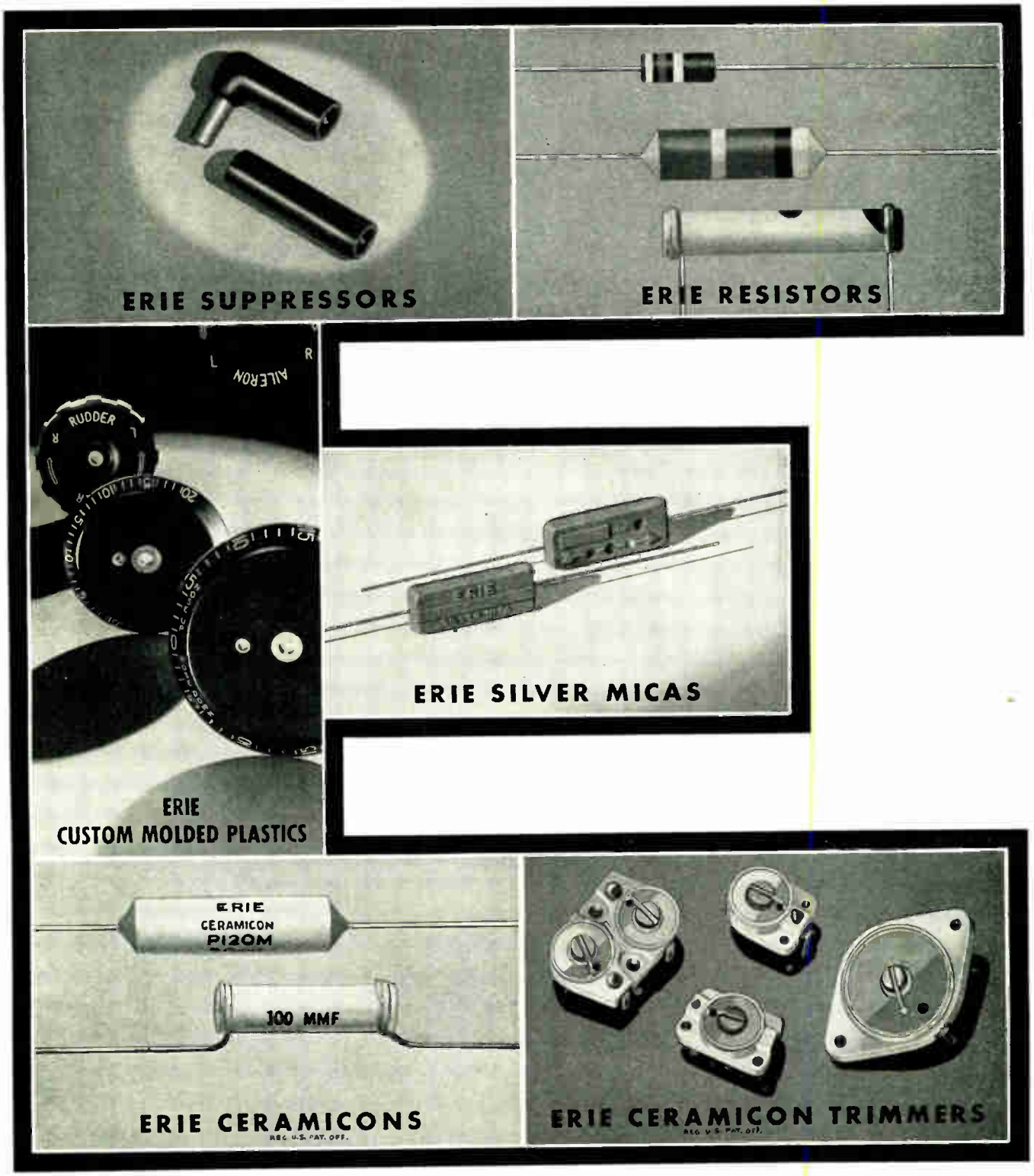


SIMPSON MODEL 260
High Sensitivity Tester

Here is a typical example of Simpson leadership. Ranges to 5000 Volts, both AC and DC, at 20,000 ohms per volt DC and 1000 ohms per volt AC. Resistance readings from ½ ohm to 10 megohms. Decibel ranges from —10 to +52 DB.

Simpson

INSTRUMENTS THAT STAY ACCURATE



ERIE RESISTOR manufactures a group of components, illustrated above, that meet the exacting requirements for war-time electronic equipment. Erie Resistors have all-round excellent operating characteristics. Suppressors prevent the interference of ignition system noise in surrounding radio receivers. Erie Silver Micas are superior condensers with inherently stable capacity. Ceramicons and Ceramicon Trimmers are widely used to compensate for frequency drift due to temperature variations. The plastics division of Erie Resistor is equipped to design and mold any desired article that can be molded by the injection and extrusion process.

Technical literature on all of these Erie Resistor products will be sent to interested electronic engineers on request.

ERIE RESISTOR CORP., ERIE, PA. LONDON, ENGLAND · TORONTO, CANADA.

"Who's Who" in ELECTRONICS

and Callite's contribution to their developments

▶ Reading like a "Who's Who" of the Electronic Industry, Callite's list of customers includes the big names behind the outstanding developments of the past years.

▶ Important advances reflect, among other things, the most painstaking selection of component materials. That's why Callite's broad background of engineering research — and precision methods of manufacture — are called upon to aid the important undertakings of such leaders as:

AMPEREX DUMONT EDISON EITEL-McCULLOUGH
ELECTRONS INC. FEDERAL TELEGRAPH MACHLETT NATIONAL UNION
PHILIPS METALIX RADIANT RCA UNITED ELECTRONICS SPERTI
SONOTONE WESTERN ELECTRIC and a host of others.

If you have a special problem, the knowledge and resourcefulness of Callite engineers may quickly provide the solution. Your inquiries are cordially invited.

Specialists in the manufacture of electrical contacts of refractory and precious metals, bi-metals, lead-in wires, filaments and grids—formed parts and raw materials for all electronic applications.

CALLITE TUNGSTEN CORPORATION

544 39th STREET — CALLITE TUNGSTEN — UNION CITY, N. J.

CABLE: "CALLITES" • BRANCHES: CHICAGO • CLEVELAND

CORNERSTONE FOR V + 2*

Some year the war will end.

There will be a swing back to the things we buy because we want them, not because they are a grim necessity. Today's work is to win the war. Executives now driving for all-out production should also be planning for V + 2. Products for tomorrow should be designed today.

For every new product, the cornerstone is Research The Research Division of American Lava Corporation is outstanding in its field. It welcomes any call for cooperation in planning for today's production . . . or for long range planning for the insulation of the future.

Meanwhile, for 1942 and as far as we can see, we pledge our utmost efforts to supply our customers with the best in steatite ceramic compositions as rapidly as possible under wartime conditions.

* 2 years after Victory, probable time required to resume full peacetime production. (Bouquets to the G. E. executive who coined this expression.)

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

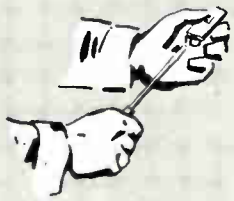
AMERICAN LAVA CORPORATION

CHATTANOOGA, TENNESSEE

CHICAGO • CLEV.-LAND • NEW YORK • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • BOSTON • PHILADELPHIA • WASHINGTON, D. C.

SPECIFY STACKPOLE

for longest possible service and dependable operation . . . *at a time when you need it most!*



PRECISION TESTED

SWITCHES

★ SLIDE OPERATED SWITCHES
★ ROTARY OPERATED SWITCHES
★ TOGGLE OPERATED SWITCHES

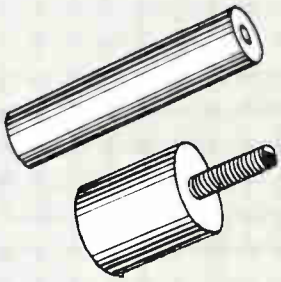
The unexcelled efficiency and sturdiness of Stackpole Switches is the result of precision manufacturing. Each phase of their assembly is the distinct responsibility of skilled operators, trained to do each individual task, well. Special treatment assures moisture resistance, highest grade materials and a 100% mechanical check, assure efficient service and long-life. Ideal for every small circuit job and available in single-pole, single-throw to four-pole double-throw and all in-between combinations.

LABORATORY CONTROLLED

RESISTORS

★ VARIABLE RESISTORS
★ FIXED RESISTORS

Every step in the process of manufacturing Stackpole Resistors is laboratory tested. All raw materials are tested for uniformity and all carbon products are tested for hardness and density and all volume controls are 100% checked for noise, 100% checked for resistance and 100% checked mechanically. Resistance ranges from 1,000 Ohms to 5 Megohms for every type volume, tone and sensitivity control and in special designs to suit your needs. All highly insulated by special processes which assure protection against moisture and weather conditions.



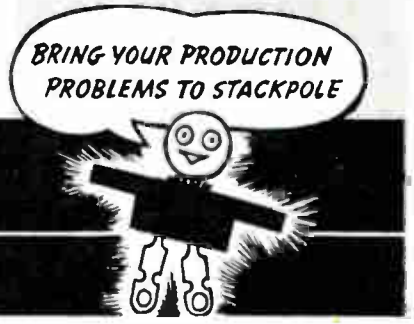
UNIFORMLY CONSTRUCTED

IRON CORES

★ FIXED INDUCTANCE
★ VARIABLE INDUCTANCE
★ STATION TUNING

Stackpole powdered Iron Cores are noted for their extreme mechanical strength which is the result of a highly controlled process of manufacture. Iron Cores are available in a wide variety of grades and sizes for use at any frequency up to 100 meg. The wide range of types include those with the "cup type" cores, with and without adjustable centers. When requesting samples of cores, please send test coils and complete data.

STACKPOLE PRODUCTS SOLD TO MANUFACTURERS ONLY
—WRITE AT ONCE FOR SAMPLES AND PRICES—



STACKPOLE CARBON CO.
ST. MARYS, PENNA. U. S. A.

to Electronic Readers

This issue of ELECTRONICS—largest ever published—includes 125 pages of advertising messages from almost 200 manufacturers.

In these pages is a wealth of information, designed not only to make it easier for you to know more about the equipment and material which you may need in your vital war work, but also to give you ready and intelligent information on the sources of supply.

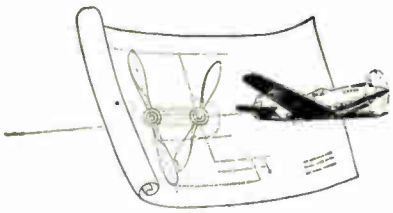
Thus, through this instrument of communication, your valuable time is conserved. Keep this useful issue within hand's reach throughout the year. It will serve you well.

electronics

A McGRAW-HILL PUBLICATION

ABC ABP

330 West 42nd Street, New York, N. Y.



A Simple Blueprint...with a Mallory Complete Contact Assembly ...May Save Many a Flier's Life!

One of the principal manufacturers of variable pitch propellers utilizes electrical contacts to actuate changes in pitch. The electrical contact assembly on this job has to be sure-fire . . . or a pilot can be in the soup before you stop blinking.

Mallory engineers went to work with this aircraft propeller manufacturer's designers when their detailing was still on the drafting boards. Together, Mallory contact specialists and the aircraft engineers developed a new electrical contact assembly, designed for rotary action. Biggest problem was abrasion on the revolving contact surface.

Happy solution came when Mallory created a tri-metallic contact assembly incorporating three Mallory-developed alloys with exactly the right electrical *and* abrasion-resistant properties.

This example of Mallory's complete contact assembly service can mean plenty to you . . . if you're planning production of almost any electrically-actuated device. See us *before* you finish your blueprints. Your Mallory representative is "on call".

Data At Your Elbow! Mallory Contact Catalog.

Complete information on every phase of electrical contact selection, design and service. You need it for your technical library. Write today. No obligation.

IS THE CURRENT AC OR DC ?

WHAT ARE NORMAL VALUES OF CURRENT AND VOLTAGE THAT MAKE AND BREAK ?

WHAT IS THE ACTION OF CONTACT... BUTTING, WIPING OR ROTARY ?

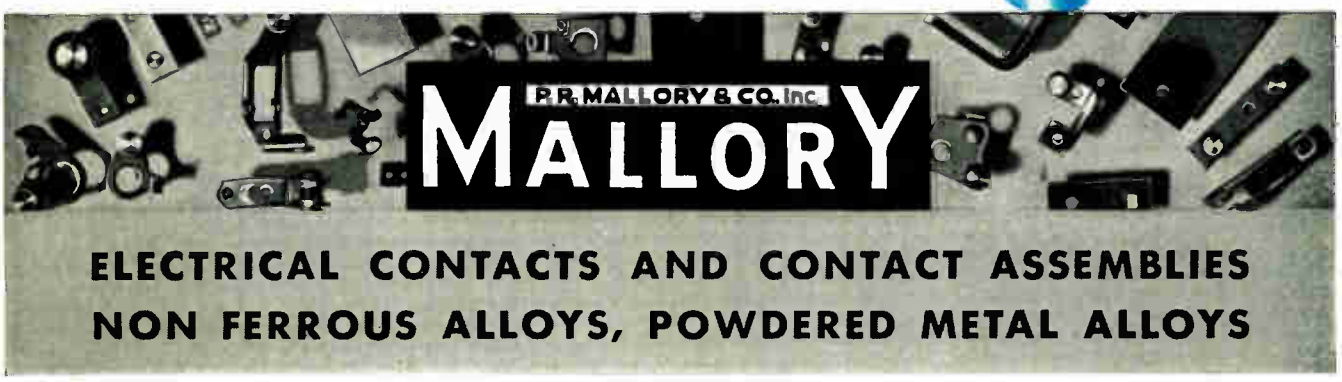
WHAT IS THE ALLOWABLE TEMPERATURE RISE ?

WHAT OVERLOAD CONDITIONS MUST BE SUSTAINED ?

WHAT OPERATING LIFE IS EXPECTED ?

See Mallory for Contact-Assemblies

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA • *Cable Address* — PELMALLO



This advertisement also appeared in:
NEW YORK TIMES
CLEVELAND PLAIN DEALER
CHICAGO DAILY NEWS
DETROIT FREE PRESS
WASHINGTON POST

You Expected to Read This NEXT YEAR!

Industry after industry is beating its promise as America's war production sets new world's records . . . Management, labor, W. P. B., Army, Navy, the Maritime Commission and other government departments are cooperating to make next year's headlines come true THIS year.

In World War I, the Kaiser feared American manpower. In World War II, Hitler is even more fearful of our rapid transition from peace to war production. . . . He has reason to be afraid.

Printing press factories are exceeding quotas on anti-aircraft gun parts.

Spark plug manufacturers are setting new speed records in machine gun production.

The heavy-transportation industry is making giant chassis for big guns at a faster rate than all the Axis powers combined.

In this industry, men who used to make locomotives and tractors are changing "Too Little and too Late" to read "Too Much and too Soon," from the enemy's viewpoint.

Starting just a few months ago, with a bale of blueprints and a knowledge of how to build such things as road-scrapers, power-shovels and trucks, the heavy-transportation industry is turning out mobile artillery that will shake the earth in more than a literal sense.

• • •

The story of how this industry joined the army carries a significance which should be understood and remembered.

The significance is that America has solved the problem of exchanging production techniques between specialized industries. This process went on unnoticed in peacetime. War gave it prominence.

OVER

▶When the bales of blueprints were first delivered, and the heavy-transportation industry started on its job of producing prime-movers and chassis for big guns in quantity, new production techniques were needed in a hurry.

▶Here are some of the questions that arose:

"How do you weld such heavy sub-assemblies?"

"What welding fixtures will handle these parts so that our workmen can always weld down-hand?"

"How can we make these long, heavy welds and have sound metal from one end to the other?"

"What's the best technique for testing welded parts? Shall we x-ray, or use the magnaflux process?"

"What's the best way to support these welded assemblies for machining?"

That's just a few of the thousands of questions that arose in the minds of experienced men when they had to solve new problems.

They illustrate the fact that American production methods depend upon specialized techniques and machines.

Each man with such a problem knew that someone, somewhere, had solved his problem, or might solve it before he could work out his own answer.

Therefore he turned to the source of industrial information he had always used when he wanted to know what others were doing . . . his industrial magazine.

Ever since the Maginot Line was flanked, the Industrial Press of America has been helping rookie industries to become veterans in the battle of war production.

▶It doesn't do this by exhortation or command, but by answering thousands of specific questions.

Just as newspapers keep their war correspondents at the front, Industrial Magazines keep their "war-production-correspondents" in the plants where weapons and equipment are made. McGraw-Hill editors are mobilized for war as literally as though they were firing weapons instead of helping to produce them. More than 90% of the time of McGraw-Hill's 153 editors and 725 engineer-correspondents is devoted either to visiting war-production plants (to study production techniques) or in writing "war stories" on how production problems were solved.

"Know-how" is the secret of the amazing records now being made by American Industry. And "know-how" comes from thousands of "little facts" like this:

Information on tool shapes for cutting the harder steels of war is vital literature to the engineer, designer or production man with the particular problem of cutting those steels confronting him.

The industrial editor does not work alone in giving vital information to men on the production line. In much the same way, manufacturers are war-converting their industrial advertising to show their readers how to use their products more effectively. For instance:

A business-paper advertisement showing how to make old taps and dies last longer has no glamour for anyone but the man who must rush production with an inadequate supply of new ones. To him it has enough "oomph" to be clipped and placed on his office wall.

To the casual observer, the Industrial Press is about as exciting as the rows of wires that stretch along every road and railway. . . . The simile is very apt. Both exist solely for the interchange of ideas. Both are typically American in the extent to which they have been developed and applied to the whole economy. . . . *This advertisement published by the McGraw-Hill Network of Industrial Communication.*

• • •

THE McGRAW-HILL NETWORK

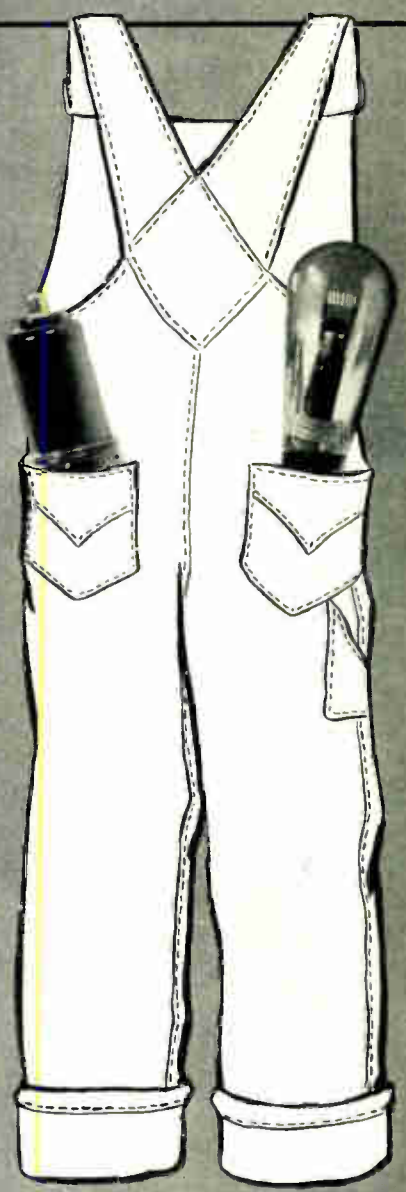
23 PUBLICATIONS WHICH HELP MORE THAN 1,000,000 EXECUTIVES, DESIGNERS AND PRODUCTION MEN TO EXCHANGE IDEAS ON WAR-PRODUCTION PROBLEMS

American Machinist • Aviation • Bus Transportation • Business Week • Chemical & Metallurgical Engineering • Coal Age • Construction Methods • Electrical Contracting • Electrical Merchandising • Electrical West • Electrical World • Electronics Engineering & Mining Journal • E. & M. J. Metal and Mineral Markets • Engineering News Record • Factory Management & Maintenance • Food Industries • Mill Supplies • Power • Product Engineering • Textile World • Transit Journal • Wholesaler's Salesman. Also publishers of thousands of books for technical and engineering schools and colleges, as well as for general business use.

McGRAW-HILL PUBLISHING COMPANY, INC.

330 WEST 42nd STREET, NEW YORK

Electron Tubes in Overalls



THE electron tube is one of the most versatile and flexible man has produced. In communication it performs duties impossible for any other mechanism. In industry it saves time, it saves in the cost of things, it protects life and property. The tube does many things better, cheaper, quicker than older devices. Many industrial jobs are performed by the tube which cannot be done in other ways. In wartime, the speed-up of production made possible by the electron tube may prove to be its greatest contribution. Tubes have gone into overalls.

It is impossible to give examples of all of the things tube can do within the confines of a single issue of ELECTRONICS. The applications described are typical, and the selection is designed to show not only the ingenuity of engineers working with tubes but the versatility and flexibility of these devices whose motivating force is the ultimate building block of the universe itself—the electron.

C O N T E N T S

CLASSIFICATION OF ELECTRON TUBES

INPUT		ELECTRICAL ENERGY															RADIANT ENERGY (Light)		
OUTPUT		ELECTRICAL ENERGY												RADIANT ENERGY (Light)			ELECTRICAL ENERGY		
SOURCE OF ELECTRONS		Thermionic Cathode							Pool Cathode			Cold Cathode		Thermionic Cathode			Photoelectric Cathode		Metallic Contact
METHOD OF CONTROL		None			Electrostatic		Electromagnetic		None	Electro-static	Igniter Electrode	None	Electro-static	Electro-static	Electro-magnetic		Radiant Energy (Light)		
CHARACTER OF CONTROLLED REGION OR SPACE		High Pressure Gas	Low Pressure Gas or Vapor	Vacuum	Gas or Vapor	Vacuum	Gas or Vapor	Vacuum	Vapor	Vapor	Vapor	Gas	Gas	Vacuum	Vacuum		Gas	Vacuum	Metallic
TUBE NAME		Tungar or Rectigon	Phanotron	Kenotron	Thyratron	Pliotron	Permatron	Magnetron	Pool Tube	Grid Pool Tube	Ignitron	Glow Tube	Grid Glow Tube	Cathode Ray Tube	Cathode Ray Tube		Phototube	Phototube	Barrier Layer Cell
FUNCTION	RECTIFIER OR SWITCH																		
	CONTROLLED RECTIFIER																		
	AMPLIFIER																		
	OSCILLATOR, GENERATOR OR INVERTER																		
	VOLTAGE REGULATOR																		
	WAVE FORM ANALYSIS														 MAG DEF				
	LIGHT DETECTION AND MEASUREMENT																		

In this tabular classification of electron tubes suitable for industrial purposes the graphical symbol for the type of tube in question is used to designate the customary or possible uses to which the tube is put. Tubes having electrical energy in both input and output circuits may be regarded as impedances, while those in which the input or output is radiant energy may be regarded as energy converters

Industrial Tube Characteristics

OF all methods of controlling energy, that afforded by the use of electron tubes is one of the most convenient and effective.

The advantages of control through the use of electron tubes may be summarized as follows: (1) There is a wide variety of energy transforming devices whose output is capable of being associated with electron tubes. (2) The electrical power output of an electron tube is capable of minute and complete control through the employment of a control element usually called a grid. (3) By coupling the appropriate energy converter to a tube, one form of energy may be transformed into an electrical voltage or current which can then be very easily and conveniently modified in almost any conceivable manner. (4) Through use of the electron tube the expenditure of a minute amount of control power may effect the control of a very considerable amount of power in the output circuit because of the amplifying properties of the tube. (5) Through the appropriate energy converting device in the output circuit of an electron tube, the controlled electrical energy may be reconverted into other forms of energy for the measurement, detection, indication, or control of certain physical, chemical, or other properties. (6) The control afforded through the use of a vacuum tube is of a flexibility and convenience not approached by any other control mechanism. (7) For many applications and in many fields of endeavor, the availability of tubes with extremely high input impedance is a decided advantage. (8) The availability of tubes to handle powers from the smallest up to hundreds of kilowatts, enables the advantages of electron tube control equipment to be applied to the power, industrial, or communications fields with equal facility. (9) With proper design, installation, and maintenance, electron tubes make a stable, rugged, flexible and convenient device of long useful life. (10) Certain types of tubes are available in which one form of energy may be directly converted into another form. Thus, phototubes convert light into an electrical current and conversely cathode-ray tubes convert electrical current into variations of light. Through the use of such tubes, vast opportunities are opened up for the industrial uses of electron tubes. (11) Finally, the unique properties of the electron tube enable it to perform a wide variety of functions, all of which are extremely useful. For example, the tube may operate in the following manner:

(a) As an amplifier, over a wide range of frequency and power.

(b) As an oscillator or generator of voltage over a wide range of frequency, power and waveform.

(c) As a trigger or relay circuit or switch.

(d) As a modulator or demodulator to combine or to separate two or more frequencies.

(e) As a measuring instrument, indicator, or comparator.

(f) As a rectifier or inverter over a very wide range of frequencies, currents, or power.

(g) As a frequency converter to change from one frequency to another.

(h) As a visual indicator or image-forming device as in the electron microscope or the television camera or projecting tube.

All of these advantages and operations cannot be obtained in a single tube. Instead, a very great number of tube types in various classifications according to mode of operation are commercially available. Furtherfore, to make an appropriate selection from the tubes already available, and to utilize the tubes advantageously, some knowledge of the method of operation and the characteristics of the most suitable tubes is necessary.

Types of Electron Tubes

The many types of tubes available for industrial service may be classified according to: (1) the type of control stimulus which causes them to perform the industrial job to which they are assigned, (2) the phenomena occurring within the tube itself, (3) the method of operation, or (4) the number of internal elements or electrodes.

Under the first method of classification, most tubes may be regarded simply as electrical impedances in which a voltage and current are applied to the input terminals and a voltage and current are obtained from the output. Another common type of tube is that which also acts as an energy converter. The phototube, for example, converts radiant energy into electrical energy, while the cathode-ray tube converts electrical energy into light.

In the second classification, we may have vacuum tubes providing smooth instantaneous control of output, or gaseous tubes providing control of the average (but not instantaneous) value of the output power. We may have two electrode tubes or rectifiers in which the useful power output is always less than the input. We may also have control tubes or multi-element tubes, in which the useful output is greater than the input control power, the power sources connected to the tube accounting for the difference.

The classification according to method of operation is largely associated with the use of the tube and will be treated in Section II. Tubes are commonly classified according to the number of electrodes. Depending upon whether they have two, three, four, or five electrodes they are known as diodes, triodes, tetrodes or pentodes. Two element tubes may be regarded as two terminal networks. All commonly used multi-element tubes in which a varying signal is impressed on only one grid, may be thought of as equivalent to a rather special kind of four terminal T or Y network, which can be analyzed by studying the input and output current and voltage relationships.

To obtain a picture of the funda-

mentals of operation, it is desirable to classify tubes according to the phenomena which makes them work.

Fundamental Operations of Control Tubes

All control tubes consist of at least three elements: (1) A source of the electrons (or ions), usually produced by the cathode, which permits conduction of an electric current through the tube; (2) an electrode (plate or anode) to collect the electrons (or ions) within the evacuated space of the tube; and (3) control elements or modifying arrangements (grid) almost always located in the space between the source of electrons and the collector and whose purpose is to modify the flow of current in some manner in accordance with the voltage on this control element. The cathode (which supplies the electrons) and the control element form the input terminals whereas the cathode and the collector form the output terminals of the tube, as usually used. Two-element tubes do not have the control element.

Let us assume that we have the most common type of control vacuum tube securely locked up in a black box with a number of terminals marked on it. Beyond the markings on these three pairs of terminals, we do not care at all, for the moment, as to the nature of the contents of the box. Our primary purpose is to investigate the properties of the device in this box in terms of external conditions which we can easily measure with electrical instruments.

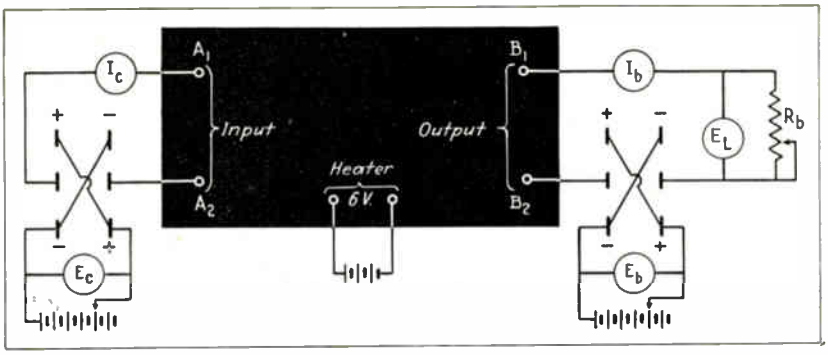


Fig. 1—Schematic wiring diagram for determining the input, output, and transfer characteristics of electron tube contained in the black box

The three sets of terminals are labelled input, output and heater. The heater terminals must be connected to a battery of proper voltage. The instruction book with the black box states that a battery must be placed in series with the output circuit and another in series with the input circuit.

If the box is connected as shown in Fig. 1 and we attach to it certain meters as indicated we are in a position to learn all we want to know about its d-c or static characteristics. All we have to do is to vary the polarity and magnitude of the voltages E_c and E_b and measure the resulting input and output currents.

We shall find that: (1) For all voltages E_c for which terminal A_1 is negative with respect to A_2, the input current (and therefore the input power) is negligible. Therefore we can state that the input impedance of the box is very high. (2) Some current flows in the output circuit if terminal B_1 is positive with respect to B_2. No current flows if this polarity is reversed. (3) For a given resistor R_b, and battery voltage E_b, the plate current, I_b, is a function of input voltage, E_c. Over a certain range, this relationship is more or less linear but in general, the relationship is not linear. (4) For a given input voltage, E_c, and load resistor R_b, the output current depends upon the voltage E_b. The voltage between B_1 and B_2 is not E_b but $E_b - I_b R_b$ since a voltage drop occurs across R_b. The plot of current, I_b, against voltage, E_b, is an S-shaped curve in the majority of cases. (5) For constant values of E_c and E_b, the current in the output, I_b, is a

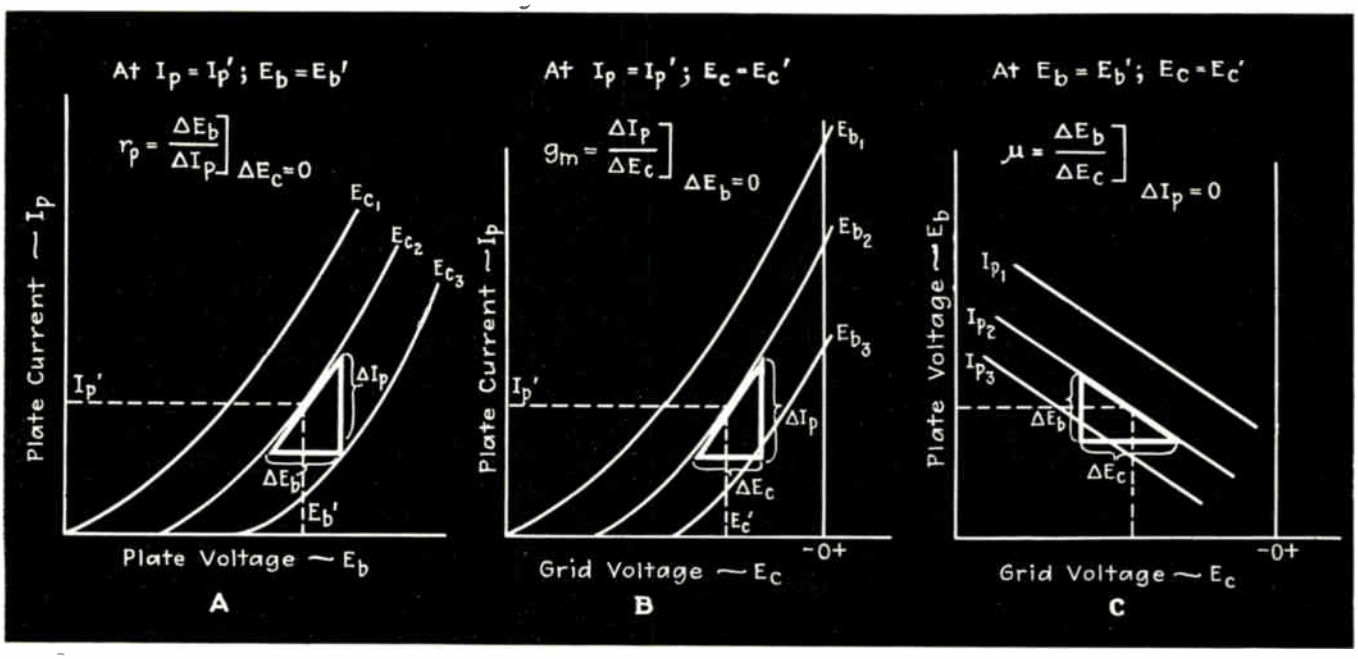


Fig. 2—Output and transfer characteristics of electron tube having characterictics of a triode. Graphical methods of determining plate resistance, r_p, transconductance, g_m, and amplification, μ, are given at *A*, *B*, and *C* respectively

function of the load resistance, R_b. (6) Even a casual examination shows that the output current I_b, is tremendously greater than the input current, and from this we infer that the box may be used as a current amplifier. (7) Voltage variations applied to the input result in a very much larger variation in voltage in the output and measured by E_L. From this, we conclude that the tube in the box may be used as a voltage amplifier. (8) From the last two statements, we conclude that the tube may be used as a power amplifier, since the input voltage and current of minute quantities are capable of controlling a very much larger amount of voltage and current in the output circuit. (9) We note, however, that the polarity of the output voltage across the resistor is opposite from that of the polarity of the input voltages and accordingly, we conclude that the tube operates as a 180 deg. phase shifting network for resistive loads. (10) Electrically we can regard the black box as an impedance, but we note that we must supply sources of power to this impedance for otherwise it will not function properly. In this respect the black box differs from a transformer in which sources of power external to that being transferred are not required to effect the necessary control or transformation. (11) By careful examination of our data, we conclude that the box is, in general, a non-linear device, but that under certain conditions of operation, the relationship between input and output may be made linear. (12) If we were to add an alternating voltage in series with the steady or d-c input voltage, we would measure alternating currents and voltages in the output circuit which are magnified replicas of their input.

If we make a graphical plot of the d-c voltages and currents in the input and output circuits, with the plate resistor short circuited, we obtain the d-c or static characteristics of the tube. The shape of these curves will depend upon the type of tube contained in the box, but the essential concepts of tube operation apply no matter what the curve shape. Typical characteristics for a triode and for a pentode are shown in Figs. 2 and 3. These static characteristics suffice to give us all the important information we need to know concerning tube operation, for from them we can obtain knowledge of: (1) the important tube parameters, amplification factor, μ, plate resistance, r_p, and transconductance, g_m, (2) the required d-c operating voltages for desired operation of the tube, (3) the mode of operation of the tube with any kind of load in its output circuit, and (4) the mode of operation of the tube with any kind of time-varying input signal applied to the grid or input.

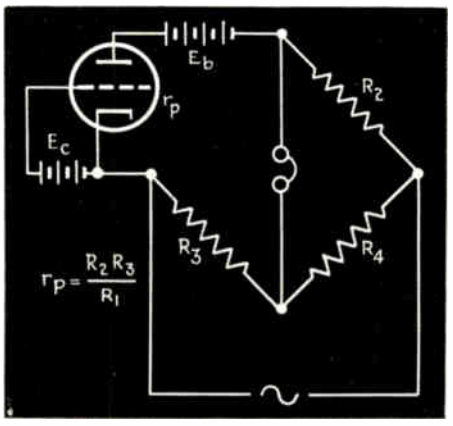


Fig. 4—Bridge circuit for measuring plate resistance for selected grid and plate operating voltages, E_c and E_b

Operating Coefficients for Vacuum Tubes

Since the plate current is a function of the plate voltage, even if the load resistance, R_L of Fig. 1, is short circuited, the plate circuit must have some internal resistance. Its d-c resistance may be determined from Ohm's law, but this value is seldom of any use to the designer and will not be found in manufacturers' literature. The resistance for small changes of plate voltage, and with the grid voltage maintained constant, is very important. It may be measured by the circuit of Fig. 4, for the operating voltages E_c and E_b, since the cathode-plate circuit takes the place of the unknown re-

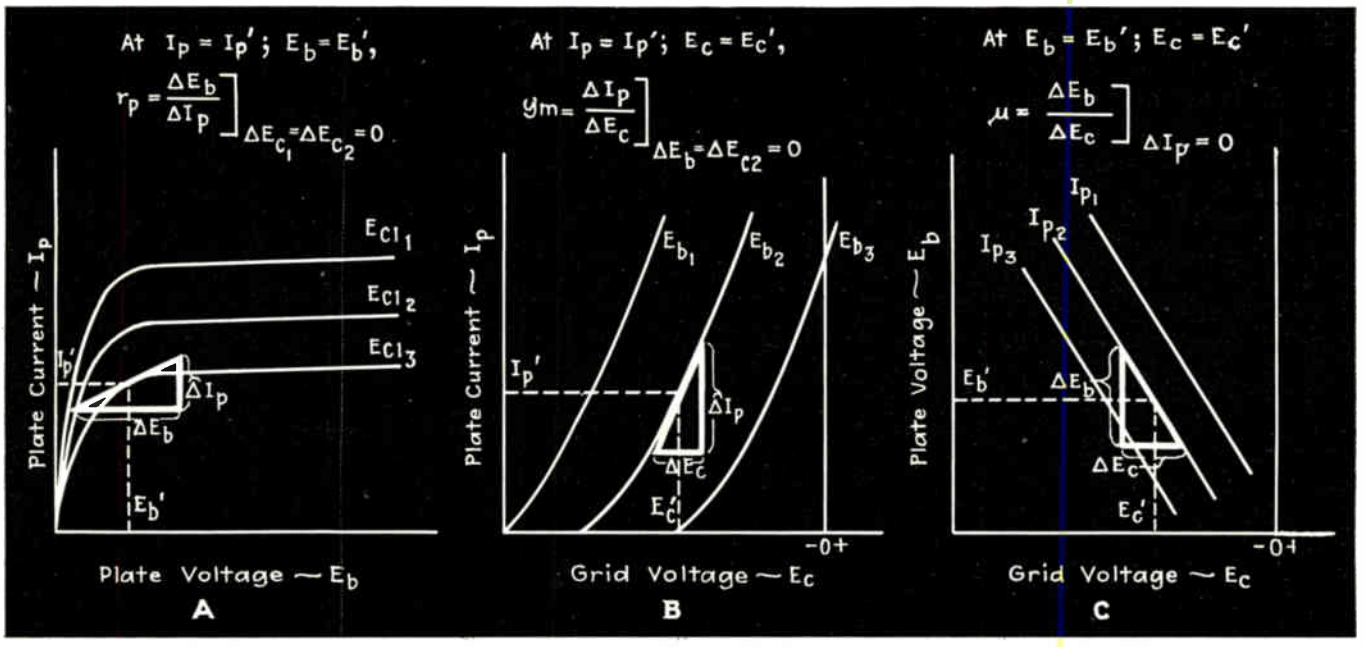


Fig. 3—Output and transfer characteristics of electron tube having characteristics of a pentode. Graphical methods of determining plate resistance, r_p, transconductance, g_m, and amplification factor, μ, are given at A, B, and C respectively

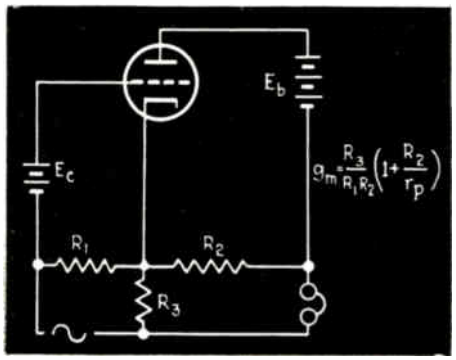


Fig. 5—Circuit for measuring transconductance for grid and plate operating voltages, E_c and E_b, respectively

sistor in one arm of the a-c Wheatstone bridge. In general, a different value of plate resistance is obtained for each new value of E_c and E_b, so these operating voltages should be specified when the plate resistance, r_p, is measured.

The plate resistance is defined as the ratio of the change in plate voltage to the corresponding change in plate current produced, all other voltages being maintained constant. The mathematical definition is given in Fig. 2A and 3A which also shows that the plate resistance at any operating point specified by the dashed lines, may be determined from the inverse slope of the E_b-I_p characteristic at this point. (This is, of course, measured in terms of voltage and current changes as measured on the graph, and not by measuring angles with a protractor.)

For a fixed value of plate voltage, the plate current is a function of the grid voltage, and it is convenient to have a tube factor, which designates the ability of the grid to control the plate current. This term, called the transconductance (formerly called mutual conductance) may be measured by the circuit of Fig. 5. It is defined as the ratio of the change in plate current to the change in grid voltage causing it, under the condition that all other electrode voltages remain constant. As shown in Figs. 2B and 3B, the transconductance is measured by the inverse slope of the E_c-I_p curve, at the point of the characteristic determined by the operating voltages (shown by the dashed lines). The unit of transconductance is the mho or reciprocal ohm, although the terms milliamperes-per-volt and micromho are also employed, since they are more convenient submultiples of the mho.

Finally, we may determine the relative effect of the grid and plate voltages upon the plate current. This is the slope of the constant-current curves of Figs. 2C and 3C, is called the amplification factor, and is designated by the Greek letter μ. The amplification factor may be measured with the circuit of Fig. 6, or it may be determined graphically, as indicated in Figs. 2C and 3C. The amplification factor is a numeric, having no dimensions; it is merely a voltage ratio.

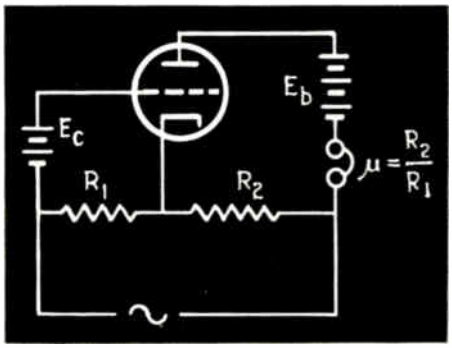


Fig. 6—Simple bridge circuit for measuring amplification factor for grid and plate operating voltages, E_c and E_b

An interesting relation connects these three tube coefficients, for

$$\mu = g_m r_p$$
$$g_m = \mu / r_p$$
$$r_p = \mu / g_m$$

Consequently, if we know the values of any two at the same operating voltages, we can easily calculate the value of the third at the same operating conditions. Tubes may have values of μ from 3 to several thousand (values of 10 for triodes and 800 for pentodes are typical); values of transconductance from 500 to 10,000 micromhos, with 1,500 micromhos a typical value; and values of plate resistance from 500 ohms to 100,000 ohms for triodes and up to several megohms for pentodes. Table I shows operating characteristics for a few typical vacuum tubes.

TABLE I — OPERATING CHARACTERISTICS OF TYPICAL VACUUM TUBES

Type No.	Description	Heater Voltage E_H (Volts)	Heater Current I_H (Amps)	Grid Voltage $-E_{c1}$ (Volts)	Anode Voltage E_b (Volts)	Screen Grid Voltage E_{c2} (Volts)	Anode Current I_b (Ma.)	Amplification Factor μ	Plate Resistance r_p (Ohms)	Transconductance g_m (μ mhos)	Plate Dissipation P_L (Watts)
	Diodes										
6H6	Full Wave Rect.	6.3	0.3	.....	117*	.....	4	.....	.....	.....	.....
12Z3	Half Wave Rect.	12.6	0.3	.....	250	.....	60	.....	.....	.....	.....
219	" " "	22.0	24.5	.....	50,000	.....	2,500	.....	.....	.....	.....
F103A	" " "	28.0	51.0	.....	50,000	.....	9,000	.....	.....	.....	.....
WL-660	" " "	10.0	10.5	.....	230,000	.....	30	.....	.....	.....	.....
	Triodes										
PJ10	Det. Amp. Osc.	5.0	0.25	−9.0	135	.....	3	8	10,000	1,250	.....
6C5	" " "	6.3	0.30	−8.0	250	.....	8	20	10,000	2,000	.....
6F5	" " "	6.3	0.30	−2.0	250	.....	0.9	100	66,000	1,500	.....
89	Amp. Osc.	6.3	0.40	−31.0	250	.....	32	4.7	26,000	1,800	8
841	" "	7.5	1.25	−9.0	425	.....	2.2	30.	40,000	750	12
842	" "	7.5	1.25	−96.0	425	.....	28.	3.	2,500	1,200	12
849	" "	11.0	5.0	*	2,500	.....	350	19.	*	*	400
848	" "	22.0	52.0	*	15,000	.....	1,000	8.	*	*	10,000
862	" "	30.0	325.0	*	20,000	.....	1,500	10.	*	*	125,000
	Tetrodes and Pentodes										
FP-54	Low Grid Cur.	2.5	0.09	*	6	.....	.....	1.0	.....	40	.....
6D6	Voltage Amp.	6.3	0.30	−3.0	250	100	8.2	1,280.	800,000	1,600	1.0
25A6	" "	25.0	0.30	−18.0	160	120	48.	100.	42,000	2,375	5.3
6L6	" "	6.3	0.90	−18.0	350	250	54.	170.	33,000	5,200	19.
813	Beam Tetrode Amp.	10.0	5.0	*	2,000	400	100	*	*	*	100.

* Depends upon method of operation

Characteristics of Gaseous Tubes

If we proceed in the manner already outlined to study the characteristics of gas tubes, we shall obtain results which at first appear to be somewhat erratic but which are, none the less, subject to an orderly and systematic classification.

If we have a two-element tube (i.e. not a control tube) in a blue box the input terminals can be short circuited and we can obtain all of the information we desire from a study of the output voltage and current.

For low values of plate voltage E_b any current which flows at all is measured in microamperes or at most a very few milliamperes. As E_b is increased, a critical value is obtained at perhaps 10 to 25 volts beyond which the current suddenly rises to a rather high and constant value determined by the external resistance R_b and the voltage E_b, according to Ohm's law. Increasing the voltage beyond the critical value will increase the current as calculated on the basis of Ohm's law, taking account only of the resistor R_b and neglecting the tube resistance. On the basis of this operation we conclude that, after the critical voltage has been reached or exceeded, the internal resistance of the gas tube had suddenly decreased to an extremely small value from its previous value of several hundred or several thousands of ohms. The relatively large current will continue to flow in R_b until E_b is reduced to a fairly low value, when the current will suddenly decrease to a negligible value.

This operation of a two-element tube indicates that it can be used as a voltage control switch. The smooth type of voltage-current control possible with vacuum tubes has now been lost and for most practical purposes the tube can be used to conduct current on an all-or-nothing basis.

If we place a control type of gas tube in a blue box with the grid and cathode connected to the input terminals and the plate or anode and cathode connected to the output terminals, the operation becomes more complicated. Let us apply steady voltages to the input and output circuits and measure the input and output currents as these voltages are varied. Again, at a given grid voltage the tube suddenly conducts at some critical value of positive plate voltage. Likewise, for a given positive plate voltage, the tube suddenly conducts at some critical grid voltage. The breakdown now depends not only upon the magnitude of the plate voltage but also upon the magnitude of the grid or input voltage. Over a considerable range of values the critical grid voltage which initiates conduction is some fairly definite fraction of the applied plate voltage. This critical grid voltage may be either positive or negative, depending upon the type of tube within the box. It will also be observed when the plate circuit of the tube becomes conducting that there is also a relatively large input or grid current flowing, even though the grid of the device is negative.

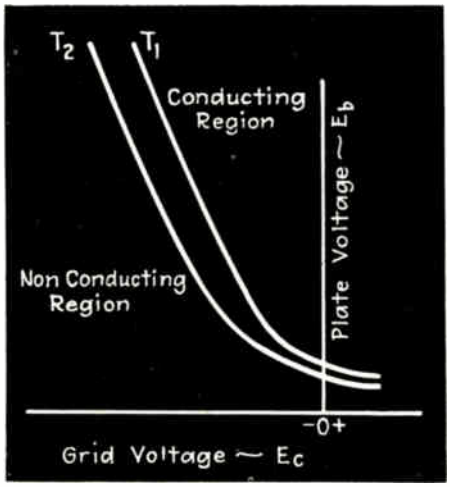


Fig. 7—Voltage control characteristics for gaseous control tube, for two different operating temperatures, T_1 and T_2

Thus, before the critical grid voltage is reached the input resistance of the tube may be fairly high but beyond the critical grid voltage it becomes relatively low. Thus, the "switch action" observed in the output circuit is also apparent in the input circuit and it will be observed that both input and output current increase simultaneously. If the tube contains mercury vapor, it will be found that the critical grid and plate voltages also depend somewhat upon the temperature at which the tube is operated.

It is convenient to plot the grid and plate voltages for the condition at which the tube suddenly becomes conducting. Such a set of curves (Fig. 7), divides the tube characteristics into two essential regions. For those conditions of voltage occurring to the left of curve, the tube is nonconducting and no appreciable current will flow through it. On the other hand, if the voltages occur to the right of the curve, the tube becomes conducting and passes a current which is limited only by the external load and by the ability of the cathode to supply electrons. Thus, Fig. 7 may be regarded as a type of "trigger diagram" to indicate the conditions under which the tube conducts. Once the gas within the tube becomes conducting the grid loses control and the tube can in general, be made non-conducting only by removal of plate voltage. The region between the various curves depends upon the ambient temperature of the tube surroundings.

For an appreciable portion of the curve of Fig. 7, a linear relation exists between the grid and plate voltages which produce breakdown. For a given temperature, the ratio of the plate voltage to the grid voltage required to initiate ionization is called the control factor. It is analogous to the amplification factor in the high vacuum grid tube, and is determined in much the same way. For gaseous conduction tubes there are no significant coefficients analogous to the transconductance and plate resistance of the vacuum tube.

When the gas within the tubes becomes ionized gaseous tubes have much lower internal resistance than vacuum tubes. Consequently greater currents may be passed through them than through vacuum tubes of equivalent structure. However, for gas or vapor tubes having pressures of a fraction of a millimeter, the maximum obtainable current is equal to the current which the cathode can supply. On the other hand, tubes containing gas or vapor at a pressure of about 5 centimeters of mercury can rectify currents of larger magnitude than the cathode emission current since the pressure of the gas tends to prevent excessively rapid evaporation of particles from the cathode. Such tubes are suitable for use only in low voltage circuits such as battery chargers.

In large industrial rectifiers, a mercury pool is frequently used instead of a hot cathode, and conduction takes place by virtue of a mercury arc between the pool and the anodes, of which two are required to maintain the device in continuous operation. Such mercury vapor rectifiers are often encased in metal tanks.

TABLE II — OPERATING CHARACTERISTICS OF TYPICAL GAS TUBES

Type No.	Description	Heater Voltage Volts	Heater Current Amps	Plate Peak Volts	Max. Av. Plate Amps	Max. Peak Plate Amps
	Diodes					
866	Half Wave Rect.	2.5	5.0	7,500	0.25	1.0-2.0
869	" " "	5.0	18.0	20,000	2.50	10
870	" " "	5.0	65.0	16,000	75.0	450
WL-670	Full Wave Rect.	2.5	24.0	1,000	9.5	.3 per anode
	Triodes					
885	Negative Grid	2.5	1.4	350	0.075	0.300
FG-17	" "	2.5	5.0	2,500	0.50	2.0
GL-414	" "	5.0	20.0	2,000	12.5	100
KU-634	" "	5.0	11.5	7,500	1.25	5.0
KU-610	Positive Grid	2.5	6.5	500	0.10	0.40
	Tetrodes					
FG-98A	Negative Grid	2.5	5.0	500	0.5	2.00
FG-154	" "	5.0	7.0	500	2.50	10.0
FG-95	" "	5.0	4.5	1,000	2.50	15.0
FG-172	" "	5.0	10.0	1,000	6.40	40.0

Instead of providing the source of electrons by means of a hot cathode, they may be provided by a cold cathode with electrons supplied by field emission. Two and three element tubes of this variety are available. Of course, such tubes would not require any cathode heating battery if connected to the circuit of Fig. 1.

The igniter principle, long used in mercury vapor rectifiers, has been applied to the ignitron. The ignitron is a gas discharge tube having a pool type cathode in which an ignition electrode is employed to control the starting of the unidirectional current flow in each operative cycle, the igniter electrode initiating the conducting arc. The ignitron has important applications as a rectifier for industrial uses.

All gas or vapor filled tubes are incapable of giving instantaneous control of current, but are capable of controlling the desired average current. Consequently, they are given average current ratings. Operating characteristics for several typical gas tubes are given in Table II.

Characteristics of Phototubes

Another electron tube of very great industrial use is the photoelectric tube or phototube. Let it be placed in a white box. It has no terminals marked heater nor has it any input terminals. It does have output terminals but where the input terminal should be, there is nothing but a piece of plane glass, or perhaps a magnifying glass. The interior of the box is completely dark.

We connect up the device as shown in Fig. 8, duplicating the connection of Fig. 1 so far as the output terminals are concerned. If B_2 is positive with respect to B_1 we find that a small current may flow, but if the polarity is reversed, no current flows.

A casual examination of the characteristics of the device with the terminal B_2 positive with respect to B_1 results in values of output current which, while they depend upon the value of the output voltage, E_b, at first do not appear to be constant. Instead they appear to vary more or less at random, even being subject to our proximity to the white box. A closer examination will show that these current variations are associated with the amount of light falling upon the glass or lens of the input circuit. By following out this line of reasoning, we find that the output current is a function of the light incident upon the lens. We have now a totally new type of device in which the output current depends upon (1) the plate voltage, if the light intensity is constant, or (2) the light intensity if the plate voltage is constant.

Suppose we maintain a steady beam of light on the lens of our white box and observe the current as the voltage is changed. Since the maximum current which we can obtain is in the neighborhood of 25 microamperes or so, we conclude that the output of the device is of extremely high impedance, especially since the voltage E_b may be as high as several hundred volts. In general, the characteristic we obtain is one which rises quite sharply for low values of voltage and then, for increased voltages, results in no appreciable increase in current. This is a typical saturation curve. If the tube is a vacuum device, then the current will be essentially constant for voltages above about 50 volts, but if the tube contains gas, we shall find that the current continues to rise concave upward as the voltage is increased. These characteristics are shown in Fig. 9 for both tubes.

If the voltage is maintained constant above the knee or saturation value and the light intensity is varied, it will be found that the current is directly proportional to the intensity of the light beam so long as the external plate resistance, R_b does not have too high a value. Even for a load resistance of 1 to 2 or perhaps 5 to 10 megohms there is a reasonably good linear relationship between output current and incident light, but not for higher resistances. This linear relationship holds true only for vacuum phototubes as shown in Fig. 10. If a gaseous phototube

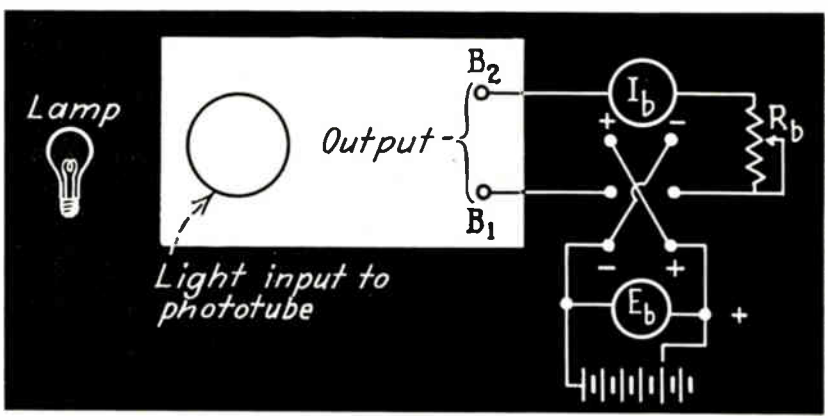


Fig. 8—Schematic diagram for determining the luminous sensitivity and electrical output characteristics of an emissive phototube. By omitting the voltage source, E_b, the same circuit could be used to determine the characteristics of barrier layer types of photoelectric cells

is used, the relationship between output current and input light is not linear, but may increase concave upward as the light intensity is increased. This immediately suggests to us that a vacuum phototube provides a very simple and convenient means for determining light intensity by electrical means. The gaseous tube is not so convenient because the relationship between input light and output current is not linear (Fig. 10).

The output current is also a function of the wavelength of light falling upon the device. Certain types of phototubes are sensitive to infrared radiation, some are sensitive throughout the visible range, whereas others (in fact practically all of them) have an appreciable sensitivity in the ultraviolet region. The relative sensitivity of the phototube to various wavelengths will be found to be a characteristic of the tube under consideration. Nevertheless, the fact that the phototube is differentially sensitive to radiation of different wavelengths indicates that the composition of the light reaching the tube must be maintained constant if we are to use the phototube as a precise light measuring instrument.

When we consider the magnitude of the current derived from the phototube and when we consider its resistance, it is apparent that the external load circuit must have a very high resistance (megohms) if maximum power is to be derived from the phototube. Even then the power available in the external circuit is extremely small. However, we may apply the output voltage developed across the resistor R_b to the input

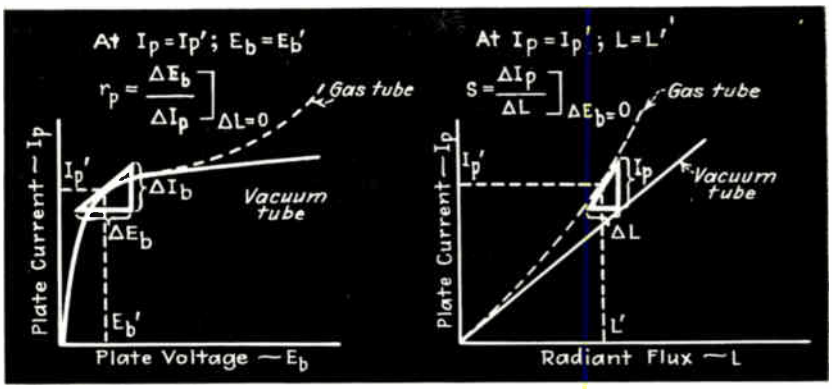


Fig. 9—Resistance or output characteristics of vacuum or gaseous phototubes may be determined from the slope of the E_b-I_p characteristics. left.

Fig. 10—The luminous sensitivity of vacuum or gaseous tubes may be determined from the slope of the current-flux characteristic, right.

of a vacuum tube to control power in the output circuit of the vacuum tube. In this way, we can use the phototube indirectly to control sizeable amounts of power by variation of the light beam falling upon the phototube.

As shown in Fig. 9 and Fig. 10, there are two characteristics of phototubes which are important. The first of these is called the variational resistance of the phototube and is defined as the ratio of the change in plate voltage to the corresponding change in current, for a specified incident light flux falling on the tube. The graph of Fig. 9 shows this resistance determined for the knee of the curve, but it could also be determined for any other part of any of the curve. The other tube characteristic is its luminous sensitivity which, for a specified plate voltage, may be defined as the ratio of the change in plate current to the corresponding change in luminous flux producing it. For the vacuum phototube this luminous sensitivity is constant, whereas it increases with increasing illumination for the case of a gaseous phototube. In all of these specifications for phototube factors, it is assumed that the quality of the light used in making the measurements is unchanged. The measurements are usually made with light produced by an incandescent filament operated at some specified temperature near 2,700 or 2,800 deg. F. Operating characteristics for a few typical phototubes are given in Table III.

Another type of photoelectric device, which incidentally can hardly be classed as an electron tube, is of importance in industrial applications of electronic devices. This is the barrier layer type of photoelectric cell which has considerable application in portable photographic exposure meters and light meters. This cell requires no external source of voltage for its operation but converts radiant energy directly into electric energy. The device is essentially a low impedance circuit element, and for this reason the output voltage, which is in the neighborhood of millivolts, cannot be conveniently amplified through the use of electron tube amplifiers. Currents of several hundred microamperes (enough to operate sensitive relays) are available from these devices, whose great virtue is that they operate without external sources of power applied to them. In many types of such devices, the spectral response is more nearly like that of the eye than is true for the emissive type of phototube already described. This type of light-sensitive device has many uses.

TABLE III — OPERATING CHARACTERISTICS OF TYPICAL PHOTOTUBES

Type No.	Cathode Surface	Max. Anode Voltage Volts	Max. Anode Current μA	Typical Sensitivity μA/L	Window Area Sq. In.	Region of Max. Sensitivity
	Vacuum Tubes					
PJ-22	Cs-O-Ag	200	20	5	0.9	Deep red & ultraviolet
SR-50	Cs-O-Ag	500	20	15	1.1	
917	Cs-O-Ag	500	30	20	0.9	3,000-11,000
CE	Cs-O	90	20	30	...	A deep red & ultraviolet
5A	Cs-O	180	100	20	...	
GL-441	Coesium	200	...	45	0.9	.....
	Gas Tubes					
PJ-23	Cs-O	90	20	50	0.9	Deep red & ultraviolet
918	Cs-O-Ag	90	5	110	0.9	3,000-11,000
CE	Cs-O	90	20	150	...	Deep red & ultraviolet
6-A	Cs-O	90	10	60	...	.....

Characteristics of Cathode-ray Tubes

In line with our previous investigations let us determine the characteristics of a cathode-ray tube. We shall find that the cathode-ray tube box contains a number of input voltage terminals and that in place of the output terminals we are faced with a circular glass disk (screen) having a white appearance as if the inner surface were frosted. From our study of phototubes we have already been accustomed to electron devices which convert energy from one type to another. We surmise therefore that electrical energy fed into the device may be converted into radiant energy manifested by light of various intensities on the glass screen. We note that the cathode-ray box is marked to be connected to a 110-volt a-c line and from this, as well as from the fact that the box is quite heavy, we infer that the box contains more than the tube itself. In fact, there is an internal power supply provided for the tube and the three pairs of output terminals are simply provided to enable us to control the pattern on the screen.

We begin our investigation by applying voltages to the two terminals marked control grid. If we apply a direct voltage, a spot of light appears in the center of the screen. By varying the control voltage we have a means of varying the intensity of the light on the screen. The current taken by the control grid is practically zero with one condition of polarity and fairly small with another so the impedance of this electrode is high.

Now, if we apply direct voltages to the two terminals marked *H*, we shall find that the spot of light is displaced in a horizontal direction across the screen in a manner which is proportional to the voltage applied to the *H* or horizontal terminals, the direction of the displacement depending upon the voltage polarity.

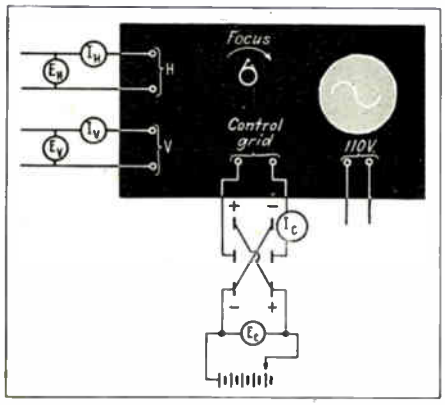


Fig. 11—Circuit arrangement for determining the intensity and deflection characteristics of a spot on the screen of a cathode-ray tube, in terms of intensity control voltage, E_c, and horizontal and deflection voltages, E_h and E_v, respectively

Likewise the vertical displacement of the spot depends upon the magnitude and polarity of the direct voltage applied to the two terminals marked *V* or vertical. The impedance of the *H* and *V* electrodes are both high as is indicated by very small currents I_H and I_V, even for voltages large enough to deflect the spot off the screen.

Now, we have three input voltages which we may control at random and independently of one another and therefore there are three possible modes of varying the spot. We can either vary the horizontal displacement of the spot or its vertical displacement and we can control its intensity. If we apply an alternating voltage to the vertical terminal and direct voltage to the horizontal terminal we shall find that the spot is lengthened out to a fine line whose length is proportional to the peak value of the voltage. If the direct voltage is applied to the vertical terminal and an alternating voltage applied to the horizontal terminal, the spot will become a thin horizontal line. If alternating voltages are applied to both the horizontal and vertical terminals, we obtain a wide variety of patterns which, if the frequencies are integrally related are known as Lissajous' figures. If we apply an alternating voltage to the control grid, then it will be possible, under certain values of adjustment, to make a portion of the Lissajous' figures disappear and to make other portions of the figures brighter than normal.

Using the three control voltages, it is possible to obtain a wide range of patterns of varying intensities on the screen. The patterns thus produced are extremely useful to one who is accustomed to their correct analysis.

The spot of light may be green in color or white or blue or perhaps some other, although less common, color. With different screen materials the image may not immediately remove itself from the screen when the control voltage is sufficiently negative. Instead, the spot tends to linger and to gradually decrease in intensity after the voltage is increased beyond its cut-off value. Such a tube would be well suited for the photography of a phenomenon which produces a stationary pattern on the screen, but would produce objectional blurring if our patterns were subject to rapid spatial changes on the screen of the tube.

For a given voltage applied to the *H* and *V* terminals, we always obtain the same spot displacement or deflection (assuming the line voltage and internal adjustments remain unchanged). It does not necessarily follow that a given voltage applied to the horizontal terminals will produce the same absolute value of displacement as when applied to the vertical terminals although usually the difference will not be more than about 20 percent. By determining the displacement of the spot for a given voltage we can specify the deflection sensitivity of the device.

In some tubes, using magnetic deflection, the deflection of the spot is controlled by current flowing through coils near the tube. In such cases the deflection depends upon the currents in the *H* and *V* coils whose impedance may be quite low. Otherwise the mode of operation is like that already described for tubes with electrostatic deflection.

The operating characteristics of a few typical cathode-ray tubes are given in Table IV.

For a list of bibliographical references relating to the material in this section, see page 69.

TABLE IV — OPERATING CHARACTERISTICS OF TYPICAL CATHODE-RAY TUBES

Type	Heater Voltage E_H (Volts)	Heater Current I_H Amps	First Anode Voltage E_1 (Volts)	Second Anode Voltage E_2 (Volts)	Approx. Sensitivity mm/volt or mm/NI	Screen Color	Screen Size
906	2.5	2.1	1,000	1,500	0.041	Green	3
1803-P4	2.5	2.1	1,900	7,000	.....	White	12
54-11-T	6.3	0.6	.....	3,000	.....	.....	5

Tubes and Their Functions

HAVING discussed the characteristics of various members of the electron tube family, let us consider the tube as part of a circuit. All high vacuum tubes have input impedances which are high (megohms) so long as the grid is maintained negative and this is the usual way of using the tube. The output impedances are high, of the order of thousands of ohms to several megohms. Both input and output impedances act like high resistances shunted by small capacitances. These capacitances may be neglected in all but unusual industrial applications.

Gas tubes have high input impedance up to the moment of conduction, and then the tube may draw appreciable current from the input circuit (milliamperes). The internal resistance of gaseous tubes is of the order of 15 to 25 ohms while the tube conducts and is very high during the non-conducting condition.

A high vacuum control tube may be regarded as a one-way device for all frequencies and applications useful to industrial processes. Very little of the output energy gets back to the input through the tube itself. The amplifier tube acts as a 180 deg.-phase shifting network for resistance loads. An amplifier tube operated over the linear part of its input-output characteristic may be looked at as a generator of voltage μe_g in series with the plate resistance of the tube; μ is the amplification factor and e_g is the applied alternating voltage.

A gaseous control tube acts as a single pole single throw switch. A phototube is an energy converter of high impedance, producing electrical energy from radiant energy. Microamperes of current can be secured from it; its output must be amplified for industrial purposes. The output of the vacuum type phototube is independent of applied voltage above about 50 volts. A linear relationship exists between input energy and output current for a high vacuum tube; but the relation is not linear for a gas phototube. The photovoltaic type of light sensitive device is essentially a low impedance device with higher current output than the phototube but delivering lower output voltages. Its output may be used with a sensitive relay which acts as an amplifier, in turn operating a heavier relay.

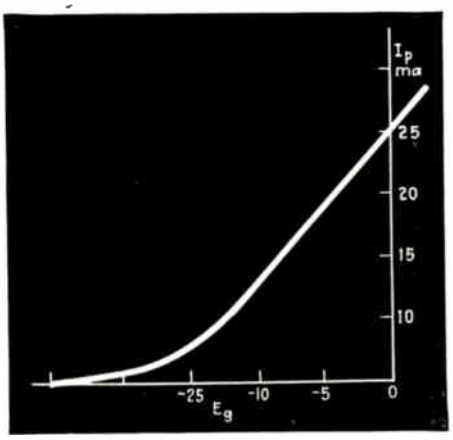


Fig. 1—Curve showing relation between input (grid) voltage, E_g, and output (plate) current, I_p, for a typical triode amplifier

How to Make the Tube Work

In industrial applications, tubes perform essentially two different types of functions. In some cases, as in rectifiers, the output of the tube is used directly, power flowing from the tube to the work to be done. In others, the tube acts merely as an accessory piece of equipment, responding to some sort of stimulus (obtained from the work to be done) and in responding releasing energy from a local source; this energy performing the desired job.

Whatever the job to be done, therefore, some means must be found for deriving from it a stimulus that can be applied to the tube, such as a voltage or illumination change. Interrupting a beam of light by an object to be counted is one method; another is to make the object to be counted change the voltage (phase, frequency or other electrical quantity) applied to the tube. Any physical quantity, such as weight, color, velocity, size; or any electrical quantity, such as voltage, phase, frequency; or any chemical quantity, such as the pH or conductivity of an electrolyte, etc., may be converted to an appropriate electrical change which will cause a tube to act.

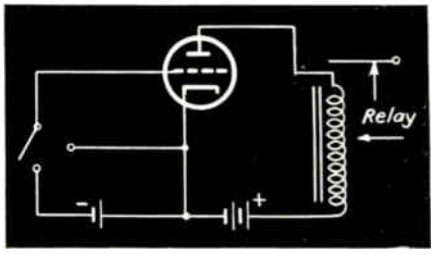


Fig. 2—Simple relay circuit using tube between a stimulus voltage and an electromagnetic relay

High Vacuum Tubes

Use of the Tube as a Relay

Consider the curve in Fig. 1, the characteristic of a typical amplifier tube. This curve expresses the relation between the voltage input and current output for a given plate voltage. Note that there is a continuous relation between current output (known as plate current or I_p and voltage input or grid voltage E_g). Thus when the grid voltage is -10 volts, the plate current is 13 milliamperes and when the grid voltage is zero the plate current has increased to 25 ma. In tubes of this type the plate current increases continuously as the grid voltage is made less negative or is made positive with respect to the cathode.

The plate circuit of the tube is the work circuit. The grid circuit is the control circuit. All that is necessary to put the tube to work as a relay tube is to change the voltage on the grid from say—10 to 0 and to use in the plate circuit an electro-mechanical relay which will remain open when 13 ma flow through it but which will close when 25 ma flow through it or vice versa. Current or power to perform the final work to be done is controlled by contacts on the relay. It is immaterial to the tube how the engineer decides to get the required input

voltage change of 10 volts. For example, an extremely simple method is to have a 13 volt battery between cathode and grid with a switch which can connect the grid directly to cathode when desired. This switch could be closed by a cam arrangement, say on a cylinder of a printing press. Once in each revolution the switch connects the grid directly to the cathode, and a counter in the plate circuit rings up another newspaper off the press.

A logical question at this point is to ask why, if 10 volts are available to control the tube, this voltage change is not applied directly to the relay and thus eliminate the tube. Certainly there is no need to use a tube if we can avoid it; and industrial engineers use tubes only if they perform jobs which cannot be done in any other way, or if they are done better by tubes—i.e., either faster, cheaper, or safer.

In this case it is power that operates the relay and not current or voltage. The 10 volt change placed upon the tube input terminals may come from a source of extremely limited power; for example the output of a phototube. The phototube current change may be of the order of 10 microamperes which is not sufficient current to operate the relay. This current, however, may be caused to flow through a 1-megohm resistance. Across this resistance will appear a 10-volt change and this in turn may be applied to the control grid of the tube.

The power through the relay may be figured as follows. If it has a resistance of 500 ohms, and if a current change of 12 ma is sufficient to make it operate, the power required to make the relay operate is 72.0×10^{-8} watts (I^2R). Now the input power required to make the tube operate works out to be 100×10^{-6} watts ($10^2\times10^{-6}$) so that the tube produced a power amplification of some 720 times—and this is why the tube is used.

Use of the Tube as an Amplifier

The tube has an extremely important ability—to amplify voltage changes placed upon its grid circuit. Across a load in the plate circuit appear voltages which are magnified images of the voltage changes placed upon the grid circuit. These images can be almost exact replicas of the input voltages, or they can be distorted in almost any manner desired. It is this amplification ability that has made radio broadcasting possible, and it is also of very great value to industrial applications.

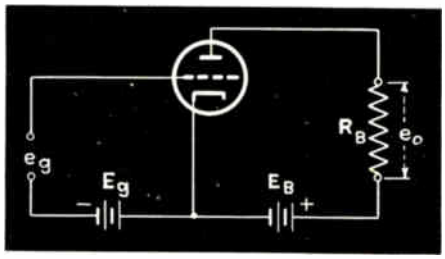


Fig. 3—Fundamental amplifier diagram. Here R_B is the load resistance across which the output alternating voltage, e_o, appears

In Fig. 3 is a simple tube amplifier circuit with a resistance load R_B. In series with the fixed grid voltage (known as a bias) is a source of alternating voltage. If the a-c terminals are shorted a steady value of plate current will flow, its value depending upon the plate voltage, upon the grid voltage, upon tube characteristics, and R_B. But if alternating voltage is applied to these terminals, the plate current will rise and fall about its former fixed value as a base. Looked at in another way, the plate circuit will have two currents in it, one a direct current and the second an alternating current.

This alternating current flowing through the plate load resistance produces a voltage drop along this resistance; and this alternating voltage will be greater than the alternating voltage placed upon the grid terminals if R_B is not too small.

Effect of Tube Resistance. The tube has an internal resistance (r_p) through which the plate current must flow. The relative value of this internal resistance and that of the load resistance govern both the magnitude of the alternating voltage developed across R_B and the power developed in R_B.

If the tube is properly biased and operated so that the plate current does not drop to zero on the negative half cycles of input alternating voltage, and the grid is always negative with respect to the cathode, the output alternating voltage, current and power are respectively

$$e_o = \frac{\mu e_g R_B}{r_p + R_B}\ ;\ i_p = \frac{\mu\, e_g}{r_p + R_B};$$

$$P_o = \frac{\mu^2 e_g^2 R_B}{(r_p + R_B)^2}$$

The maximum output voltage across R_B will be secured when R_B is large compared to r_p. The maximum power in R_B will be secured when R_B is equal to r_p. Then the power output is

$$P_{o\ max} = \frac{\mu^2 e_g^2}{4\, R_B}$$

where e_g = rms input grid voltage or

$$P_{o\ max} = \frac{\mu^2\, e_g^2}{8\, R_B}$$

where e_g = peak input grid voltage.

Under no conditions can the amplification of voltage (e_o/e_g) be greater than the amplification factor of the tube and approaches this value only when R_o is much greater than r_p. If $R_o = 3r_p$ the amplification will be 75 percent of the amplification factor of the tube.

If the load resistance is much less than the tube resistance (as is frequently the case in using certain tubes with very high internal resistance) the voltage amplification is approximately equal to

$$e_o/e_g = g_m R_B$$

where g_m = transconductance of the tube, and here again the maximum amplification depends upon how large the load resistance is.

Plate Battery Requirements. It is a disadvantage to place too high a load resistance in the plate circuit of a tube, especially when using the low resistance tubes. This arises from the fact that the plate current not only flows through the tube but through the load too, and for every milliampere of current drawn

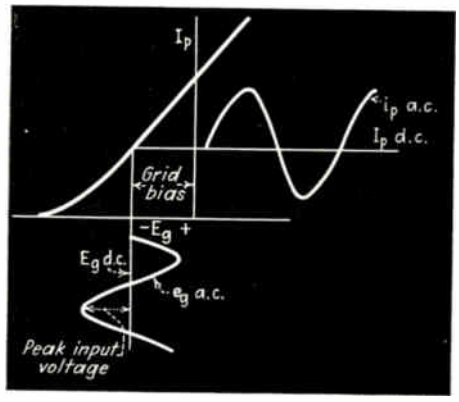


Fig. 4—Tubes usually operate with a fixed direct voltage on both plate and grid. In addition, alternating voltages may be placed upon the grid circuit. Then alternating currents will flow in the plate circuit. Here E_g and I_p are steady values of grid voltage and plate current; e_g and i_p are peak values of alternating grid voltage and plate current

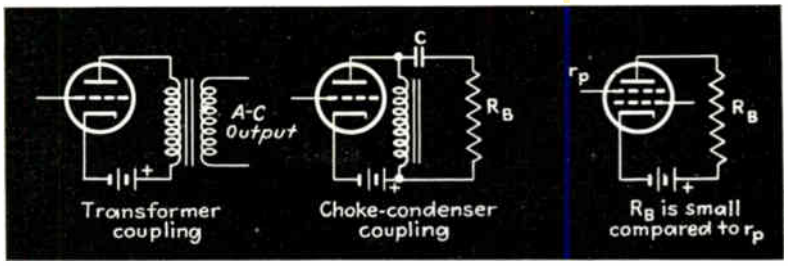


Fig. 5—Ways of avoiding use of high plate battery voltage with resistance loads. The resistance of the choke (center) is low, its inductance high

through a thousand ohms of resistance, 1 volt is lost—it does not appear across the cathode-plate path. Thus if 10 ma flow through 10,000 ohms, 100 volts appear across R_B. If the tube requires 250 volts across the resistance of the tube and if 100 volts are lost across R_B, the plate battery must supply 350 volts.

It is worth noting here that there is but a single source of voltage in the plate circuit—the plate battery. Current from this battery flows through the tube and through the load resistance. The way in which the total plate circuit voltage divides, part appearing across the tube and part across the load, depends upon the relative resistances of the tube and the load but the sum of the two voltages is never greater than the plate battery voltage. When the voltage drop across the load is high due to high plate current, the voltage across the tube is low and vice versa.

Use of high resistance loads which cause large voltage drops which must be supplied by high plate battery voltages can be avoided by: (1) use of a transformer between the tube and the load so that the desired a-c power is developed in the load without the steady plate current having to flow through it; (2) use of a low-resistance inductance through which the direct current flows as in Fig. 5; (3) use of tubes of high intrinsic plate resistance with loads which have resistances lower than that of the tube. Then the tube acts more or less like a constant-current source and variations in load voltage with consequent variations in plate voltage are much less important.

Tube Efficiency. If $R_B = r_p$, the efficiency of the plate circuit is 50 percent since half the power developed will be lost in the tube and half will be usefully developed in the load resistance. Greater efficiency can be had by raising the value of R_B, but less power will be secured thereby unless the plate voltages and currents are increased.

The amount of power that a tube can deliver depends upon how much it can safely dissipate on its own plate and its efficiency of operation. A tube that can safely dissipate 10 watts can also deliver 10 watts to a load at 50 percent efficiency; but at higher efficiencies, higher power can be developed in the load without raising the 10 watt limit in plate dissipation.

In most industrial cases, it is more important to get the maximum power into a load (such as an electro-mechanical relay) rather than to achieve efficiency and in this case the load must be adapted to the tube or vice versa. This means that the resistance of the load should approximate the resistance of the tube. The reduction in power is not very great if the load resistance is greater than that of the tube by 2 or 3 times, but considerable loss occurs if R_B is very much less than r_p.

Where maximum voltage output (contrasted with maximum power output) is desired, R_B must be high compared with r_p if possible. This is not possible with pentode tubes and here R_B should be as high as possible or convenient.

Tubes in Parallel or Push-pull. If more output is desired than a single tube will deliver, two or more of them may be operated in parallel. Under these conditions the effective internal resistance of the tube part of the circuit goes down; and if one

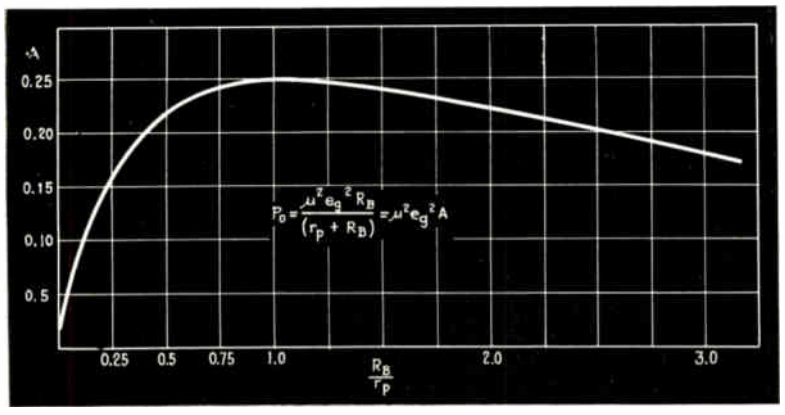


Fig. 6—Power output from an amplifier tube depends upon the relative values of the internal tube resistance, r_p, and the load resistance, R_B. Maximum power output occurs when R_B is equal to r_p

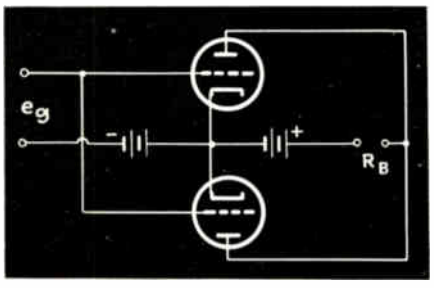


Fig. 7—Use of tubes in parallel to increase output over that obtainable from a single tube

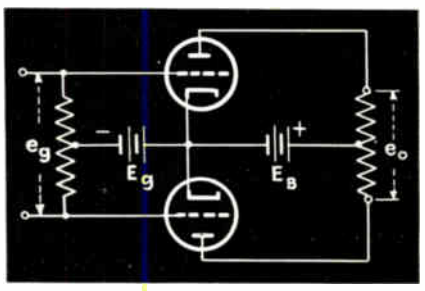


Fig. 8—Push-pull arrangement of tubes decreases harmonic content of output and increases power output over that obtainable from a single tube

tube will deliver 10 watts, two of them will deliver 20 watts—if the output circuit is appropriately changed to take account of the decreased tube resistance.

It is often more economical to use two or more tubes in parallel than using a single tube of greater output power.

Tubes may also be operated in push-pull. More power output may be secured; but the big advantage is the fact that the waveform of the output can be made to resemble more closely the waveform of the original. This is not a matter of great importance to industrial applications, except in unusual cases.

Tubes can also be connected with their grids in parallel and plates in series or with grids in series and plates in parallel.

Use of Tube as Generator. Because a tube will amplify, it will also generate alternating currents from direct currents. A voltage applied to the grid of the tube results in a larger voltage appearing in the output. If a part of this output is fed back into the input in the proper phase, this portion of the input will reappear in the output in amplified form. If the amount of energy fed back is sufficient to overcome all the losses in the input circuit, it will be found that the initial driving voltage applied to the tube from an external voltage supply may be eliminated and the tube will continue to develop power in the load. In practice no external exciting grid voltage need be applied to start oscillations since any small instability (such as mechanical, thermal or electrical change) will set the circuit into oscillation.

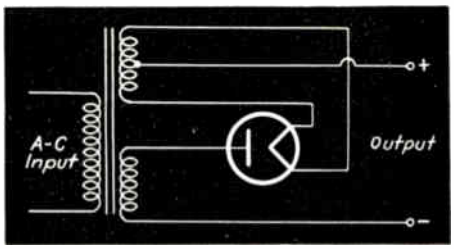


Fig. 9—Simple half-wave single-phase rectifier comprising anode and cathode only. Output load is in series with anode

The tube is now acting as a generator, the frequency of the generated power depending upon the inductance, capacitance and resistance of the circuit elements attached to the tube. The amount of power developed in the load depends upon the tube, the voltages used and the load characteristics.

Alternating currents of practically any frequency, of practically any waveform, or of any power may be produced in this manner. Direct potentials need to be applied to the tube, some sort of energy feedback from output to input must be provided, and as a result alternating currents will be produced.

Tubes can be made to generate oscillations in other ways (dynatron, Barkhausen oscillators, etc.) but these methods are not used industrially at the present time.

Tube as a Frequency Converter. Suppose a tube has two grids and that voltages of different frequencies are placed upon these grids. Now if the plate circuit can be explored with some sort of frequency discriminating detector, two (or more) frequencies will be discovered. If there exists a linear relation between each grid and the output, only the two input frequencies will be detected; but if any non-linearity exists between the input and output, or in the output E_p-I_p curve, then the detector will indicate not only the original input frequencies but others as well. Among the new frequencies found may be the sum and the difference of the two input frequencies.

This is known as frequency conversion, since we convert two originating frequencies into other frequencies with totally different values. This is the principle of the superheterodyne radio receiver; but the principle has some application to laboratory and industrial problems as well. The two voltages can differ widely in frequency or can be alike or very nearly alike in frequency. One can be variable and the other fixed so that a variable frequency, differing from either originating frequencies, can be secured from the converter.

Modulation. If a high frequency and a low frequency are "mixed" properly, the high frequency will act as a carrier for the lower frequency (as in radio or carrier telephone communication). This process is called modulation and can be performed by varying the amplitude, the phase or the frequency of the carrier by the modulating frequency.

Conversely, if two frequencies have been mixed, they can again be separated by going through an inverse process. Thus from a modulated carrier, the modulating frequency can be secured and put to whatever use is desired.

Other Tube Functions. High-vacuum control tubes can also be used as frequency multipliers or dividers to deliver to a load higher or lower frequencies which may or may not be integral multiples of the originating frequency. The number of the output frequencies is practically unlimited.

When properly associated with other circuit elements, the tube can be made to perform an extremely wide variety of useful functions. For example tube circuits can be made to count impulses occurring

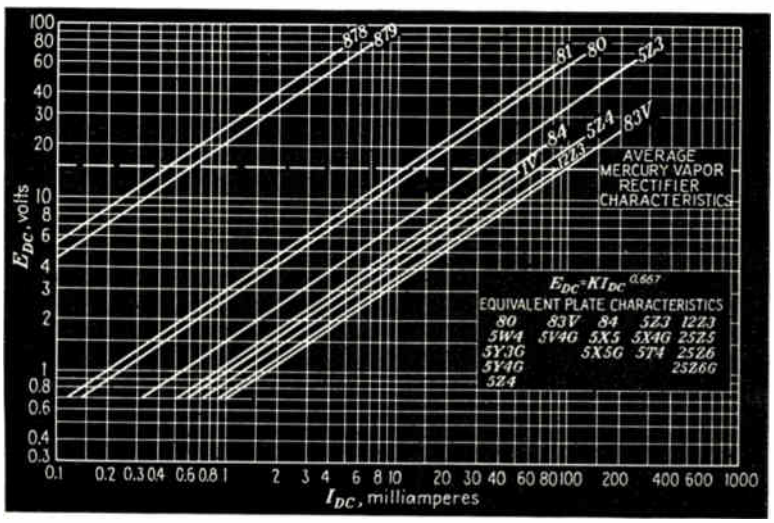


Fig. 10—Current-voltage characteristics of typical rectifier tubes. Current output is proportional to the 3/2's power of plate voltage

much too rapidly for any mechanical counter, to differentiate or integrate mathematical expressions descriptive of electrical, mechanical or other phenomena, can be used as a variable reactance and is widely used through laboratory practices as a measuring tool.

High Vacuum Tube Limitations. The high vacuum tube is a low current-high voltage device. If high currents at low voltages are desired, some other means must be used. Since the tube amplifies, and since a considerable amount of amplification can be secured with a single tube and its accompanying apparatus, care must be taken that the grid or input circuit has impressed on it only the desired voltages and that it be protected from stray fields, such as power line fields, etc. Since the output is a function of the plate voltage, the plate voltage must be steady if a steady output is necessary. If the tube is to amplify (and not to generate oscillations) care must be taken to see that none of the output voltage is allowed to get back into the input circuit in phase with the input voltage.

Rectification

Since the tube conducts current only when its plate is positive with respect to the cathode, an alternating voltage placed between a tube and a load will cause current to flow through the load on the half cycles when the plate is positive. On the half cycles of the alternating voltage when the plate is negative with respect to the cathode, no current will flow in the load. The tube acts as a one-way switch or like a check valve in a pump. This tube phenomenon is called rectification. Only two electrodes are necessary—a cathode to supply electrons and a plate to collect them.

There are two kinds of rectifier tubes, high vacuum tubes and gas tubes. Some rectifiers have control grids in them so that control over the output current is possible. These will be discussed below.

Half-wave Rectifier. In this case a single tube is used and only one half of the a-c cycle is rectified. Current flows in spurts through the load. If continuous current is desired through the load, the output of the rectifier may be put through a filter and then into the load. The filter smoothes out the spurts of current so that the load current resembles that from a d-c source.

The half-wave single-phase rectifier is simple and inexpensive. Its output is relatively difficult to filter and is seldom used.

Full-wave Rectifier. In this case two tubes are used (or a single tube with two sets of elements) and both halves of the a-c cycle are rectified, each tube conducting current when its anode is positive and remaining non-conducting while the other tube conducts. Output from this rectifier is relatively easy to filter and is widely used where currents of 1 ampere at 1000 volts or less are desired.

When a half-wave rectifier works directly into a resistance load without any intervening filter circuit, the average current passed through the load is

$$I_{av} = \frac{0.45\,(V_{rms}) - V_{drop}}{R_L}$$

where V_{rms} is the rms voltage across the power transformer secondary terminals, V_{drop} is the voltage drop across the rectifier tube, for the average current passing through the tube, and R_L is the resistance of the load. V_{drop} is obtained from Fig. 10.

When mercury vapor rectifiers are used, V_{drop} is about 15 volts and is independent of the current drawn from the tube.

In full-wave circuits, the average current is twice that given by the half-wave equation. In this case V_{rms} is the rms voltage between the center tap and one end of the transformer secondary.

$$V_{av} = I_{av} R_L \text{ volts}$$

Polyphase Rectifiers. In polyphase circuits, half- or full-wave rectifiers may be provided for each phase. Such polyphase rectifiers are of considerable industrial application where high power direct current is to be obtained. The output from polyphase rectifiers is often used without filtering, although if filtering is required, this can be carried out relatively easily because the output voltage is relatively high throughout the cycle and because the frequency components to be filtered are higher multiples of the supply frequency.

Voltage Doubler. In this circuit two rectifier units are used. The output voltage is approximately

TABLE I — RECTIFIER CIRCUITS

	Circuit A	Circuit B	Circuit C	Circuit D	Circuit E
Average d-c volts, E_a	0.45 E_{rms} 0.32 E_{max}	0.90 E_{rms} 0.64 E_{max}	1.07 E_{rms} 0.83 E_{max}	1.07 E_{rms} 0.83 E_{max}	2.32 E_{rms} 1.65 E_{max}
Peak volts across tube	3.14 E_a	1.57 E_a	2.09 E_a	2.09 E_a	1.05 E_a
Secondary kva*	1.57	1.11	1.48	1.48	1.05
Primary kva*	1.11	1.11	1.21	1.05	1.05
R-m-s ripple, % of E_a	48	48	18	4	4

Note: Drop through rectifier tubes neglected.
* Per kw power delivered to load, transformer losses neglected.

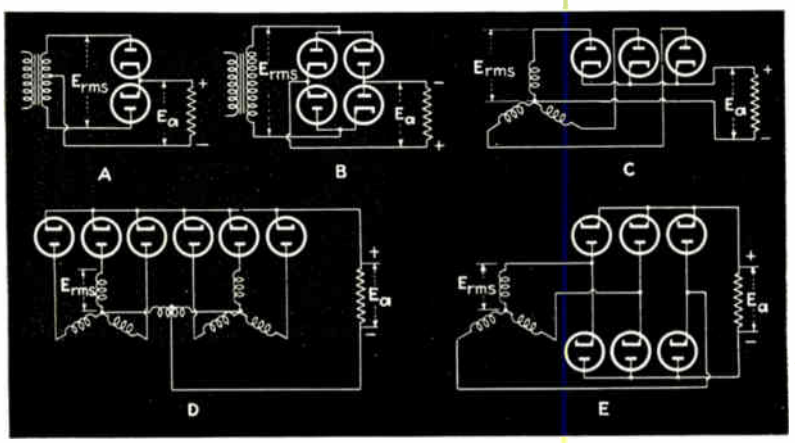


Fig. 11—Several rectifier circuits including. *A*, full-wave single-phase circuit; *B*, bridge arrangement; and *C*, *D* and *E*, polyphase circuits

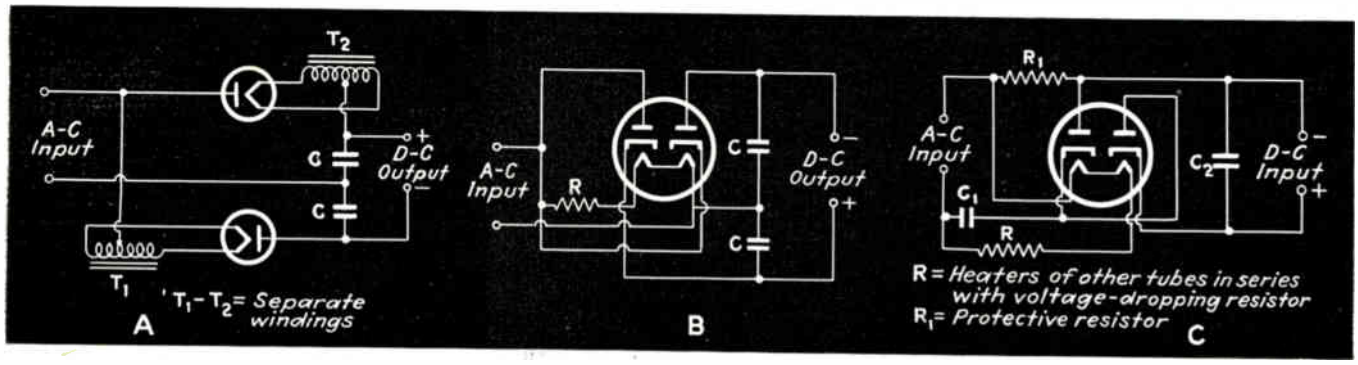


Fig. 12—Voltage doubler circuits. In *A*, separate filament transformer windings are necessary. This circuit is called a full-wave doubler because each tube conducts current to the load on each half of the a-c input cycle. In *B* and *C* both tubes are placed in a single bulb. In *B*, the d-c load cannot be grounded or connected to one side of the a-c supply line. *C* gets around this difficulty but is a half-wave rectifier since rectified current flows to the load only on alternate half cycles of the a-c input cycle

twice the alterating voltage supplied to the rectifier. This is because each condenser (Fig. 12) is charged to the full voltage delivered by the transformer but since the two condensers are in series the total voltage across them is twice that across either.

The voltage doubler is often used where voltages of about 250 are to be obtained from the 110 volt a-c line in the most economical manner. Voltage is fed to the tubes directly from the power line, no transformer being needed. Economy is the reason. This rectifier is also employed in x-ray work where a single tube cannot deliver the required direct voltage output.

Filters for Rectifiers. The smoothing circuits, known as low pass filters, consist of series inductances (or resistance when the current output is small) and shunt capacities. These series and shunt elements tend to maintain the voltage across the output and the current through the output constant, independent of the spurts of current as supplied by the tube. With sufficiently good filtering the output from the filter can be as free from ripple as desired.

Rectifier Applications. The obvious use for a rectifier is to supply direct current from an a-c source. A rectifier, however, can perform other functions than as a source of direct-current power. For example, a d-c meter in the plate circuit of a rectifier will read a current which is some function of the alternating voltage applied to the tube. Thus the tube may be calibrated as an a-c voltmeter by merely placing various known alternating voltages on the tube and noting the rectified current that passes through the meter.

Gaseous Tubes

If a gas, or a vapor such as mercury vapor, is admitted to the tube after all other gases have been pumped out, the characteristic of the tube changes radically. This change in characteristic requires certain changes in the way the tube is used, and enables the tube to perform functions not possible with vacuum tubes.

Gas tubes either conduct or they do not conduct—there is no smooth control of current from zero to the maximum value as is true with high vacuum tubes. When conducting, the voltage drop across the tube is fairly low (15 to 25 volts), fairly constant and independent of current taken from the tube. The current output is limited only by the output load and by the ability of the cathode to supply electrons. Very much higher currents may be supplied by gas tubes than by high vacuum tubes.

Proper Operating Conditions. Since the current during the conducting period is often very high, the cathode may be injured unless means are taken to prevent too great a current flow in case the load should be short circuited. Such means can be a resistance in series with the tube and the load; or an overload circuit breaker or fuse, etc. Furthermore the tube should not be allowed to pass current to the load until the cathode is at the proper temperature. A time delay relay placed between the tube and the load serves this purpose.

Gas tubes are prone to cause radio interference; small inductances in series with the anodes and physically close to them will eliminate this trouble.

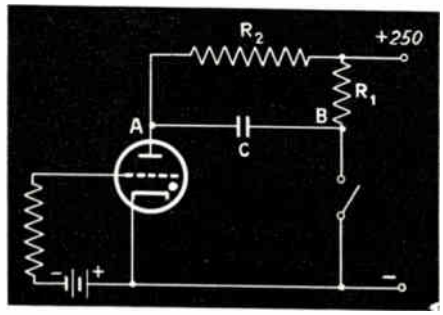


Fig. 13—Control of thyratron tube by suddenly lowering voltage of plate below point at which the tube will conduct

Control-type Gaseous Rectifiers

D-c Operation. Two or more grids in a gaseous rectifier make it possible to control the starting of conduction but not to control the stopping of conduction. In general the only way to stop the tube from conducting is to remove the plate voltage or make it negative. Furthermore a definite time is required for the grid to re-establish control after the plate voltage has been removed. This time is required for the ions to diffuse and leave the vicinity of the grid. This time is of the order of a few micro- or milliseconds and is known as the deionization time. This brief interval between removal of the plate voltage and the establishment of control by the grid limits the frequency of operations the gas tube can control.

In Fig. 13 is shown a simple method of controlling a gas tube. If d-c power is connected to the plate and cathode terminals, and if the

grid voltage is correct, anode current will flow. Removing or changing in any way the grid voltage will not have any effect upon the plate current. If, however, the switch is closed the tube will stop conducting.

When the tube conducts, the drop across it will be of the order of 15 volts. The rest of the line voltage, say 250 volts, is impressed across resistance R_2. Terminal A of the condenser is at the same voltage as the anode (15 volts) and terminal B is at line voltage (250) being charged through R_1. Now if the switch is closed, B becomes zero and terminal A will suffer an instantaneous drop in voltage equivalent to $-250 + 15$ volts or to the value of minus 235 volts. The plate has now, for an instant, become negative with respect to the cathode and conduction ceases. If the time taken to recharge the condenser through R_1 is greater than the de-ionization time of the tube, the grid will regain control and conduction will not start until the grid voltage is again the proper value.

R_1 should be high enough in resistance so that closing the switch does not blow the line fuses or circuit breakers.

If a glow tube (a tube with two elements in a gaseous atmosphere which conducts current only when a certain voltage is impressed across the elements) is placed across the switch terminals, the gas tube can be started and stopped intermittently. As soon as the condenser voltage becomes equal to the voltage at which the glow tube conducts, current flows through the glow tube, reducing the voltage across it sufficiently to cause the plate voltage to become negative. The gas tube goes out, de-ionization takes place, the condenser recharges and when the plate is again at a potential higher than that necessary to cause conduction (as controlled by the voltage on the grid) the tube conducts again, and the cycle is repeated. A 1-microfarad condenser and a 874 glow tube will cut off a 1-ampere current in an FG-67 tube.

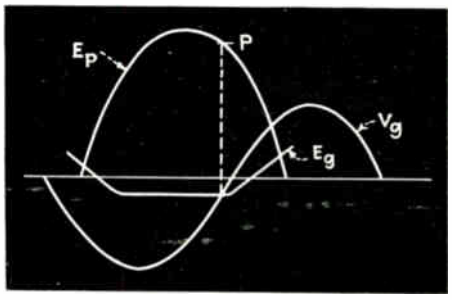


Fig. 14—Control of thyratron by alternating voltages. E_g is the voltage that must be on the grid to start current flow at the value of plate voltage immediately above it. V_g is the control voltage applied to tube. Where E_g and V_g cross, the tube will conduct or "fire"

A-c Operation. If direct voltage is placed upon the grid and alternating voltages upon the plate, conduction will take place whenever the proper relative values of grid and plate voltage occur. If the grid voltage is such that conduction occurs for any positive value of plate voltage, then current will pass through the tube on the entire half cycles which make the plate positive.

If, however, the grid is at such a potential that conduction will not occur at the highest positive voltage placed upon the plate (the peak value of the alternating voltage applied) then conduction will not occur in any part of the positive half cycle of alternating voltage.

Conduction can take place for all of the half cycle or any part of it or none of it, as desired; conduction can be prevented from taking place for all of the half cycle (180 deg.) or for 90 deg. or less than 90 deg., that is, if the tube conducts at all it will do so for 90 or more degrees of the half cycle.

Phase Control. A more elegant way to control the time in the cycle at which conduction begins, and therefore the portion of the half cycle during which conduction takes place is to use alternating voltages on both plate and grid. By adjusting the phase between these two voltages and their relative magnitudes, the average current flowing during a half cycle may be adjusted to any value from zero to the maximum corresponding to conduction for a full 180 deg.

Consider Fig. 14. Here E_p is the anode potential which can have any waveform, and E_g is the grid bias which will just prevent the tube from conducting at the value of E_p shown on the curve. V_g is a sine wave of grid voltage (other waveforms can be used). V_g may be moved along the time axis so that it can be moved into or out of phase with E_p. The tube will fire (conduct) at the earliest point in the cycle at which V_g *crosses* E_g; in the figure point P. By advancing the phase of the grid voltage with respect to the plate voltage, current can be made to pass through the tube for a longer and longer period until the entire 180 deg. is a conducting period. If the grid and plate voltages are out of phase, current does not pass at all. The average current flowing may be found from

$$I_{av} = I_{peak}\frac{(1 + \cos\phi)}{\pi}$$

where ϕ = angle at which tube starts to conduct.

A simple way in which this phase control can be effected is shown in Fig. 15.

The phase-shift method of control is the preferred method, and should be used where a continuous control of power is required. This method permits fixing the time of starting of anode current anywhere in the positive half cycle of anode voltage. The average value of the anode current may be controlled completely from zero to maximum. Some of the more usual methods of obtaining phase shift are (1) an induction phase shifter, such as a Selsyn motor on a polyphase source; (2) capacity-inductance-resistance bridge; (3) by combining two alternating voltages which are out of phase and by varying the magnitude of one of them; (4) by a saturable peaking transformer having a d-c winding and varying the amount of direct current (5) combining an alternating voltage, which is out of phase with the anode voltage, with a d-c bias voltage.

It is good practice to supply the grid with voltages considerably

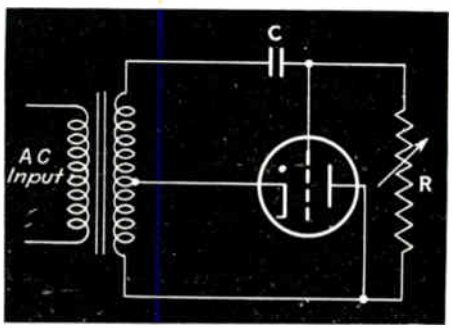


Fig. 15—Method of regulating phase between grid and plate voltages for controlling time in cycle when conduction starts

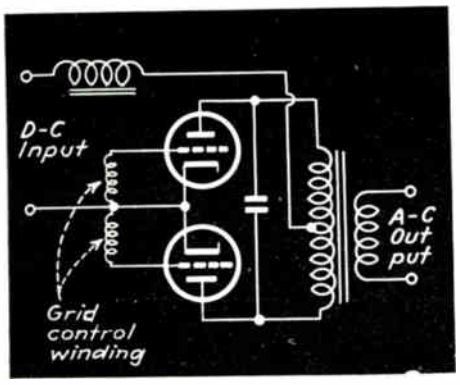


Fig. 16—Elementary circuit showing use of gas triode as an inverter—i. e., a tube which produces alternating currents from a direct voltage input. An actual inverter circuit would be more complex than this

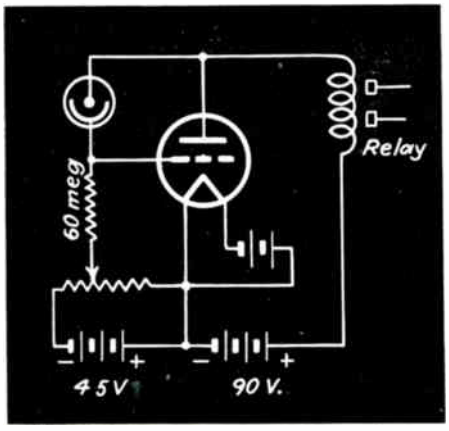


Fig. 17—Simple phototube-amplifier-relay circuit using direct voltages

greater than that just required to start conduction; this practice insures conduction when desired.

Inverter Service. Gas-filled tubes may be used also in tube inverter circuits for conversion of direct current to alternating current. As there are many types of inverter circuits, it is impossible here to do more than cover the fundamental principles.

In all such circuits direct current is applied to the anodes of the tubes and the grid is supplied with the desired frequency, either from an external exciter or by means of coupling with the output circuit. In this respect an inverter may be considered also as an amplifier or oscillator. The function of the tubes is to commutate or, in other words, to perform a switching operation. In all inverters some form of power storage is necessary to supply power during the commutation period, e.g., from static condensers, from a power system, or from rotating apparatus.

The fundamental action of inverters may be illustrated by the simplified, single-phase case of Fig. 16 although, in practice, the larger sizes are polyphase. The anodes of both tubes are positive. Let it be assumed that the grid of the upper tube is positive. Current will flow from the positive d-c source through the transformer to the negative d-c line by way of this tube. The grid of the lower tube is negative and allows no current to pass. The condenser is charged with the potential drop across the output transformer owing to the current flow in the upper half of the winding, the upper terminal of the condenser becoming negative, and the lower positive. Toward the end of the cycle the grids exchange polarity because of reversal of the exciting voltage. This action has no direct effect on the current flow through the first tube, but allows current flow through the second, which in effect connects the lower side of the condenser to the negative lead. This places a negative voltage of short duration on the upper anode, allowing the upper grid to regain control and terminate a half cycle of the a-c output. Corresponding actions in inverse order result in producing the following half cycle of a-c output.

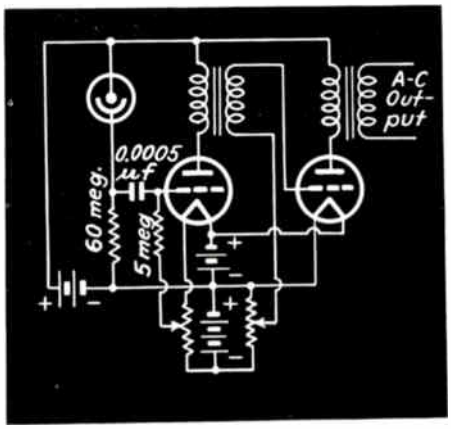


Fig. 18—Phototube circuit useful when alternating voltages secured from a modulated light beam are to be used

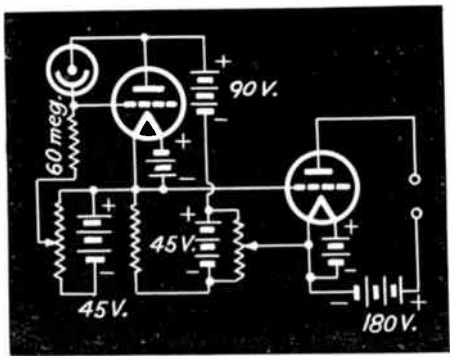


Fig. 19—Circuit useful in amplifying direct voltages. Voltage across resistor in cathode circuit of first amplifier is applied to the second amplifier

Phototube Applications

Phototubes can be used to initiate any electrical control desired by means of light impulses. If the linear relation between light intensity and current output is to be utilized (as in measurements), the tube should be operated with direct voltages; but if a relay is to be operated as a result of a change in illumination intensity (as for door opening, counting, etc.) alternating voltages may be used. In Fig. 17 will be found a circuit useful for d-c operation. Care must be taken to see that the maximum voltage rating of gas tubes is not exceeded.

In Fig. 20 is a typical a-c operated circuit. Since the output of the amplifier is pulsating direct current (rectified current), the relay will chatter unless a condenser is placed across its coil. The variable resistance between amplifier cathode and grid (through the phototube) provides bias; the sensitivity of the circuit may be controlled by varying the capacity of the grid condenser.

If modulated light impulses are to be employed, the circuit of Fig. 18 may be used. This is a straight transformer-coupled amplifier, the only difference being the phototube connection to the first tube. Where direct currents are to be amplified, Fig. 19 is satisfactory. Circuits amplifying direct currents are not as stable as when alternating currents are employed and are to be avoided if possible.

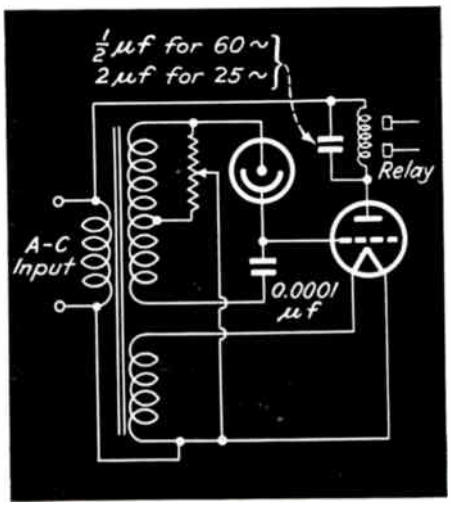


Fig. 20—Alternating current operated phototube relay. The tube rectifies the alternating voltage placed upon it; the voltage appearing across the condenser is then applied to the grid of the amplifier

Light-relay design. The amount of illumination change necessary to cause a tube to close an electro-mechanical relay may be found from

$$L = \frac{E_c}{SR_c} \text{ lumens}$$

Where L is the increment in light falling upon the phototube cathode, required to actuate the relay, S is the luminous sensitivity of the phototube in microamperes per lumen, R_c is the coupling resistance in megohms, and E_c is the increment in grid volts required to actuate the relay. The amplifier current increases if cathode of phototube is connected to the amplifier grid; decreases when phototube anode is connected to amplifier grid.

Cathode-Ray Tubes

Because of their ability to produce a wide variety of traces over a very wide range of frequencies, cathode-ray tubes are extensively used where visual comparisons of electrical operations are to be made, or where the voltages or currents in a circuit are to be examined. The phenomenon to be studied is applied as a voltage to one set of deflecting plates, usually the vertical plates, while some convenient standard of comparison, or a timing wave, is applied as a voltage to the horizontal pair of deflecting plates.

A fundamental circuit for the operation of the cathode-ray tube is shown in Fig. 21 for a tube having electrostatic deflection. This simple circuit is useful for the comparison of two voltages applied to the two pairs of deflecting plates, the image on the screen depending upon the relative magnitudes, frequencies, and phase displacements of the two voltages under comparison. This simple circuit is not suited for the examination of a single voltage or current as a function of time, since no timing wave is provided to form the reference axis.

Many types of sweep circuit generators can be used to provide suitable timing axes, the charging and discharging of a condenser through a gaseous tube forming a very simple and common method. The sweep circuit diagram of Fig. 22 is an improvement over the simple gas tube generators and provides a timing axis which is very convenient for the examination of recurrent phenomena.

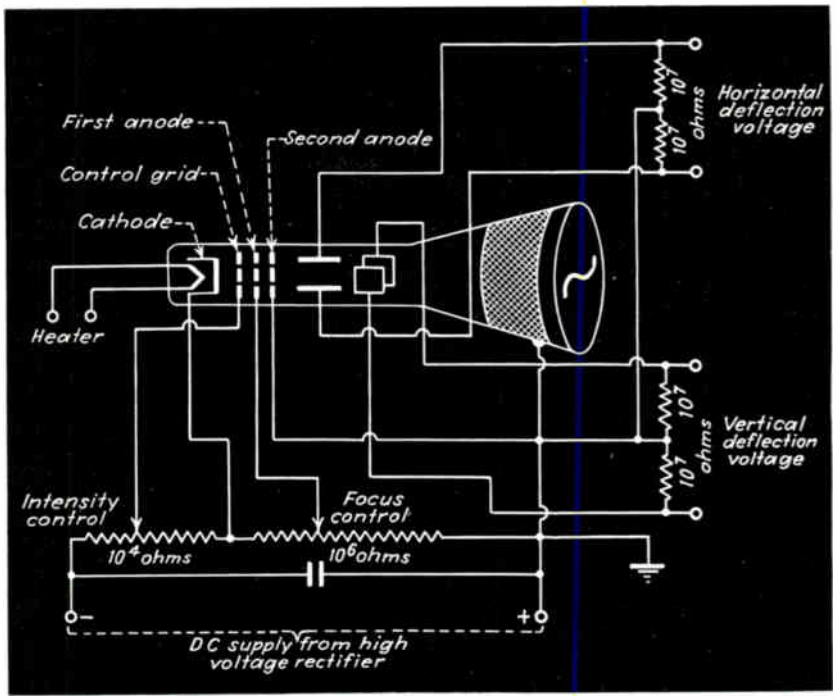


Fig. 21—Circuit arrangement of cathode-ray tube having electrostatic deflection

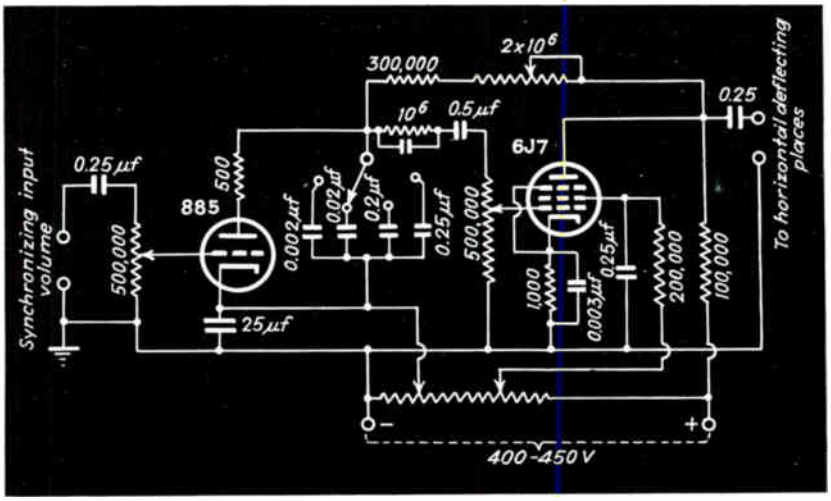


Fig. 22—Sweep circuit generator with amplifier for supplying a cathode ray tube setup with a time basis

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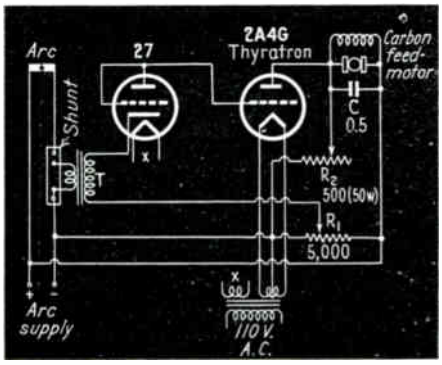
Tubes At Work

Stimulus—ELECTRICAL

Carbon Arc Electrode Feed Control

THE LENGTH OF THE gap between the electrodes of a carbon arc operated on d.c. has a direct bearing upon illumination intensity, steadiness, formation of craters at the positive electrode and the rate at which carbons are consumed. Such arcs are more critical with respect to current density than to voltage across their electrodes, hence current variations may be employed as a source of energy to automatically adjust the arc gap for optimum performance.



Carbon arc electrode feed control. Change in arc current acts to speed up or slow down the drive motor as carbons burn away and so automatically maintains the most efficient spacing

Where the source of d.c. operating the arc is pulsating in character, as from an unfiltered half-wave rectifier, the circuit shown provides suitable control. A heavy shunt having a value sufficient to produce 10 millivolts drop across the primary of transformer T is connected in series with the power supply feeding the arc. The secondary winding of T delivers 25 volts to the type 27 tube used as a diode rectifier and d-c voltage developed by this rectifier is applied as negative bias to the grid of the 2A4G thyratron.

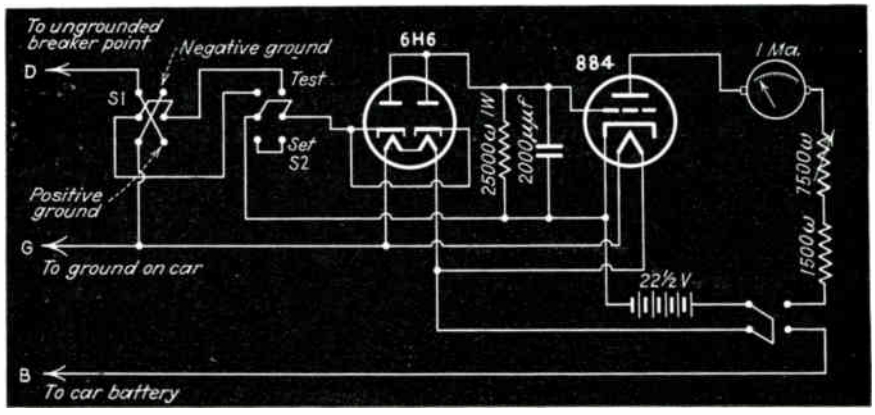
The arm of R_1 is rotated to the most negative point and, with the arc burning, R_2 is adjusted until the carbon-feed motor driving the electrodes closer together as the carbons are consumed, is just barely turning over. R_1 is then varied until the arc assumes its most efficient length, held at this position until the carbon crater forms and is then re-adjusted for optimum arc length. Thereafter, any increase in arc current caused by too rapid carbon feed develops a higher negative bias on the grid of the thyratron, cuts this tube off and slows down the feed motor. Conversely, any decrease in arc current speeds the motor up.—Flaherty, ELECTRONICS, March, 1942, p. 65.

Auto Distributor Point Checker

ADJUSTMENT OF AUTOMOBILE distributor point spacing by means of a feeler gauge does not insure optimum ignition system performance in high-speed engines. Sparking voltage is dependent upon current flowing in the primary of the ignition coil at the moment the points break and the value to which current may build up is limited by the length of time the points are closed between breaks. The device diagrammed provides a visual indication of the percentage of time points are closed. Its meter may also be calibrated to indicate distributor point driving cam angle, the method of checking preferred by the automotive industry. Voltage developed across a condenser and then discharged supplies motivating energy.

Input terminals D and G are connected across the condenser placed in parallel with the points by the automobile manufacturer to minimize point burning. When the points are closed, or switch S_2 is in the "set" position so that the meter may be adjusted to full scale by varying the 7,500 ohm resistor, the input to the 6H6 rectifier tube is short-circuited and no current flows in the 25,000 ohm resistor constituting the load for this tube. The grid of the 884 thyratron, connected to cathode through this same resistor, receives no bias voltage and the 22½ volt battery potential initiates a discharge and causes anode current to flow through the meter.

When the distributor points open, an oscillation voltage appears across the condenser in parallel with the points. Voltage appears across the input to the 6H6, rectified current flows through the 25,000 ohm resistor and a voltage drop appears across it. The grid of the 884 receives a large negative bias voltage sufficient to stop discharge and cut off anode current flowing through the meter. Ionization of a thyratron operating on d.c. may be stopped in this unconventional manner provided current flowing in the anode circuit is limited as, in this case, by the 7,500 and 1,500 ohm resistors.



Distributor point checker. It draws only two to three ma from the ignition system to which it is connected and spark intensity is not affected by this negligible primary circuit loading

IN Sections I and II of this discussion of tubes as applied to industrial problems will be found first, a treatment of the several types of tubes used and their characteristics, and second, how these tubes are integrated into electrical circuits; i.e. how tubes act as amplifiers, as rectifiers, as energy converters, etc., and how tubes are associated with relays, resistances, capacitances and other electric or mechanical equipment.

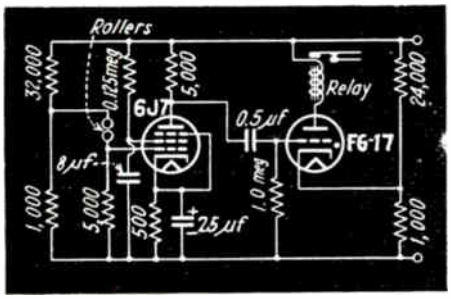
In Section III will be found many typical examples of how tubes are used in industry. No pretense is made that the following pages cover the entire field of electronics in industry. Only a dictionary-sized book could do that. This third section is intended as an idea stimulator; as a place to look when the engineer seeks ways in which tubes might solve problems. Although the applications are specific, the basic phenomenon back of each one of them may be applied in many other ways.

The applications are divided into three major divisions so that the reader may more easily find what he is looking for. These divisions are arranged according to the control stimulus that is available to make the tube perform its job. Thus there are applications depending upon an electrical stimulus; upon a physical or chemical stimulus; and upon a light stimulus. In each case the basic phenomenon is outlined, sufficient detail is given to explain the use to which the tube is put, and a reference tells where the reader may find more complete data.

Extinction of the thyratron discharge does not occur simultaneously with the opening of the distributor points but is slightly delayed. This delay is capable of introducing considerable measurement error. The error is made negligible by the inclusion of the 2,000 $\mu\mu$f capacitor, which delays initiation of the discharge when the points close by approximately the same amount.—Eltgroth, ELECTRONICS, April, 1942, p. 34.

Pinhole Detector

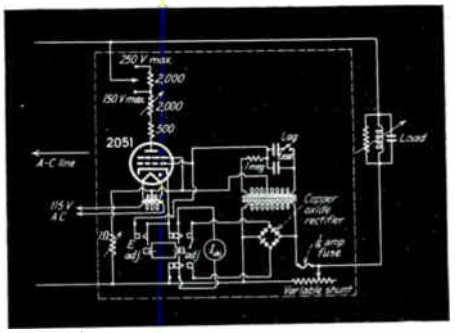
RUBBERIZED CANVAS sheeting is passed between two rollers which are saturated with a conducting liquid. Each roller is connected to the grid circuit of an over-biased amplifier. If there is even an extremely small pinhole in the canvas, the conducting liquid will penetrate it and form a conducting path through the canvas. Thus, a positive voltage, whose value is determined by the voltage divider made up of the 32,000-ohm, the 1,000-ohm, the 5,000-ohm resistors and the conducting liquid between the rollers, is applied to the grid of the pentode. This reduces the bias on the grid and permits an anode current to flow for an instant. This impulse is passed on to the grid of a gas triode which then actuates a relay. The relay operates an alarm or a marking device to locate the defect. This circuit must be operated on a.c. with one side grounded so that the grid of the gaseous triode can gain control after each operation.—*Electronic Engineering* (London), July 1941.



Pinhole detector circuit diagram. This instrument will sound an alarm or mark the location of the pinhole

Power Factor Meter

THIS METHOD OF MEASURING power factor involves the use of a thyratron whose anode current is a function of the phase angle between a voltage and a current. Line voltage, or a voltage having the same phase as the line voltage, is applied to the anode and another voltage whose phase is the same as the load current is applied to the grid. The grid voltage is obtained by passing the load current through a resistor and passing the voltage across the resistor through a step-up transformer to attain the proper value. Since conduction in a gaseous tube cannot ordinarily be stopped by increasing the negative potential of the control grid, lagging power factors cannot be measured because all such factors would give the same indication on the anode current meter. To overcome this an adjustable phase-shifting network is employed in the grid circuit so that any point, preferably the midpoint, of the meter scale may be used to indicate unity power factor with lower anode currents to indicate lagging power factors and higher anode currents to indicate leading power factors. In some cases



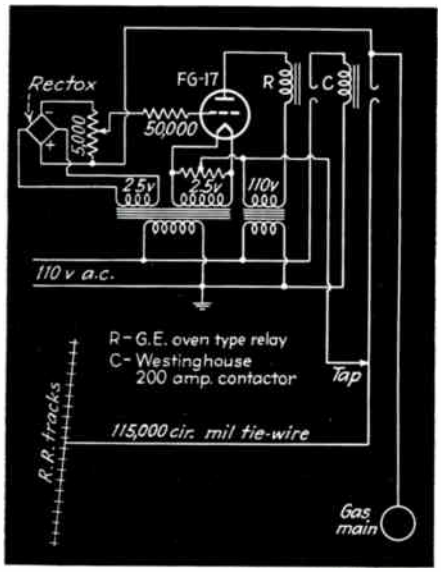
Power factor meter circuit diagram. The anode voltage is in phase with the line voltage and the grid voltage is in phase with the load current. The average anode current is a measure of the phase angle between the load voltage and current

it may be desirable to have the unity power factor points at different points of the scale. This may be done by proper selection of the condensers of the grid phase shifting networks. The anode current is rectified by a copper oxide rectifier and a d-c meter is calibrated in power factor. The same meter may be used for measuring both the rectified anode current and the a-c grid voltage.—Bereskin, ELECTRONICS, October, 1941, p. 38.

Anti-Electrolysis Relay

WHEN A GAS MAIN IS located close to an electric railway, stray currents from the railway frequently damage the main by producing electrolytic action and corrosion. Damage is done when the main is at positive potential with respect to the rails, causing a current flow from rails to main. It may be avoided by using a directional relay circuit such as the one illustrated which employs a thyratron tube.

When the rails are positive with



Anti-electrolysis relay. This circuit protects a gas main by preventing current flow from electrified railway tracks to main

respect to the gas main, voltage from the tie-wire tap bucks the fixed bias supplied to the grid of the FG-17 by the Rectox unit, making the grid of the tube less negative with respect to the cathode. The tube conducts and anode current closes relay *R*, which closes contactor *C* and permits current to flow from main to rails. Reversal of external voltage polarity produces an increase in negative bias on the tube, causing it to cease conducting and opening up the tie-wire circuit between main and rails.—Davis and Wainwright, ELECTRONICS, March, 1942, p. 72.

Electrostatic Powder Separator

CERTAIN DRY, POWDERED materials may be separated from each other by electrostatic action. In the chemical field, for example, among the materials which may be separated in this manner are sphalerite and iron pyrites, graphite and mica, biotite micas and muscovites, garnet and metal particles. These have essentially different electrical characteristics and this difference provides a means of attack.

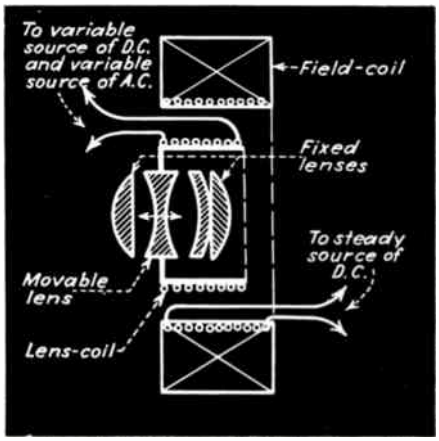
The materials electrically unlike to be separated are passed over or between electrodes charged to about 15,000 volts d.c. One material picks up and retains a charge in its passage over or between electrodes sufficient to cause it to adhere to an electrode. The other material flows unimpeded through the separator to a collecting hopper. High voltage d.c. to operate such separators is readily obtained by stepping up a-c power line voltages through suitable transformers and then rectifying electronically.—ELECTRONICS, January, 1942, p. 58.

Remote Control of Camera Focus

IF ONE OPTICAL element of a complex photographic lens system is substituted for the conventional cone of an electro-dynamic loudspeaker, focus of the lens system may be adjusted by electrical remote control.

A constant d-c potential is fed to the field-coil of the unit. A variable source of d.c. is connected to the coil carrying the movable optical element. By altering the lens-coil potential and/or polarity this coil may be caused to assume various positions with respect to the field coil, hence the movable optical element may be made to assume various positions with respect to the fixed lens elements.

If a.c. is also fed to the lens coil



Electronically controlled lens of a motion picture camera. The principle appears to have possibilities for use in connection with other optical devices

this coil may also be caused to oscillate back and forth about an axis, the speed of oscillation being dependent upon the frequency of the supply voltage and the distance of travel being dependent upon its amplitude. If the lens system is designed so that changes in focal length do not result in changes in image size, lens element oscillation can materially increase the depth of focus. The source of a.c., variable with respect to frequency and amplitude, may be a vacuum tube oscillator.—MacDonald, ELECTRONICS, March, 1942, p. 44.

Precipitator for Matter Suspended in Gases

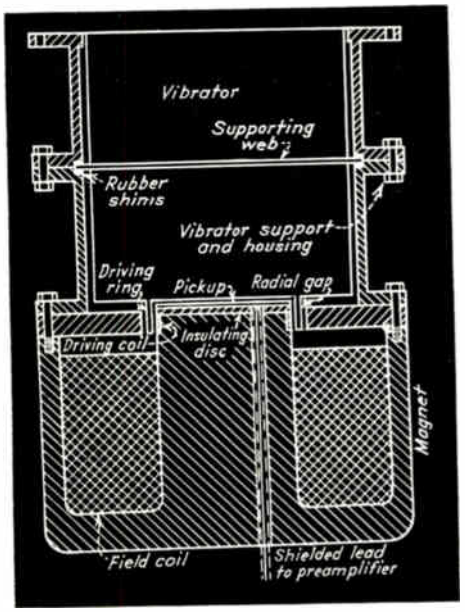
IT IS KNOWN THAT suspended matter in smoke, fumes or fog can be flocculated, or caused to form clouds or masses which precipitate, by high frequency sound vibrations of the order of 17,000 cps. This knowledge has distinct industrial possibilities but one stumbling-block is the design of sound generators which will develop sufficient power for the purpose.

One experimental generator comprises a solid cylinder of duralumin supported in an open-ended housing by an annular web or ring which is an integral part of the cylinder and extends out from its mid-section. A driving ring electrically equivalent to a single-turn coil, also made as an integral part of the cylinder and at its bottom end, projects into the radial gap of a pot magnet energized by a field coil. The ring is inductively excited by an adjacent driving coil. The unit thus resembles a dynamic loudspeaker in construction, the duralumin cylinder taking the place of the conventional diaphragm or cone and the "voice-coil" being driven inductively to eliminate frictional damping.

The cylindrical duralumin cylinder is designed to vibrate at one critical frequency and is an extremely efficient device for translating electrical energy into high frequency sound at this frequency. Efficiency is so critical with respect to frequency, in fact, that it is desirable to use the sound generating device itself as a frequency control element for the electronic equipment which supplies driving power. This is done by placing a small disc of metal on the top of the pot magnet and insulated

from it by a thin disc of Bakelite. This disc, in conjunction with the closely adjacent bottom end of the duralumin cylinder or vibrator, serves as a condenser microphone connected to the input circuit of an associated amplifier. It will thus be seen that the overall equipment operates as a mechano-electronic oscillator, a.c. generated by changes in spacing between the plates of the condenser microphone energizing the amplifier at the resonant frequency of the duralumin cylinder and supplying power for the operation of the sound generator at that frequency.

Amplifier power output used in recent experiments has been about 200 watts. Overall translator efficiency of the order of 30 percent or more has been obtained.—St. Clair, *Review of Scientific Instruments*, May, 1941, p. 250.



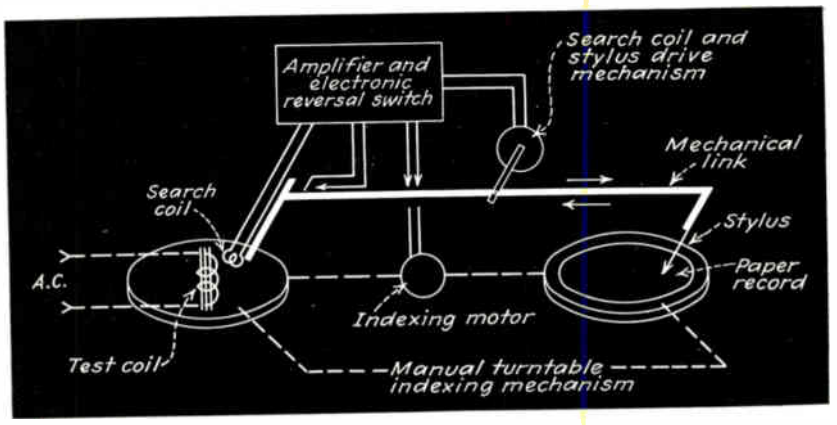
High-frequency, high-power sound generator. Critically resonant, it serves as its own frequency controlling source

Magnetic Field Plotter

THE MAGNETIC FIELD PATTERN of coils may be automatically plotted on paper records by means of the device illustrated here in elemental form.

The coil to be tested is fastened to the center of the turntable shown at the left and energized by a.c. Both turntables are held still and the search coil-recording stylus drive mechanism is started, causing the search coil to approach the center of the test coil turntable while the recording stylus approaches the center of the recording turntable. During this period the recording stylus draws a line from the periphery of the paper disc toward its center. At a point determined by the strength of the test coil field and by the sensitivity adjustment of the amplifier sufficient voltage is induced into the search coil to trip the electronic reversal switch and the mechanical link returns both search coil and recording stylus toward the peripheries of their respective turntables. When the peripheries are reached a mechanically actuated limit switch starts a motor which turns both turntables simultaneously to the next index position, stops them and then starts search coil and stylus once more toward the centers of the turntables.

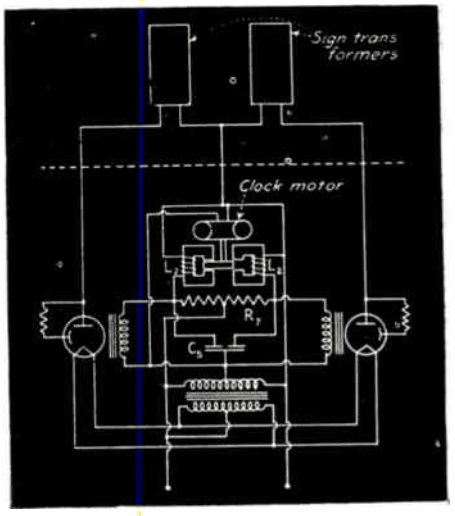
It will be seen that when this cycling process has been completed for every index position around the entire 360 degrees of turntable rotation the configuration of the test coil field may be determined by noting the shape of the pattern formed by the inner ends of the lines drawn on the paper record. In practice, the stylus of the field plotting device may be a fine metal wire and the paper record may be of high resistance metallic material. If a spark is caused to arc through the paper record at the instant the search coil reaches its innermost point of travel and no record trace is made except at this instant field configuration may be determined as before and the record may be re-used for other positions of the test coil or other test coil plots. It is also practical to energize the test coil with d.c. if the search coil is arranged so that it rotates at a constant and high rate of speed, rotation of the search coil providing the a-c impulses necessary for operation of the amplifier.—Weiller, ELECTRONICS, May, 1942, p. 52.



Automatic coil field plotting machine in elemental form

Fader for Neon Signs

THE BRILLIANCY OF neon signs cannot be effectively reduced by cutting down the a-c voltage applied to them by conventional means, such as tapping down on the transformer secondary or introduction of a primary circuit "losser", since ionization producing the characteristic glow will cease before the voltage has been dropped enough to produce perceptible dimming. Brilliancy may, however, be reduced by varying the time in each cycle during which voltage is applied. This amounts to reduction in effective a-c voltage but if a gaseous control tube is used in the primary of the sign transformer to accomplish it the surge voltage introduced by the sharp starting charac-



Fader circuit for neon signs, using Permatron magnetically controlled tubes

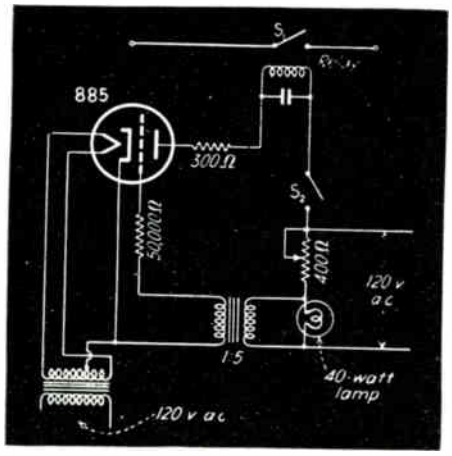
teristic of the tube will be sufficient to ignite the sign even at low brilliancy levels.

The figure shows a method of fading a neon sign of one color into a neon sign of another color. Permatron tubes are magnetically controlled by a phase-shift circuit consisting of reactors L_2 and resistor R_7. The inductance of the reactors is periodically varied in opposite sequence by a synchronous motor-driven cam which moves iron in and out of the gaps in the reactor cores. The amount of inductance in the reactors at a given instant determines the amount of voltage magnetically applied to the Permatrons and therefore controls conduction.

Condenser C_5 resonates the control coils to reduce the load on the phase-shift circuits.—Overbeck, ELECTRONICS, April, 1939, p. 25.

Overvoltage Relay

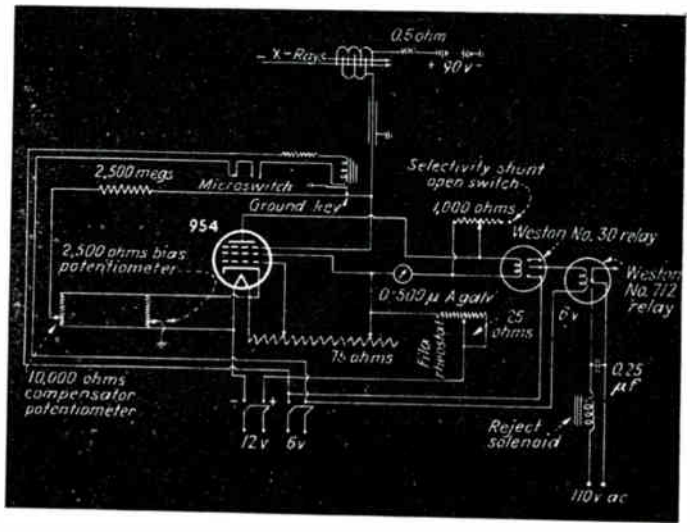
EQUIPMENT MAY BE protected against overvoltage by a relay making use of a gaseous triode. The line voltage is applied to the anode in series with an electromagnetic relay and a portion of the line voltage is reversed in phase and reduced (in a transformer) to a point near the critical grid voltage for application to the grid. The circuit is shown in the accompanying diagram. A voltage divider consisting of a 400-ohm rheostat and a 40-watt incandescent lamp is connected directly across the line and a step-down transformer is connected across the lamp. The secondary of the transformer applies voltage, its phase reversed, between the cathode and the grid. When the line voltage increases, the grid voltage increases in a negative direction and, at a point determined by the setting of the rheostat, will cause the type 885 tube to cease passing current thereby de-energizing the relay and opening the line switch. The purpose of using the lamp is to magnify the voltage increase somewhat because of the temperature-resistance characteristic of the filament.—Kretschmar, ELECTRONICS, February, 1941, p. 48.



This overvoltage relay reverses the phase of the line voltage, reduces it to a voltage close to the critical grid voltage of a type 885 gaseous triode, and applies it to the grid to control a power line relay

Checking Internal Soldered Joints

THE QUALITY OF THE internal soldered joints between the handle and the tang of a table knife is checked by the degree of absorbtion of x-rays in joint (depends upon the amount of lead present) at the factory of Oneida, Ltd. If such a joint is satisfactory, the x-rays will be almost entirely absorbed, but if the joint is imperfect, x-rays will pass through the knife and into a chamber where the air will be ionized to some degree. If a pair of oppositely charged electrodes are placed within the chamber, a very small current will flow because of the migration of ions to the electrodes. In this particular case the amplitude of the current is of the order of 10^{-9} (one billionth) ampere. To make this current useful in rejecting a defective knife, a vacuum tube amplifier of unusual design is used. A type 954 acorn tube with low voltages applied to the electrodes is used. The plate voltage is 7.7 v and the voltage on the first grid is positive. The filament, however, operates at normal voltage. The ionization current is passed through a 2500-megohm resistor and the resultant voltage is applied to the suppressor grid. This causes a larger current to pass through the tube and to operate a relay in the plate circuit. A second relay actuates the reject solenoid. This device is capable of testing table knives at the rate of 1400 per hour.—Woods and Kenna, ELECTRONICS, April 1941, p. 29.



Circuit diagram of the amplifier used to increase the current through the ionization chamber from a value of 10^{-9} ampere to a level which is capable of operating relays and a solenoid

Resistance Welding Control

RESISTANCE WELDING may theoretically be accomplished by connecting welding electrodes to the low-voltage, high-current secondary of a welding transformer and supplying the primary of the transformer with a.c. This would be equivalent to using the upper part of the circuit shown in the accompanying figure, including the connection indicated as a dotted line and excluding everything beneath this line. In practice, satisfactory welds could scarcely be made in this manner due to variations in the resistance of metals to be welded. Extremely low resistance, for example, would permit all the current available from the line and passed by the transformer to flow through the work, with the result that either the work or the electrodes or both would burn up. Some method of controlling the amount of current flowing through the work, or the time during which current flows, or both, is required.

In the basic circuit shown, one leg of the a-c supply line is broken and

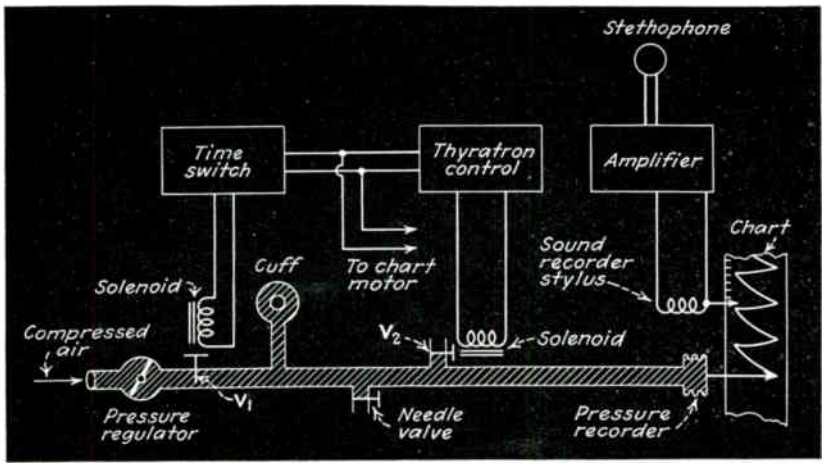
(*Continued on page 98*)

Blood Pressure Recorder

WHEN BLOOD PRESSURE is determined by a physician an inflatable cuff is placed around the arm of the patient and a stethoscope is applied below the cuff. The pressure in the cuff is raised above systolic pressure (heart contracted) and allowed to fall gradually. When pressure in the cuff is slightly below systolic pressure the arterial walls slap together rhythmically and produce sounds which may be heard in the stethoscope until cuff pressure falls below diastolic pressure (heart relaxed), at which time the sounds cease.

Systolic and diastolic blood pressures may be recorded automatically. An air pressure recording instrument is substituted for the gage. A contact microphone or stethophone is substituted for the stethoscope and drives an amplifier, the output of which operates a pen which makes intermittent marks on the edge of the pressure chart so long as sounds are present as outlined above. Thus the physician need not listen for blood sounds but may merely note recorded cuff pressures at points where blood sound stylus marks start and stop.

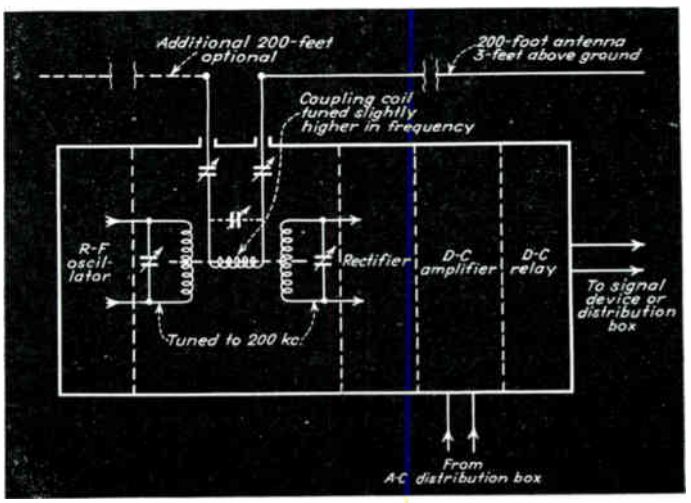
Recent refinements eliminate the necessity for manipulating the air valves and repeat measurements are made automatically at intervals of a few seconds or minutes. A motor driven switch opens and closes intake valve V_1 at required intervals. A thyratron tube circuit opens and closes outlet valve V_2, starts and stops movement of paper through the recording instrument, controls circuit timing.—Gilson, ELECTRONICS —May, 1942, p. 54.



Blood pressures are recorded using an air pressure and sound pressure actuated styli. Cycling of the device is accomplished by electronic control

Capacity Burglar Alarm

IF A WIRE OR ANTENNA is stretched out a few feet above the ground on insulated supports there will be a definite electrical capacity between that wire and the ground. Movement of a foreign body into the field of the wire will increase antenna-to-ground capacity. Weeds growing up beneath the wire, change in ground conductivity due to moisture or formation of ice on the wire will also increase capacity, producing a false alarm unless the circuit is designed to be insensitive to relatively slow capacity changes.



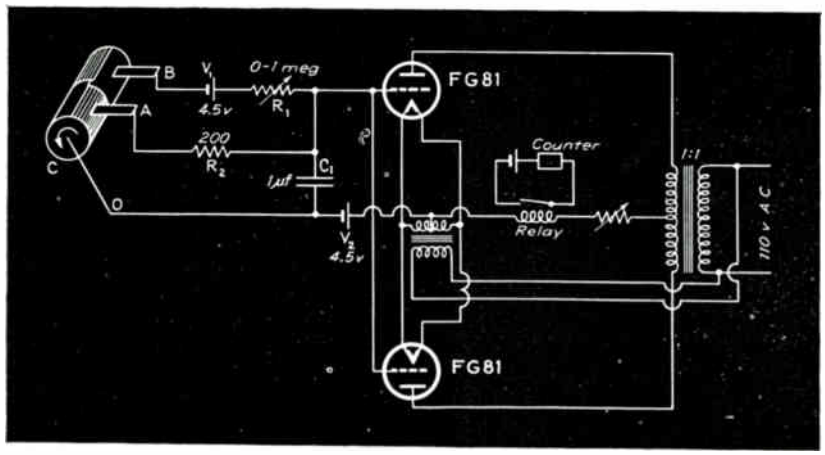
Block diagram of capacity operated alarm designed for outdoor boundary protection service. It employs a circuit minimizing effects of relatively slow changes in capacity caused to growing weeds and by rain, ice and snow

One effective method of accomplishing the above objective is illustrated in the block diagram. A radio-frequency oscillator is tuned to a given frequency and coupled through an intermediate coil to a rectifier tuned to the same frequency. The intermediate coil forms part of the antenna circuit and is tuned to a frequency slightly higher than that of the oscillator and rectifier. The d-c output of the rectifier is amplified, delivering current to the signalling relay only when it receives sharp pulses of input voltage. Slow input voltage changes leak off the coupling capacitors to ground through the amplifier grid resistors before voltage can build up sufficiently to trip the relay.

When an intruder enters the field of the antenna, increased antenna-to-ground capacity is reflected back into the antenna coil. This intermediate coupling circuit more closely approaches the resonant frequency of the oscillator and rectifier, coupling between oscillator and rectifier is increased and the d-c amplifier receives a sharp pulse of input voltage. Or, if the designer so desires, the circuit may be arranged so that when the antenna approaches the resonant frequency of the oscillator sufficient power is absorbed from the oscillator circuit to "rob" the detector of input power and produce a sharp decrease in input voltage to the d-c amplifier. Either method of coupling will actuate such an alarm.—Mac Donald, ELECTRONICS, February, 1942, p. 38.

Hydraulic Flow Indicator

MANY INDUSTRIAL PROCESSES require continuous indication of the rate of flow of a liquid. Others require only



Hydraulic flow indicator. It counts when commutator rotation speed is sub-normal

that sub-normal rates of flow be indicated. This electronic device operates a counter when liquid flow is sub-normal. The portion of time in a given period in which flow is sub-normal may be calculated.

Commutator C is rotated by the flowing liquid in any desired manner. When it is in the position shown, thyratron tube grids are biased sufficiently negative with respect to cathodes by battery V_2 to prevent flow of anode current through the counter. As the commutator rotates, brush A breaks contact with C while brush B makes contact with C. In this position battery V_1 charges capacitor C_1 through variable resistor R_1. If the voltage across C_1 reaches a value sufficient to "neutralize" the negative bias supplied by V_2 the thyratrons fire and their anode current operates the counter.

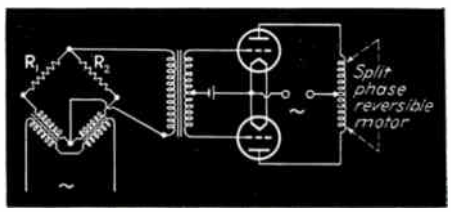
The time required to charge C_1 is dependent upon the resistance of R_1. To adjust the instrument the commutator is rotated at normal speed and the value of R_1 is set so that the thyratrons are on the verge of firing. If the commutator rotates faster than normal, brush B is in contact with C so short a time in each rotation cycle that the thyratrons cannot fire under any anode voltage condition. Should the commutator revolve slower than normal, however, C_1 charging time is increased so that the tubes fire and the counter operates once each cycle so long as sub-normal liquid flow continues.—Ware, ELECTRONICS, October, 1940, p. 36.

Liquid Level Indicator

WHERE THE LEVEL of a liquid having appreciable electrical conductivity must be continuously measured or recorded and it is desirable that the measurement equipment introduce a minimum of physical disturbance at the surface of the liquid the operating principle of the device shown will be found useful.

The resistance between a sharply pointed metal electrode and the surface of the liquid is used as the variable arm of a bridge circuit energized by a.c. The resistance of the variable arm is dependent upon the area of the metal electrode contacted by the liquid; therefore bridge output voltage is proportional to unbalance caused by rise or fall in liquid level.

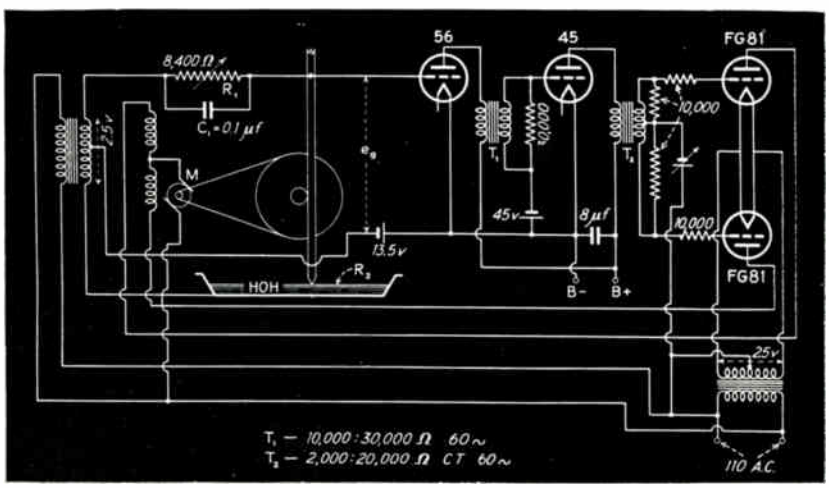
Bridge output voltage is amplified and applied to the grids of two thyratron rectifier tubes whose anodes are operated from the same a-c source that drives the bridge. Thyratron grid-anode voltage phase relationship as controlled by the bridge output voltage permits only one thyratron to fire under a given set of operating conditions, the tube fired depending upon the phase of bridge output voltage. If R_1 is greater than R_2 one thyratron rectifier fires and the other remains idle while if R_2 is greater than R_1 the first thyratron cuts off and the second thyratron fires. The metal electrode of the device is geared to a split-field electric motor. One thyratron rectifier supplies d.c. to one of the motor field windings while the other thyratron supplies d.c. to the second field winding. Circuit connections are such that a falling liquid level causes the metal electrode of the device to be driven down toward the liquid surface while a rising liquid level causes the metal electrode to be raised until the bridge balances. Just the tip of the metal electrode touches the liquid surface due to follow-up action.



Fundamental circuit often used for controlling direction of rotation of a motor by means of a phase-shifting bridge

Mechanical movement of the metal electrode may be used to move a level-indicating stylus or to actuate a continuous recorder.—Ware, ELECTRONICS, March, 1940, p. 23.

(*Continued on page* 102)



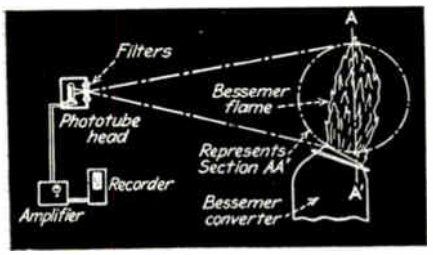
Liquid level indicator. A metal electrode touching the surface of the liquid follows the surface closely as level rises or falls

Stimulus—LIGHT

Control of Bessemer Converter

INVESTIGATION OF THE LUMINOUS energy content of the flame of a Bessemer converter has shown that the quality of the steel produced bears a direct relation to the history of the flame. A record is made by photoelectric means at the steel plant of the Jones and Laughlin Steel Corp. in Pittsburgh, and this record is used in controlling the operation of the converter.

The phototube unit is located in this particular case about 60 feet from the converter and is so arranged that light from other sources do not affect its operation. Suitable filters are used to emphasise the characteristics of the flame which are most important to the characteristics of the steel being produced.



Arrangement of the photoelectric equipment in relation to the flame of the Bessemer converter

In the graph point *A* is the start of the blow and the direction of increasing time is from right to left. *A-B* is called the silicon blow because a large part of the silicon content is burned out during this period. The portion *B-E* is called the carbon blow for similar reasons. The maximum height represents the metal temperature and gives an indication of the nitrogen content of the steel. Near the end of the blow the intensity of the flame dies down and the point where this occurs is referred to as the end point because it has served to indicate when the blow should be turned down. Point *F* is generally called the flash back and is caused artificially or by the flame inpinging against the shield on the wall of the building. This is a valuable reference point for checking the after-blow and a special effort is made to select a filter combination on the phototube housing that shows this clearly.—Work, ELECTRONICS, June 1941, p. 124.

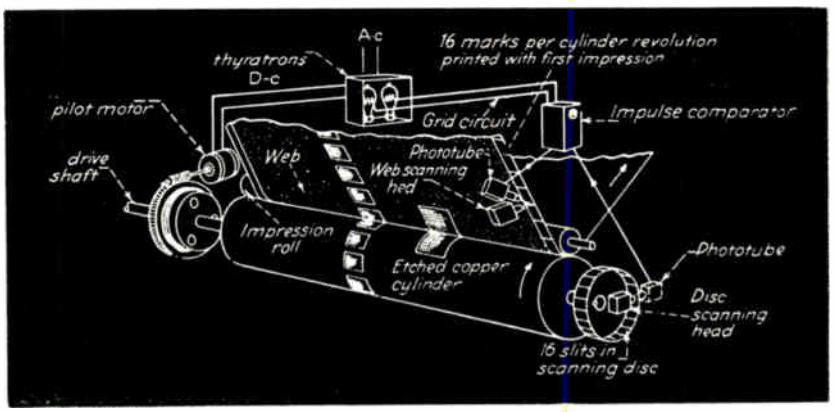
Register Control

COLOR PRINTING BY the rotogravure process requires precise control of register, i.e., successive color impressions must line up. Perfect register is difficult to achieve due to variations in the speed of motors and sag or tension in the paper. It is facilitated by electronic control, one example of which appears here.

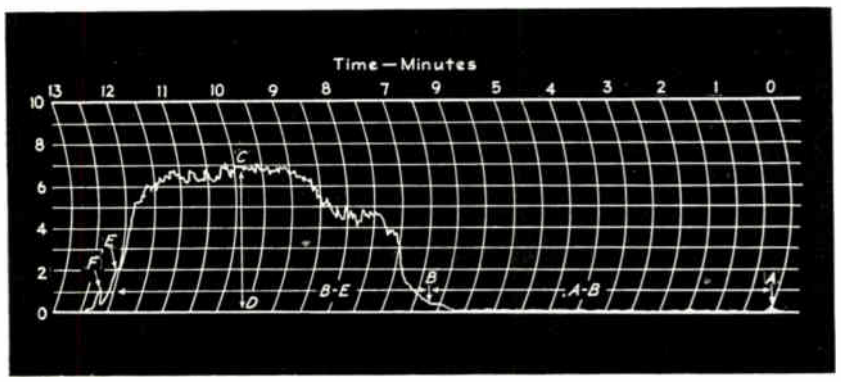
In brief, register marks are printed at regular intervals along a margin or fold of the paper web by the cylinder making the first color impression. As the web passes over the cylinder making the second color impression these marks are scanned by a light source and phototube. To one end of the cylinder making the second color impression a disc having slots comparable in number and spacing to the register marks is simultaneously scanned by another light source and phototube. The output of both scanning units is then passed to an impulse timing comparator.

When successive color rolls are operating in exact synchronism and the paper web has not sagged or tightened between cylinders impulses from the two scanning heads arrive at the comparator at the same time and, it might be said, neutralize each other. If impulses from the paper web scanner arrive too early or too late in relation to impulses from the slotted disc at the end of the cylinder a thyratron-controlled pilot motor slows down or speeds up the cylinder or moves rolls manipulating the web until synchronism is restored.

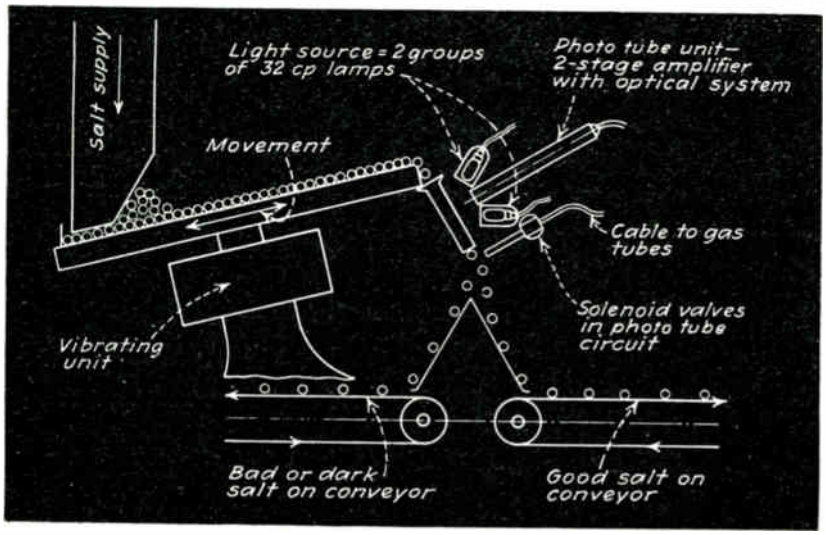
Third and fourth impression rolls may be provided with similar slotted discs and scanning heads, the register marks printed with the first color serving as the basis of comparison throughout an entire multicolor printing process.—Wright, *G. E. Review*, November, 1941. (ELECTRONICS, February, 1942, p. 72.)



Printing register control using phototubes and thyratrons. The scheme may be applied to four-color presses



Typical record of luminous energy content of Bessemer flame produced by photo tube equipment



Method of operation of rock salt sorting machine. The pieces of salt drop one at a time past the photoelectric unit. The dark pieces reflect less light causing a blast of air to blow them off the path of the good pieces

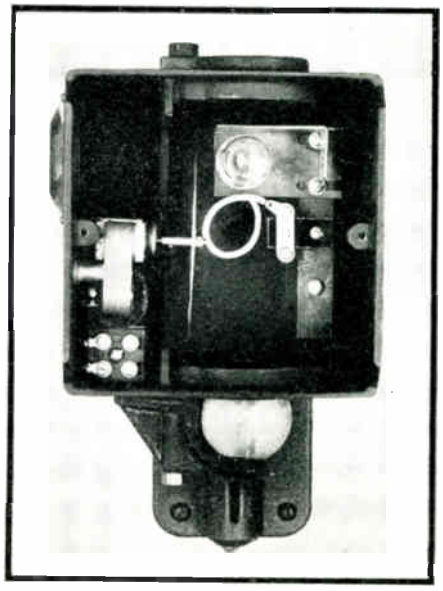
Rock Salt Sorting Machine

ROCK SALT MUST BE sorted to remove the dark colored pieces before it can be sold. A photoelectric method can be used by differentiating between the reflection characteristics of the desired white particles and the undesired dark particles. The particles are about ⅛ inch in diameter and can be individually examined. Here, the mechanical portion of the system was more difficult to develop than the photoelectric portion. After considerable experimentation the mechanism shown in the diagram was built. The vibrating conveyor feeds the salt in ten individual rows. The salt falls off, one crystal at a time, through the small directional chutes. Each of the ten chutes is arranged with a phototube housing in the form of a 2-inch square stick about 18 inches long. Each phototube unit contains a two-stage amplifier. The power supply and the thyratrons are located at a remote point. If a dark salt crystal appears before any one of the ten photoelectric units, a small fast-acting solenoid valve opens long enough to allow a squirt of air to move that dark crystal out of the normal path of fall. It then falls on one side of a "camel back" while the good pieces fall on the other side. The solenoid air valves must open very rapidly and they operate directly in the anode circuits of the thyratrons. The valves close automatically to eliminate the possibility of rejecting good salt. The valves were designed to open and close 20 times per second against an air pressure of 90 pounds per square inch. By adjustment of the grid bias on the amplifiers and the intensity of the light beam various grades of salt can be sorted for different degrees of purity.—Powers, ELECTRONICS, August 1941, p. 33.

Modulated Beam Photoelectric Alarm

CONVENTIONAL PHOTOELECTRIC burglar alarm systems employ a light source of constant output. Interruption by an intruder of an infrared beam projected to a distant phototube reduces the d-c output of the phototube and its associated d-c amplifier and actuates a relay controlling a signalling device. Such systems are sometimes rendered insensitive by increases in ambient light, such as those caused outdoors by the transition from darkness to daylight or indoors by the turning on of artificial illumination. Ambient light level may become so high that the relay is held open by phototube current even when the beam is interrupted.

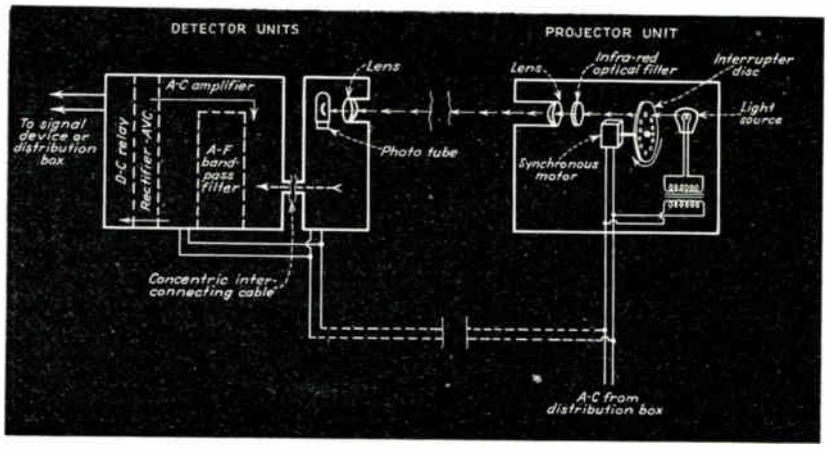
This difficulty may be minimized by using modulated light. A motor-



Projector unit of typical modulated-beam photoelectric system. Edge of disc which interrupts light appears as a vertical white line just to the left of center

rotated disc with holes punched in its periphery is introduced between the light source and the projection lens. The projected light beam is chopped up at a rate dependent upon the speed of the motor and number of holes in the disc, usually between 500 and 1,500 times per second. The phototube in the distant receiving unit operates into an a-c amplifier equipped with a band-pass filter which permits amplification only when current delivered by the phototube is modulated at the prescribed

(*Continued on page* 83)



Block-diagram of typical modulated-beam photoelectric alarm system. Beam-throw distances of 1,000 feet or more are proving practical with such systems

A QUICK-SELECTION CHART OF ELECTRONIC TUBES FOR INDUSTRY

THERE'S A G-E TUBE FOR EVERY ELECTRONIC DEVICE

KENOTRON—A high-vacuum thermionic tube in which no means is provided for controlling the unidirectional current flow.

THYRATRON—A hot-cathode, gas-discharge tube in which one or more electrodes are employed to control electrostatically the starting of the unidirectional current flow.

IGNITRON—A gas-discharge tube with a pool-type cathode (liquid or solid) in which an ignition electrode is used to control the starting of the unidirectional current flow in each operative cycle.

GLOW TUBE—A cold-cathode, gas-discharge tube in which no means is provided for controlling the unidirectional current flow.

PHANOTRON—A hot-cathode, gas-discharge tube in which no means is provided for controlling the unidirectional current flow.

BALLAST TUBE—A resistor-type tube used to maintain a constant average current—resistance varies with temperature so rapidly that, as the voltage across the tube varies, the current remains practically constant.

PLIOTRON—A high-vacuum tube in which one or more electrodes are used to control the unidirectional current flow.

PHOTOTUBE—A light-sensitive vacuum tube in which electron emission is produced directly by radiation falling upon an electrode.

KEEP THIS TIME-SAVING CHART FOR READY REFERENCE

ON the following two pages, we give you the *first* comprehensive list of electronic tubes for industrial use. This makes it almost as easy to choose a tube for your electronic device or application as it is to select an ordinary light bulb. The streamlined technical data on each tube, in easy-to-get tabular form, makes it a simple procedure to select the tube to fit your particular requirement.

● You'll notice bulletin numbers for each tube listed in the column farthest right on each page. These and other bulletins, described briefly on the fourth page, contain valuable installation, operating, and technical data. Get them on every G-E tube type you are now using or plan to use. You'll find them invaluable when designing electronic devices or discovering new ways of solving production problems electronically.

● If you have a special design problem, call on G-E engineers.

GENERAL ELECTRIC

Prices effective May 18, 1942

PHANOTRONS — gaseous-discharge-rectifier tubes

Type No.	Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Peak Volts	PLATE Peak Amp	Avg Amp	Temp Range Condensed Mercury C	Shipping Weight in Lb	Ask for This Bulletin
GL-866A/866	$1.50	2	2.5	5	10000	1	0.25	40—+5	3	GET-966
FG-190	18.75	3	2.5	12	175	5	1.25	−20—+60*	6	GET-969
GL-872	9.00	2	5.0	10	7500	5	1.25	40—+5	3	GET-917
GL-872A	11.00	2	5.0	6.75	10000	5	1.25	40—+5	3	GET-745
GL-512	33.00	2	5.0	10	15000	6	1.5	15—50§	3	GET-993
FG-32	11.00	2	5.0	4.5	1000	15	2.5	30—80	6	GET-969
GL-869B	125.00	2	5.0	18	20000 15000‡	15	2.5 5.0‡	35—+5	6	GET-964
FG-280	35.00	2	5.0	10	1000	40	6.4	40—80	3	
FG-104	27.50	2	5.0	10	3000	40	6.4	40—80	9	GET-733
GL-510	240.00	2	5.0	30	22000	40	5.0 10.0‡	30—40	9½	GET-993
FG-166	98.00	2	2.5	100	1500	75	20	20—60	9	GET-735

‡Quadrature operation. § Ambient temperature range.

THYRATRONS — grid-controlled gaseous-discharge-rectifier tubes

Type No.	Price	No. of Elec-trodes	CATHODE Volts	CATHODE Amp	PLATE Peak Volts	PLATE Peak Amp	Avg Amp	Starting Grid Voltage	Temp Range Condensed Mercury, C	Shipping Weight in Lb	Ask for This Bulletin
GL-2051	$2.50	4	6.3	0.6	730	0.375	0.075	Neg		3	GET-984
GL-2050	3.00	4	6.3	0.6	1300	0.500	0.100	Neg		3	GET-984
FG-178-A	14.00	3	2.5	2.25	500	0.500	0.125	Neg	−20—+50*	3	GET-618
FG-81-A	11.00	3	2.5	5.0	500	2.0	0.5	Neg	−20—+50*	3	GET-465
FG-98-A	15.50	4	2.5	5.0	500	2.0	0.5	Neg	−20—+50*	3	GET-743
FG-97	15.50	4	2.5	5.0	1000	2.0	0.5	Var	40—80	3	GET-743
FG-17	9.50	3	2.5	5.0	2500	2.0	0.5	Neg	40—80	3	GET-428
FG-154	23.00	4	5.0	7.0	500	10.0	2.5	Neg	−20—+50*	6	GET-743
FG-27-A	17.00	3	5.0	4.5	1000	10.0	2.5	Neg	40—80	6	GET-428
FG-33	16.25	3	5.0	4.5	1000	15.0	2.5	Pos	35—80	6	GET-435
FG-57	15.00	3	5.0	4.5	1000	15.0	2.5	Neg	40—80	6	GET-428
FG-67	15.75	3	5.0	4.5	1000	15.0	2.5	Var	40—80	6	GET-438
FG-95	19.00	4	5.0 †5.5	4.5 5.0	1000 1000	15.0 40.0	2.5 0.5	Var Var	40—80 40—80	6	GET-743
GL-429	47.50	4	5.0	10.0	1000	40.0	3.0	Var	50—70	9	GET-962
FG-105	38.00	4	5.0	10.0	1000	40.0	6.4	Var	40—80	9	GET-743
FG-172	35.00	4	5.0	10.0	1000	40.0	6.4	Var	40—80	9	GET-619
FG-41	92.00	3	5.0	20.0	10000	75.0	12.5	Neg	40—65	9	GET-436
GL-414	92.00	4	5.0	20.0	2000	100.0	12.5	Neg	40—80	9	

* These tubes are inert-gas-filled, and the temperature ratings are expressed in terms of the ambient temperature range over which the tubes will operate.
† These ratings apply only when the tube is used for ignitor firing.

PLIOTRONS — grid-controlled high-vacuum tubes

Control Types	Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Max Volts	PLATE Max Amp	Max Dis Watts	Mu	Shipping Wt Lb	Ask for This Bulletin
PJ-21	$6.25	3	4.5	1.1	350		7.5	3	3	GET-496
PJ-7	6.25	3	4.5	1.1	350	0.040	10	30	3	GET-492
PJ-8	6.25	3	4.5	1.1	350	0.040	10	8.5	3	GET-493
Special Purpose										
FP-54	$56.00	4	2.5	0.09	6	0.0060	Low grid-current measurement tube		9	GET-484
FP-62	27.00	3	4.5	1.48	112.5	0.010	For gas-pressure measurements		9	GET-485

Therapy Types	Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Max Volts	PLATE Max Amp	Max Input	Max Dis Watts	Mu	Shipping Wt Lb	Ask for This Bulletin
FP-285	$15.00	3	10	3.25	1350	0.200	270	100	12	6	GET-738
FP-252A	25.00	3	10	3.85	2000	0.200	400	150	18	6	GET-750
FP-265	23.75	3	10	5.20	1500	0.200	300	160	75	6	

Power Triodes for high-frequency heating.	Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Max Volts	PLATE Max Amp	Max Dissip. Watts	Mu	Type of Cooling	Shipping Weight in Lb	Ask for This Bulletin
GL-483	$160.00	3	11	15.5	2500	1.00	750	20.5	.....	9	GET-989
GL-8002	200.00	3	16	39.0	3500	1.00	1200	20.5	Water		GET-960
GL-8002R	325.00 ★	3	16	39.0	3500	1.00	1200	20.5	Air	15	GET-961
GL-891R	410.00 ★	3	22	60.0	10000	2.00	4000	8	Air	90	GET-914
GL-509	275.00	3	11	125.0	8500	2.00	5000	21	Water	9	GET-992
GL-509R	425.00 ★	3	11	125.0	8500	2.00	5000	21	Air	52	GET-992
GL-891	285.00	3	22	60.0	12000	2.00	6000	8	Water	9	GET-913
GL-207	275.00	3	22	52.0	15000	2.00	10000	20	Water	9	GET-763
GL-452	285.00	3	22	60.0	15000	2.00	10000	50	Water	9	GET-975
GL-893	750.00	3	20	183.0	20000	4.00	20000	36	Water	27	GET-766
GL-893R	1150.00 ★	3	20	183.0	20000	4.00	20000	36	Air	290	GET-959
GL-862	1650.00	3	33	207.0	20000	10.00	100000	45	Water	175	GET-919
GL-898	1650.00	3	33	207.0	20000	10.00	100000	45	Water	175	GET-767

★Lower prices apply when new tube is purchased, and radiator in good condition is returned prepaid.

KENOTRONS — high-vacuum rectifier tubes

Type No.	Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Peak Volts	PLATE Peak Amp	Shipping Weight in Lb	Ask for This Bulletin
FP-400	$14.00	2	4.0	2.25	100	0.025	6	GET-746
FP-92	155.00	2	10	14.5	150000	0.3	9	GET-734
GL-411	130.00	2	10	14.5	100000	0.3	9	GET-734
KC-4	140.00	2	20	24.5	150000	1.0	9	GET-734

FOR INDUSTRIAL USE

IGNITRONS — high-peak-current, pool-cathode tubes

Welding Control Types*	Price	MAXIMUM RATINGS: Kva Demand	Corresponding Average Anode Current Amperes	Maximum Average Anode Current Amperes	Corresponding Kva Demand	Type of Cooling	Shipping Weight in Lb	Ask for This Bulletin
GL-415	$33.00	300	12.1	22.4	100	Water	6	GET-968
FG-271	55.00	600	30.2	56.0	200	Water	12	GET-967
FG-235-A	110.00	1200	75.6	140	400	Water	16	GET-967
FG-258-A	250.00	2400	192.0	355	800	Water	45	GET-967

* Ratings are for voltages of 600 volts rms and below. Ignitor requirements for all welding-control types are 200 volts and 40 amperes.

Power Rectifier Types†	Price	MAXIMUM CURRENT: D-c Volts	Peak Amp	Average Amp	Average Amp 1 Minute	Type of Cooling	Shipping Weight in Lb	Ask for This Bulletin
GL-427	$55.00	125	30	5	.....	.....	3	
FG-238-B	355.00	300	1800	300	400	Water	35	GEA-3565
		600	1200	225	300			
FG-259-B	200.00	300	900	150	200	Water	22	GEA-3565
		600	600	100	133			

† Typical ignitor requirements for power-rectifier ignitrons are 75–125 volts, 15–20 amperes. Maximum requirements are 150 volts, 40 amperes.

PHOTOTUBES — light-sensitive tubes

Type No.	Price	Gas or Vacuum	Cathode Surface Material	Anode Volts	Sensitivity in Microamperes per Lumen	Window Area Sq In.	Max Amb Temp, C	Shipping Weight in Lb	Ask for This Bulletin
PJ-22	$2.60	Vacuum	Caesium	200	14	0.9	50	3	GET-742
PJ-23	2.60	Gas	Caesium	90	50	0.9	50	3	GET-742
FJ-401	6.75	Gas	Rubidium	90		0.9	50	3	GET-742
FJ-405	44.00	Vacuum	Sodium	200		0.75	50	6	GET-742
GL-441	7.50	Vacuum	Caesium	200	45	0.9	100	3	GET-742
GL-917	4.75	Vacuum	Caesium	500	20	0.9	50	3	
GL-919	4.75	Vacuum	Caesium	500	20	0.9	50	3	
GL-921	2.00	Gas	Caesium	90	100	0.38	50	3	
GL-922	2.00	Vacuum	Caesium	500	20	0.38	50	3	
GL-923	2.60	Gas	Caesium	90	100	0.43	50	3	GET-983
GL-927	3.70	Gas	Caesium	90	75	0.4	50	3	
GL-929	3.00	Vacuum	Caesium	250	45	0.6	100	3	GET-983
GL-930	2.00	Gas	Caesium	90	100	0.6	100	3	GET-983
GL-931	12.00	Vacuum	Caesium	1250	2.3×10^6	0.25	50	3	

BALLAST TUBES — resistor-type tubes used to maintain a constant average current

Type No.	Price	VOLTS: Min	VOLTS: Max	AMPERES: Min	AMPERES: Max	Shipping Wt Lb	Ask for This Bulletin
FB-50	$4.50	5	8	0.225	0.275	3	GEH-1000
B-25	3.00	7	16	1.07	1.16	3	GEH-1000
B-47	3.75	8	18	2.05	2.35	3	GEH-1000
B-46	4.25	8	18	2.70	3.25	3	GEH-1000
B-6	4.50	15	21	0.95	1.01	3	GEH-1000
B-4	25.50	105	125	1.24	1.36	3	GEH-1000

GLOW TUBES — cold-cathode tubes for use as voltage regulators

Type No.	Price	Starting Supply Voltage, D-c, Min	Operating Voltage Maintained, D-c, Approx	OPERATING CURRENT, MILLIAMPERES: Min	OPERATING CURRENT, MILLIAMPERES: Max	Shipping Wt Lb	Ask for This Bulletin
GL-75-30	$1.25	105	75	5	30	3	GET-985
GL-874	1.50	125	90	10	50	3	GET-985
GL-105-30	1.25	137	105	5	30	3	GET-985
GL-150-30	1.25	180	150	5	30	3	GET-985

VACUUM SWITCHES

Type No.	Description	Price	A-c	D-c	Amp	Shipping Wt Lb	Ask for This Bulletin
FA-6	Single-pole double-throw	$8.75	440	500	10	3	GET-609
FA-15	Single-pole double-throw	6.25	3000	3000	8	3	GET-729

VACUUM GAGES—to measure gas pressure

Type No.	Price	Volts	Range in Microns	Shipping Wt Lb	Ask for This Bulletin
FA-13	$14.00	6	0–600	3	GEI-8695
FA-14	11.00	6	‡	3	GEI-8695

‡ Used with FA-13 to compensate for temperature and voltage changes.

USE THESE OTHER G-E PRODUCTS IN YOUR ELECTRONIC DEVICES

G-E MYCALEX
Bulletin GET-1012

SMALL INSTRUMENTS
Bulletin GEA-2645A

SENSITIVE RELAYS
Bulletin GEA-3819

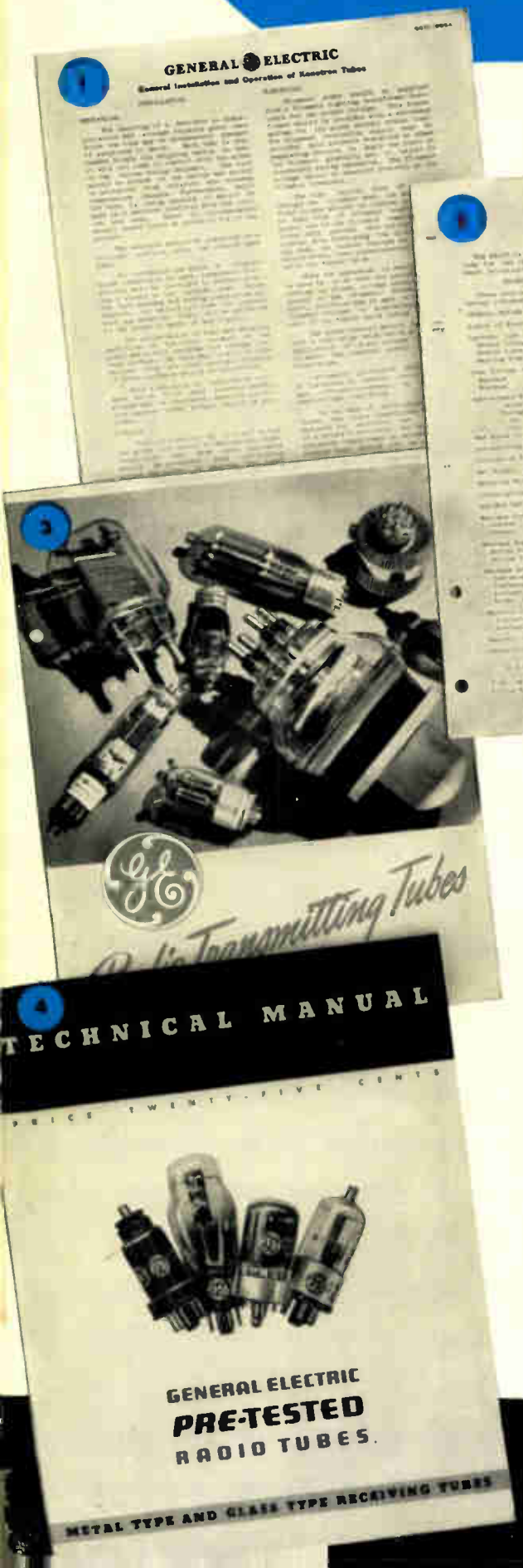
TIME-DELAY RELAYS
Bulletin GEA-1540B

PYRANOL CAPACITORS
Bulletin GEA-2621

Prices and other data are subject to change without notice.

ASK FOR THESE G-E DATA SHEETS

You'll Find Them Helpful In Designing Electronic Devices



1 INSTALLATION AND OPERATING INSTRUCTIONS. These "How to" bulletins will help you get the most production hours out of your tubes. They are available on every class of G-E electronic tube. They include instructions on handling, mounting, testing, and cooling; tell what protective devices to use with the tube, what types of meters are best suited for indicating operating conditions; give circuit information, and operating data for every class of service.

2 TECHNICAL DATA SHEETS. You'll find these bulletins invaluable when designing electronic devices. They contain the descriptions and ratings of individual tubes or group of tubes, general design information, and maximum ratings; indicate typical operating conditions for all classes of service; characteristics curves, and base and tube dimension diagrams.

3 HANDY TRANSMITTING-TUBE REFERENCE GUIDE—containing condensed technical data and prices on General Electric's complete line. As many of these tubes have industrial applications, a copy of this bulletin should be in your file. Ask for GEA-3315.

4 DATA BOOK ON G-E RECEIVING TUBES. It lies flat; the type is easy to read; technical data is in easy-to-get tabular form. Includes tube ratings, dimensions, base connection diagrams, and interchangeability chart. Ask for MAQ-114.

HOW TO OBTAIN DATA SHEETS

THESE data sheets, plus extra copies of this time-saving chart, can be obtained—without charge—by writing direct to General Electric at Schenectady. The installation and technical data sheets (1 and 2) are available on any G-E tube you are currently using or plan to use. Just let us know the type number, or the application you wish to make, and we'll send you the bulletins to cover your requirements.

The electronic circuit is entering more and more into industrial work as an automatic hand, a new means of generating heat. On the preceding pages are data on the various types of tubes which we have made available to industry—tubes that are making possible today's industrial miracles. The wide range of design and operating characteristics of these tubes give you a broad selection of tubes for your electronic device or application.

General Electric has been in the tube business for 29 years, making such contributions as thoriated tungsten filaments, the screen-grid tube, and metal tubes for both radio and industry. Today, in the tradition of Steinmetz, Alexanderson, Coolidge, Langmuir, Whitney, our tube engineers are accomplishing things in design that weren't dreamed of even a year ago. New concepts of function, new strata of the radio spectrum are being explored and exploited.

General Electric is ready to help you meet the challenge of a new era—the age of electronics. *General Electric Company, Radio, Television, and Electronics Department, Schenectady, N. Y.*

GENERAL ELECTRIC

(*Continued from page 78*)

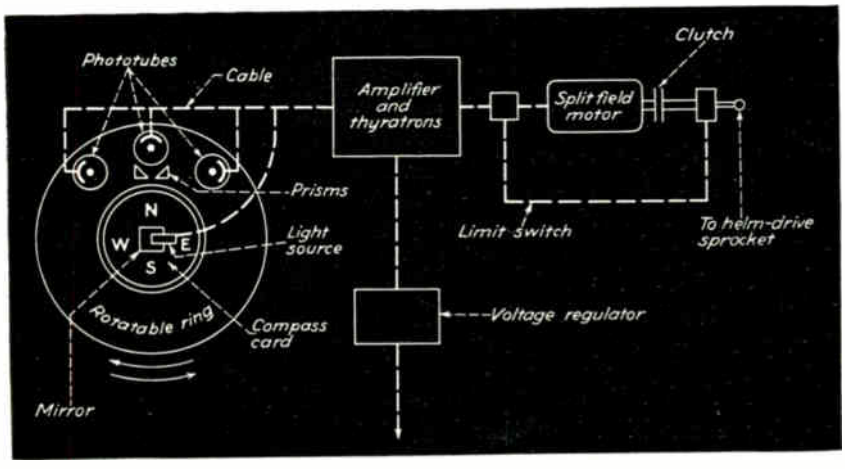
rate. The output of the amplifier is rectified and the resultant d.c. keeps the warning device relay open in the usual manner until the light beam is broken.

The warning device relay is held open only when the receiving unit phototube receives light modulated at the prescribed frequency. Light which is unmodulated or light that is modulated at other than the prescribed frequency, such as that from lamps powered by 60 cycle lines, does not paralyze such systems as they are not affected by reasonable variations in light intensity.—MacDonald, ELECTRONICS, February, 1942, p. 38.

Automatic Ship-Steering Device

NO MATTER HOW perfectly designed, a ship set upon a given compass course will not exactly hold that course with the tiller lashed down or the steering wheel locked. The helmsman must continuously correct off-course variations caused by the action of sea or wind upon hull and rudder if the desired course is to be made good. Continuous correction may be accomplished automatically, one device designed for this purpose scanning the ship's compass card photoelectrically and using off-course movement of the card to initiate movement of the rudder in a compensating direction.

The compass card carries a mirror which reflects a beam of light from a source directly above it to a system of prisms and phototubes. When the ship is on her set course the middle phototube is illuminated and this phototube's output current renders automatic steering mechanisms inoperative. A deviation in course throws the light into one of the phototubes to the side of center and the output current of the phototube so illuminated actuates an electronic amplifier which trips a thyratron that operates a split-field motor in the direction necessary to move the rudder so that the ship is brought back on course. When the light shines on the middle phototube, denoting return to the desired course, the automatic mechanism is rendered inoperative until the ship yaws again. —Chance, ELECTRONICS, June, 1939, p. 41.



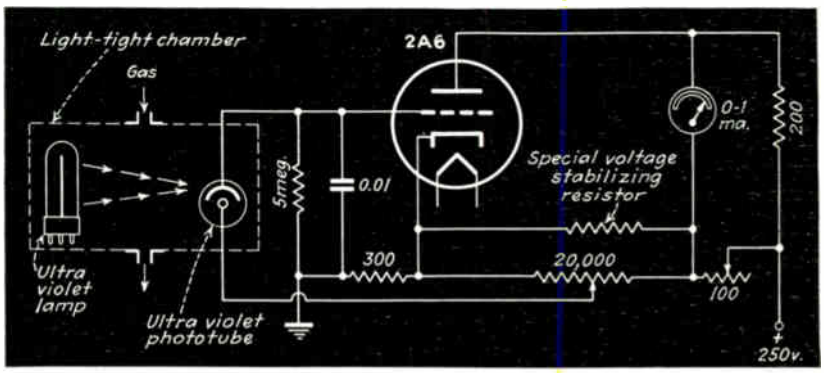
Automatic ship-steering device. When the ship yaws off a set course the light beam illuminates one of the side phototubes, causing the split-field motor to move the rudder in a compensating direction

Mercury Vapor Detector

THE PRESENCE OF SMALL quantities of mercury vapor in air or other gasses may be detected photoelectrically. If, for example, a phototube sensitive to ultraviolet light is exposed to light from an ultraviolet lamp the presence of mercury vapor in the space intervening between phototube and lamp will decrease phototube output because of scattering of the light. This measurement principal is industrially useful since it permits mercury vapor boilers and mercury vapor turbines to be adjusted so that a minimum of expensive mercury goes up the flue.

The device uses a Wheatstone bridge circuit, the 2A6 amplifier tube constituting one arm of the bridge. It is adjusted for operation by balancing the meter to zero through variation of the 100 ohm resistor with the lamp operating and the air intervening between lamp and phototube clear of Hg and then, with the lamp turned off, varying the 20,000 ohm resistor until the meter reads full scale.

In operation after such adjustment, Hg vapor between lamp and phototube causes a reduction of transmitted ultraviolet light, a reduction of phototube current, less negative bias on the grid of the 2A6, more plate current and a meter reading comparable with the quantity of mercury vapor in the air or gas.—Woodson, *Review of Scientific Instruments*, October, 1939, p. 308.



The uv lamp and uv phototube in this mercury vapor detector are placed at opposite ends of a chamber excluding external light. Gas to be checked is introduced into the chamber

Dew-Point of Gas Measured by Photoelectric Method

THE INTENSITY OF A light beam after it passes through a film of moisture condensate on the surface of a glass window or mirror is considerably less than if the moisture is not present. This principal is used in the design of a dew-point recorder used by the Colorado Interstate Gas Co., at the Denver metering plant where natural gas arrives from Texas. The purpose of this instrument is to determine the amount of moisture present in the gas and to remove some of it by

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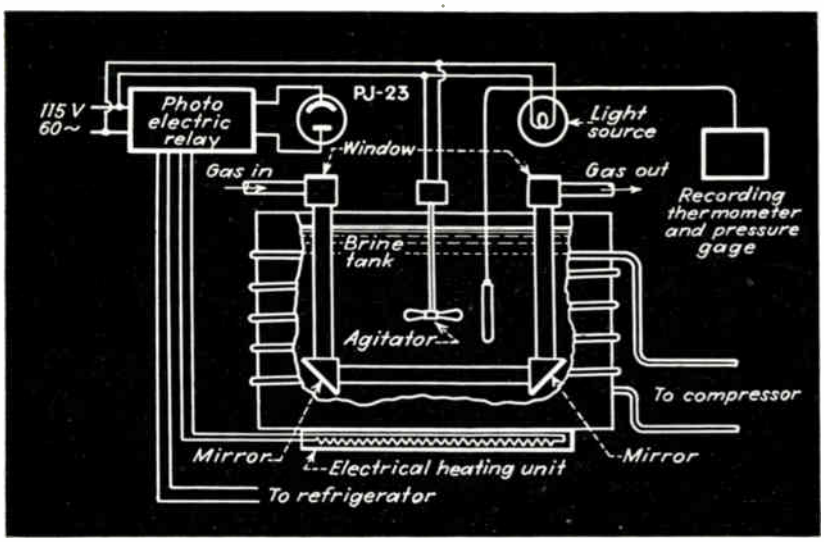


The gas in the U-shaped tube is alternately cooled just below and heated just above the dew-point by cooling coils and an electric heater controlled by a phototube relay which is operated by a light beam whose intensity is decreased by the presence of condensed moisture

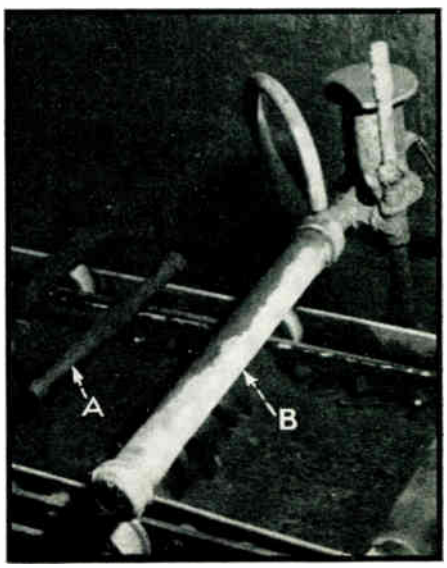
dehydration if there is any danger of the moisture condensing and freezing.

A continuous flow from a bypass valve in the main line passes through a U-shaped tube which has a plate glass window at the top of each side of the U, glass mirrors at the square corners of the U as shown. The interior of the tube is gold plated and highly polished. A light source is located above one window and a phototube (type PJ-23) is located above the other window. If a film of moisture can be made to condense upon the glass and gold-plated surfaces, the intensity of the light beam reaching the phototube will be reduced. This can be done by immersing the U-tube in a brine bath cooled by cooling coils connected to a refrigerating compressor. When the moisture film appears, the cooling coils are cut off and a heating unit is turned on to heat the gas and evaporate the moisture at which time the heater is turned off and the cycle repeated. Measurements on a recording thermometer whose element is located in the brine bath will indicate that the temperature changes approximately according to a sine wave. In this installation the temperature difference between the tops and bottoms of the curves is about 2 to 3 degrees. The cycle of operation is about 10 to 15 minutes. The pressure of the gas is also recorded and the dew-point can be calculated from the records of temperature and pressure.—Setter, ELECTRONICS, November 1941, p. 72.

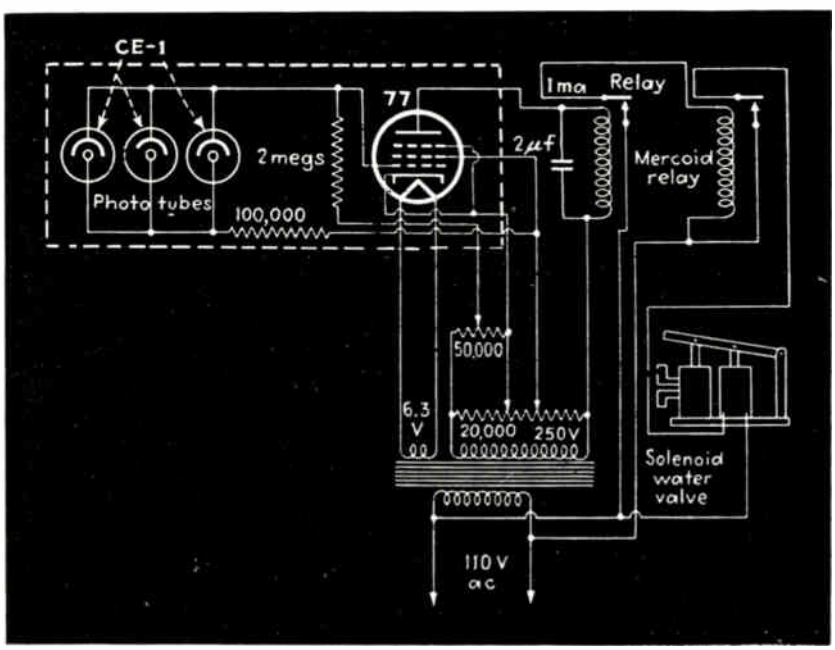
Photoelectric Cooling Control

AT THE TVA FERTILIZER WORKS phosphate ore is heated to a high temperature and crushed to sizes varying from fine dust to two inches in diameter. The phosphate must be cooled by a water spray on a moving conveyor before further processing, but if a continuous spray of water of sufficient capacity to cool the larger pieces is used, the finer and cooler material is flooded, making a mud that clogs the equipment.

The problem is to provide cooling water when it is necessary to cool large, hot pieces and to shut it off when the relatively cool smaller pieces are passing by on the conveyor. The solution is to use a phototube relay using tubes which are sensitive to infrared heat rays to operate a solenoid water valve. Three type CE-1 phototubes are mounted a few inches above the ore in the conveyer and a few inches ahead of the water nozzles to allow for the time delay in the relay and valve circuit. Because of the heat involved, the phototubes are mounted in a Pyrex glass cylinder and a current of air



The actual setup showing the conveyor which moves from right to left. The water spray *(A)* is mounted away from the phototubes *(B)* to permit the ore to reach it before water flows



Circuit diagram of the infrared sensitive phototube relay. The three phototubes connected in parallel are mounted within a Pyrex cylinder for protection from heat

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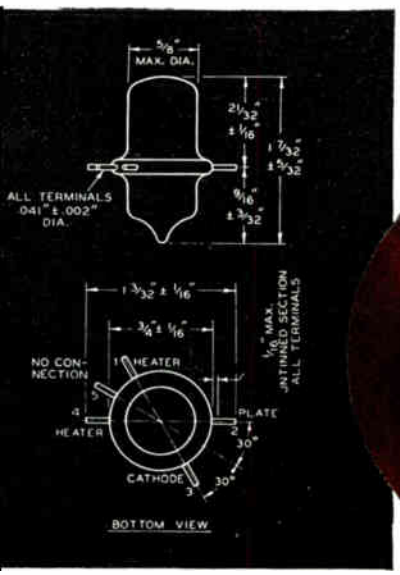
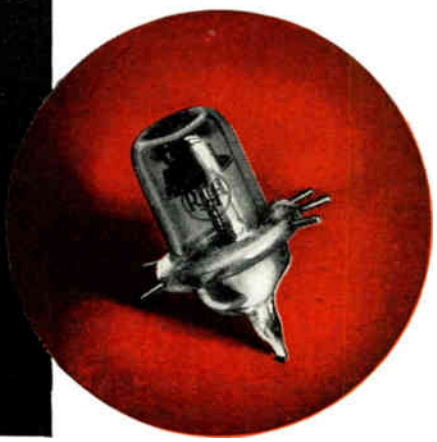
Complete descriptions and operating characteristics for each of the seven tubes are given in the following tabulations of technical data.



RCA-9004
U-H-F DIODE
Acorn Type (Tentative Data)



The 9004 is a heater-cathode type of Acorn diode suitable for use as a detector, mixer, or measuring device in u-h-f circuits. The resonant frequency of the 9004 is approximately 850 megacycles.

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.15	Ampere
DIRECT INTERELECTRODE CAPACITANCES:*		
Plate to Cathode	1.3	μμf
Plate to Heater	0.3 approx.	μμf
Heater to Cathode	2.2 approx.	μμf
OVERALL LENGTH	1 7/32" ± 5/32"	
OVERALL DIAMETER	1 3/32" ± 1/16"	
BULB	T-4½	
RCA SOCKET	Stock No. 9925	
MOUNTING POSITION	Any	

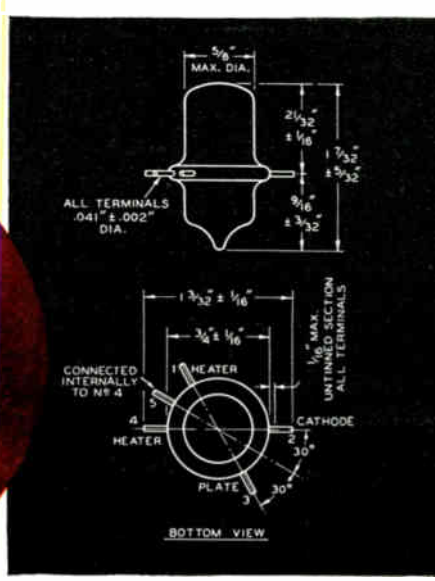
* With no external shield.

RECTIFIER

Maximum Ratings Are Based on a Line-Voltage Design Center of 117 Volts

A-C PLATE VOLTAGE (RMS)	117 max.	Volts
D-C OUTPUT CURRENT	5 max.	Milliamperes

RCA-9005
U-H-F DIODE
Acorn Type (Tentative Data)



The 9005 is a heater-cathode type of Acorn diode suitable for use as a detector, mixer, or measuring device in u-h-f circuits. The resonant frequency of the 9005 is approximately 1500 megacycles.

HEATER VOLTAGE (A.C. or D.C.)	3.6	Volts
HEATER CURRENT	0.165	Ampere
DIRECT INTERELECTRODE CAPACITANCES:*		
Plate to Cathode	0.8	μμf
Plate to Heater	0.2 approx.	μμf
Heater to Cathode	1.1 approx.	μμf
OVERALL LENGTH	1 7/32" ± 5/32"	
OVERALL DIAMETER	1 3/32" ± 1/16"	
BULB	T-4½	
RCA SOCKET	Stock No. 9925	
MOUNTING POSITION	Any	

* With no external shield.

RECTIFIER

Maximum Ratings Are Based on a Line-Voltage Design Center of 117 Volts

A-C PLATE VOLTAGE (RMS)	117 max.	Volts
D-C OUTPUT CURRENT	1.0 max.	Milliamperes

RCA 6C4

H-F POWER TRIODE

Miniature Type (Tentative Data)

The 6C4 is a heater-cathode type of Miniature tube intended for use as class C amplifier and oscillator in compact, light-weight, portable equipment, but it is useful in other applications where a medium-mu miniature triode with high transconductance is desired. In class C service, the 6C4 will deliver a power output of about 5.5 watts at moderate frequencies, and 2.5 watts at 150 megacycles. The heater is designed to operate at 6.3 volts, 0.15 ampere.

HEATER VOLTAGE (A.C. or D.C.)†	6.3	Volts
HEATER CURRENT	0.15	Amp.
DIRECT INTERELECTRODE CAPACITANCES:*		
Grid to Plate (Cgp)	1.6	μμf
Grid to Cathode [Cg (h + k)]	1.8	μμf
Plate to Cathode [Cp (h + k)]	1.3	μμf
MAXIMUM OVERALL LENGTH	2⅛"	
MAXIMUM SEATED HEIGHT	1⅞"	
MAXIMUM DIAMETER	¾"	
BULB	T-5½	
BASE	Miniature Button 7-Pin♦	
MOUNTING POSITION	Any	

* With no external shield.

A-F AMPLIFIER

PLATE VOLTAGE	300 max.		Volts
PLATE DISSIPATION	3.5 max.		Watts
Characteristics—Class A_1 Amplifier:			
Plate Voltage	100	250	Volts
Grid Voltage**	0	−8.5	Volts
Amplification Factor	19.5	17	
Plate Resistance (Approx.)	6250	7700	Ohms
Transconductance	3100	2200	μmhos
Plate Current	11.8	10.5	Ma.

** The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. Under maximum rated conditions, the resistance in the grid circuit should not exceed 0.25 megohm with fixed bias, or 1.0 megohm with cathode bias.

R-F POWER AMPLIFIER & OSCILLATOR—CLASS C TELEGRAPHY

D-C PLATE VOLTAGE	300 max.	Volts
D-C GRID VOLTAGE	−50 max.	Volts
D-C PLATE CURRENT	25 max.	Ma.
D-C GRID CURRENT	8 max.	Ma.
PLATE DISSIPATION	5 max.	Watts
Typical Operation‡		
D-C Plate Voltage	300	Volts
D-C Grid Voltage	−27	Volts
D-C Plate Current	25	Ma.
D-C Grid Current (Approx.)	7	Ma.
Driving Power (Approx.)	0.35	Watt
Power Output (Approx.)	5.5	Watts

‡ Approximately 2.5 watts can be obtained when the 6C4 is used at 150 Mc as an oscillator with grid resistor of 10,000 ohms and maximum rated input.

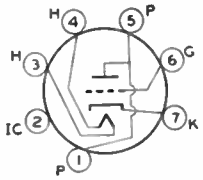
† In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

♦ The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Plate
Pin 2—Internal Connection
Pin 3—Heater
Pin 4—Heater
Pin 5—Plate
Pin 6—Grid
Pin 7—Cathode



RCA 1L4

R-F AMPLIFIER PENTODE

Miniature Type (Tentative Data)

The 1L4 is an r-f pentode of the Miniature type with a sharp cut-off characteristic. It is recommended for use wherever a sharp cut-off pentode is required in compact, light-weight, portable receivers. The tube is, therefore, of interest in FM receivers and other circuits not requiring avc. The 1L4 features internal shielding which eliminates the need for an external bulb shield, but a socket with shielding is essential if minimum grid-plate capacitance is to be obtained.

FILAMENT VOLTAGE (D.C.)	1.4	Volts
FILAMENT CURRENT	0.05	Amp.
DIRECT INTERELECTRODE CAPACITANCES:*		
Grid to Plate [C_{g_1P}]	0.008 max.	μμf
Input [C_{g_1} (f & g_3 & internal shield + g_1)]	3.6	μμf
Output [Cp (f & g_3 & internal shield + g_1)]	7.5	μμf
MAXIMUM OVERALL LENGTH	2⅛"	
MAXIMUM SEATED HEIGHT	1⅞"	
MAXIMUM DIAMETER	¾"	
BULB	T-5½	
BASE	Miniature Button 7-Pin♦	
MOUNTING POSITION	Any	

* With no external shield.

AMPLIFIER

PLATE VOLTAGE	110 max.	Volts
SCREEN VOLTAGE (Grid No. 2)	90 max.	Volts
SCREEN SUPPLY VOLTAGE	110 max.	Volts
GRID VOLTAGE (Grid No. 1)	0 min.	Volts
TOTAL CATHODE CURRENT	6.5 max.	Ma.

Typical Operating Conditions and Characteristics —Class A_1 Amplifier:

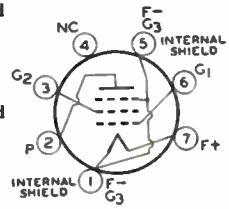
Plate Voltage	90	90	Volts
Screen Voltage	67.5	90	Volts
Grid Voltage	0	0	Volts
Plate Resistance	0.6	0.35	Meg.
Transconductance	925	1025	μmhos
Grid Bias for Plate Current =10μamp.	−6	−8	Volts
Plate Current	2.9	4.5	Ma.
Screen Current	1.2	2.0	Ma.

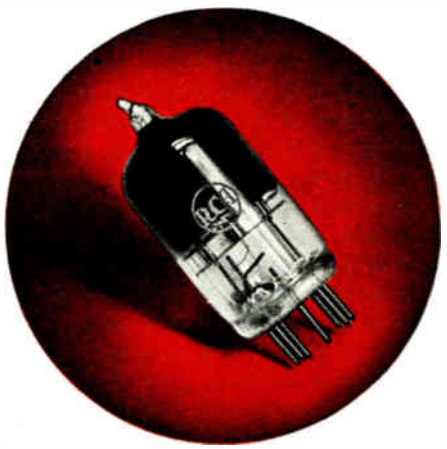
Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

♦ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Filament (−), Grid No. 3, Internal Shield
Pin 2—Plate
Pin 3—Screen
Pin 4—No Connection
Pin 5—Filament (−), Grid No. 3, Internal Shield
Pin 6—Grid
Pin 7—Filament (+)





RCA 1A3

H-F DIODE

Midget Type (Tentative Data)

The 1A3 is a heater-cathode type of Midget diode particularly useful as a discriminator tube in portable FM receivers, and in portable high-frequency measuring equipment. Its interelectrode capacitances are very low, being in the order of 0.5 micro-micro-farad. The resonant frequency of the 1A3 is approximately 1000 megacycles. The glass button base provides short leads and low lead inductance.

HEATER VOLTAGE (A.C. or D.C.)	1.4	Volts
HEATER CURRENT	0.15	Amp.
DIRECT INTERELECTRODE CAPACITANCES (Approx.):*		
Plate to Cathode (Cpk)	0.4	μμf
Plate to Heater (Cph)	0.6	μμf
Heater to Cathode (Chk)	0.6	μμf
MAXIMUM OVERALL LENGTH	1¹³⁄₁₆"	
MAXIMUM SEATED HEIGHT	1⅜"	
MAXIMUM DIAMETER	¾"	
BULB	T-5½	
BASE	Miniature Button 7-Pin♦	
MOUNTING POSITION	Any	

* With no external shield.

RECTIFIER

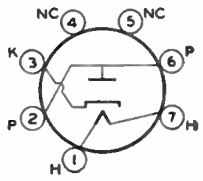
A-C PLATE VOLTAGE (RMS)	117 max.	Volts
D-C OUTPUT CURRENT	0.5 max.	Ma.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40)

♦ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Heater
Pin 2—Plate
Pin 3—Cathode
Pin 4—No Connection
Pin 5—No Connection
Pin 6—Plate
Pin 7—Heater



RCA 3A4

POWER AMPLIFIER PENTODE

Miniature Type (Tentative Data)

The 3A4 is a Miniature type of power amplifier pentode designed for use in compact, light-weight, portable equipment. The relatively large filament employed in the 3A4 enables it to supply the high peak currents required in r-f power applications. In r-f amplifier service, the 3A4 will deliver a power output of about 1.2 watts at 10 megacycles. The filament of the 3A4 can be operated either with series connection on 2.8 volts or parallel connection on 1.4 volts.

	*Series Filament Arrangement**	*Parallel Filament Arrangement***	
FILAMENT VOLTAGE (D.C.)	2.8	1.4	Volts
FILAMENT CURRENT	0.1	0.2	Amp.
DIRECT INTERELECTRODE CAPACITANCES:†			
Grid to Plate (C_{g_1p})		0.2 max.	μμf
Input [C_{g_1} (f & g_2 + g_2)]		4.9	μμf
Output [Cp (f & g_2 + g_2)]		4.2	μμf
MAXIMUM OVERALL LENGTH			2⅛"
MAXIMUM SEATED HEIGHT			1⅞"
MAXIMUM DIAMETER			¾"
BULB			T-5½
BASE		Miniature Button 7-Pin◊	
MOUNTING POSITION			Any

† With no external shield.

A-F POWER AMPLIFIER

PLATE VOLTAGE	150 max.	Volts
SCREEN VOLTAGE	90 max.	Volts
PLATE DISSIPATION	2 max.	Watts
SCREEN DISSIPATION	0.4 max.	Watt
TOTAL ZERO-SIGNAL CATHODE CURRENT††	18 max.	Ma.

Typical Operating Conditions and Characteristics —Class A_1 Amplifier‡

	135	*Parallel Filament Arrangement*** 150	
Plate Voltage	135	150	Volts
Screen Voltage (Grid No. 2)	90	90	Volts
Grid Voltage (Grid No. 1)	−7.5	−8.4	Volts
Peak A-F Grid Voltage	7.5	8.4	Volts
Zero-Signal Plate Current	14.8	13.3	Ma.
Max.-Signal Plate Current	14.9	14.1	Ma.
Zero-Signal Screen Current	2.6	2.2	Ma.
Max.-Signal Screen Current	3.5	3.5	Ma.
Plate Resistance	90,000	100,000	Ohms
Transconductance	1900	1900	μmhos
Load Resistance	8000	8000	Ohms
Total Harmonic Distortion	5	6	%
Max.-Signal Power Output	0.6	0.7	Watt

R-F POWER AMPLIFIER

D-C PLATE VOLTAGE	150 max.	Volts
D-C SCREEN VOLT. (Grid No. 2)	135 max.	Volts
D-C GRID VOLT. (Grid. No. 1)	−30 max.	Volts
D-C PLATE CURRENT	20 max.	Ma.
D-C GRID CURRENT	0.25 max.	Ma.
TOTAL D-C CATH. CURRENT††	25 max.	Ma.
PLATE INPUT	3 max.	Watts
SCREEN INPUT	0.9 max.	Watt
PLATE DISSIPATION	2 max.	Watts

Typical Operation‡

	*Parallel Filament Arrangement***	
D-C Plate Voltage	150	Volts
D-C Screen Voltage	135	Volts
Grid Resistor	0.2	Meg.
D-C Plate Current	18.3	Ma.
D-C Screen Current	6.5	Ma.
D-C Grid Current	0.13	Ma.
Power Output (Approx.)	1.2	Watts

* Filament voltage applied across the two sections in series between pins No. 1 and No. 7. Grid voltage is referred to pin No. 1.

** Filament voltage applied across the two sections in parallel between pin No. 5 and pins No. 1 and No. 7 connected together. Grid voltage is referred to pin No. 5.

†† For series-filament operation, a shunting resistor must be connected across the section between pins No. 1 and No. 5 to by-pass excess cathode current in this section. The value of the shunting resistor should be adjusted to make the voltage across the shunted section equal to the voltage across the section between pins No. 5 and No. 7. When other tubes in series-filament arrangement contribute to the filament current of the 3A4, an additional shunting resistor may be required between pins No. 1 and No. 7.

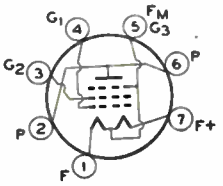
‡ Typical operating values for the 3A4 with filament sections in series will be approximately the same as those shown for parallel-filament operation.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

◊ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Filament (— for series operation)
Pin 2—Plate
Pin 3—Screen
Pin 4—Grid
Pin 5—Filament Mid-Tap (— for parallel operation), Grid No. 3
Pin 6—Plate
Pin 7—Filament (+)



RCA 3A5

H-F TWIN TRIODE

Miniature Type (Tentative Data)

The 3A5 is a twin triode of the Miniature type intended for use in high-frequency applications. The relatively large filament employed in the 3A5 enables it to supply the high peak currents required in r-f power applications. In class C service, a 3A5 with its units in push-pull will deliver a power output of approximately 2 watts at 40 megacycles. It may be used at still higher frequencies with reduced efficiency. Each triode may be used independently of the other. The filament of the 3A5 can be operated either with series connection on 2.8 volts or parallel connection on 1.4 volts.

	*Series Filament Arrangement**	*Parallel Filament Arrangement***	
FILAMENT VOLTAGE (D.C.)	2.8	1.4	Volts
FILAMENT CURRENT	0.11	0.22	Amp.
DIRECT INTERELECTRODE CAPACITANCES:†			
	Triode Unit T_1	*Triode Unit T_2*	
Grid to Plate (Cgp)	3.2	3.2	μμf
Grid to Filament (Cgf)	0.9	0.9	μμf
Plate to Filament (Cpf)	1.0	1.0	μμf
Plate to Plate ($C_{p_1p_2}$)		0.32	μμf
MAXIMUM OVERALL LENGTH			2⅛"
MAXIMUM SEATED HEIGHT			1⅞"
MAXIMUM DIAMETER			¾"
BULB			T-5½
BASE		Miniature Button 7-Pin◊	
MOUNTING POSITION			Any

† With no external shield.

A-F AMPLIFIER—Each Unit

PLATE VOLTAGE	135 max.	Volts
PLATE CURRENT	5 max.	Ma.
PLATE DISSIPATION	0.5 max.	Watt

Characteristics—Class A_1 Amplifier

Plate Voltage	90	Volts
Grid Voltage	−2.5	Volts
Amplification Factor	15	
Plate Resistance	8300	Ohms
Transconductance	1800	μmhos
Plate Current	3.7	Ma.

R-F POWER AMPLIFIER & OSCILLATOR— CLASS C TELEGRAPHY

D-C PLATE VOLTAGE	135 max.	Volts
D-C GRID VOLTAGE	−30 max.	Volts
D-C PLATE CURRENT (per unit)	15 max.	Ma.
D-C GRID CURRENT (per unit)	2.5 max.	Ma.
PLATE INPUT (per unit)	2.0 max.	Watts
PLATE DISSIPATION (per unit)	1.0 max.	Watt

Typical Operation at 40 Mc with Both Units:
Push-Pull Power Amplifier & Oscillator
(Key-down conditions per tube without modulation)

D-C Plate Voltage	135	Volts
D-C Grid Voltage		
From a fixed supply of	−20	Volts
From a grid resistor of	4000	Ohms
From a cathode resistor of	570	Ohms
Peak R-F Grid-to-Grid Voltage	90	Volts
D-C Plate Current	30	Ma.
D-C Grid Current (Approx.)	5	Ma.
Driving Power (Approx.)	0.2	Watt
Power Output (Approx.)	2	Watts

* Filament voltage applied across the two sections in series between pins No. 1 and No. 7. Grid voltage is referred to pin No. 1. For series-filament operation, a shunting resistor must be connected across the section between pins No. 1 and No. 4 to by-pass excess cathode current in this section. The value of the shunting resistor should be adjusted to make the voltage across the shunted section equal to the voltage across the section between pins No. 4 and No. 7. When other tubes in series-filament arrangement contribute to the filament current of the 3A5, an additional shunting resistor may be required between pins No. 1 and No. 7.

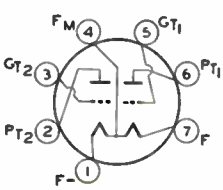
** Filament voltage applied across the two sections in parallel between pin No. 4 and pins No. 1 and No. 7 connected together. Grid voltage is referred to pins No. 1 and No. 7 tied together.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

◊ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Filament (—)
Pin 2—Plate (Triode T_2)
Pin 3—Grid (Triode T_2)
Pin 4—Filament Mid-Tap (+ for parallel operation)
Pin 5—Grid (Triode T_1)
Pin 6—Plate (Triode T_1)
Pin 7—Filament (+ for series operation)



RCA MANUFACTURING CO., INC.
CAMDEN, NEW JERSEY

(NOTE: For additional copies of literature on these tubes, address RCA, Commercial Engineering Section, Harrison, N. J.)

is blown past them. Because of the dust conditions prevalent at ore treating plants, the relay is placed in a dust-proof glass container.

The sensitive relay has a drop-out current which is about 80 percent of its take-up current. The circuit may be adjusted to operate at any desired radiant heat by adjustment of the amplifier grid bias control (50,000-ohm potentiometer).—Ewald, ELECTRONICS, November, 1941, p. 55.

Photoflash Synchronizer Tester

TYPICAL FLASHLAMPS used in photography reach peak brilliancy 20 milliseconds after filament voltage is applied. Synchronizing devices must open the camera shutter in that short space of time if maximum illumination and film exposure are to coincide. A convenient instrument for determining the time required for a shutter to open measures it in terms of voltage attained by a condenser charging from a steady source of potential during that period.

A beam of light from a steady external source is directed into the type 917 phototube. The camera shutter to be actuated by the synchronizer is interposed in this beam of light. The input terminals of the testing device are substituted for the flashlamp, which is not used, in such a manner that when the synchronizer switch is closed the battery within the synchronizer is connected to the input terminals.

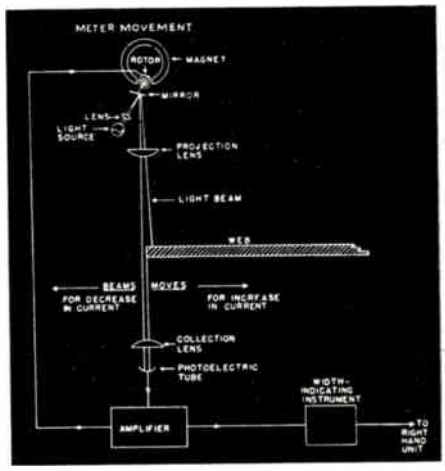
When the synchronizer switch is closed the negative bias applied to the control grid of the first type 2051 thyratron is reduced, causing this tube to conduct. Anode circuit capacitor C_1 starts to charge and continues to charge until the camera shutter blocking off the light beam opens. When the shutter opens the output of the phototube trips the second 2051, which reduces the voltage applied to the anode of the first thyratron by an amount equal to the drop in resistor R_1 sufficient to stop conduction in the first 2051. The capacitor is left with a definite charge, which may then be measured by means of the 6C5G tube connected as a vacuum tube voltmeter calibrated in milliseconds. — Marsal, ELECTRONICS, January, 1942, p. 34.

Width Gage for Moving Webs

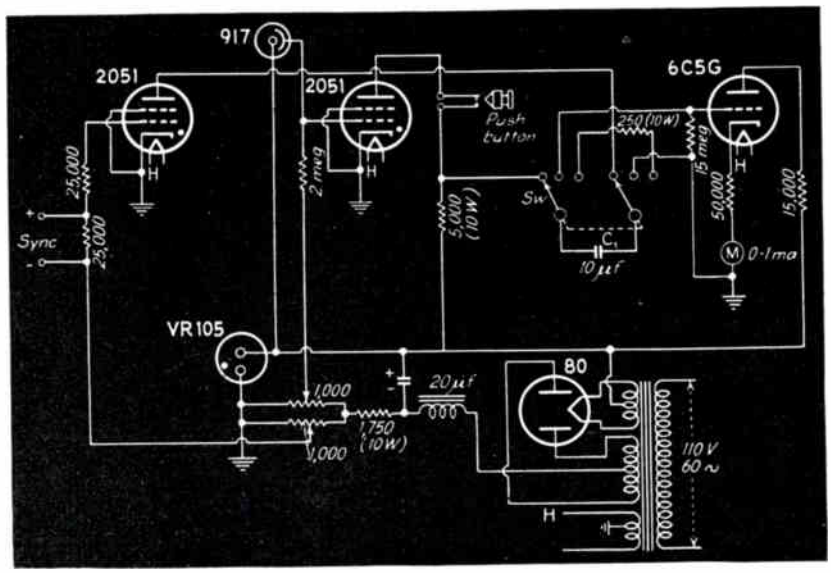
THE WIDTH OF A continuously moving sheet or web of material may be measured during manufacture or processing even where the web shifts slightly from side to side while passing through the fabricating or finishing machine. One measurement system involves photoelectric scanning of each edge of the material, with mechanical movement of the web itself controlling the quantity of light transmitted and causing the beams to follow the material edges as they shift.

Considering one of the two scanning units involved, a light source is focussed upon a mirror fastened to the moving coil of a meter. The light is reflected by the mirror past the edge of the material into a phototube, the initial adjustment permitting the edge of the material to partially cut off the beam. The output of the phototube is fed into an amplifier and the output of the amplifier drives the meter carrying the mirror. Reduction in transmitted light by movement of the web deeper into the light beam changes the mirror angle and causes the beam to move away from the edge of the web until the initial condition of balance is restored. Movement of the web away from the light beam, conversely, increases the light received by the phototube and the meter moves the mirror in such a manner that the beam follows the edge.

The output of the scanning devices at either edge of the sheet or web is combined in an electronic totalizing and indicating device. The indicating device may be calibrated in terms of width despite lateral shifts in the web as, with constant web width, the output of one amplifier declines while that of the other amplifier rises and vice versa, depending upon which way the web shifts. If the width of the measured web remains constant, in other words, shifts from side to side simply add current to the detector on one side and subtract a like amount from the other side, with the net result that there is no change in the position of the indicator. Increasing current indicates increased web width while decreasing current indicates decreasing web width as, under these conditions, amplifier output is additive or subtractive.—Alexander, ELECTRONICS, January, 1942, p. 66.



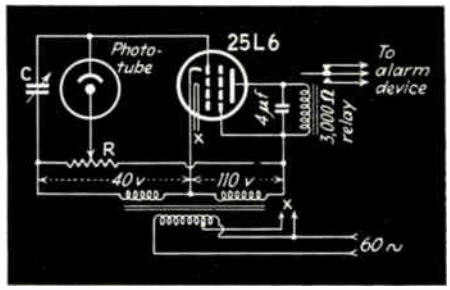
Width gage for moving webs. Two scanning devices are needed, one at each edge. Their outputs are combined in an electronic totalizer and indicator



Photoflash synchronizer tester designed to measure the elapsed time between closing of the switch and opening of the camera shutter

Static Beam Photoelectric Alarm

THE FIGURE SHOWS the schematic of a simple static beam photoelectric alarm device. Light from a distant source is directed across the area to be protected into the phototube. D-c output of the phototube is amplified by the 25L6 and holds a signalling device relay closed so long as the light is uninterrupted by an intruder.



Simple static beamelectric alarm circuit. The 25L6 amplifier phototube self-rectifies its own operating potentials

Capacitor *C* provides a timing adjustment, the length of time required to discharge this capacitor when the beam is interrupted determining the speed with which the device operates. Resistor *R* is a sensitivity adjustment, permitting the bias on the 25L6 to be varied to suit the amount of light impinging upon the phototube.

In this elemental example d-c potentials required for the operation of the amplifier are obtained through self-rectification of applied a.c. by the 25L6 itself. A majority of static beam alarm devices now being made have d-c powerpacks supplying required operating potentials to the amplifier tube or tubes.—MacDonald, ELECTRONICS, February, 1942, p. 38.

Optical Filter Tester

LIGHT LOST IN TRANSMISSION through an optical filter may be measured by the following method:

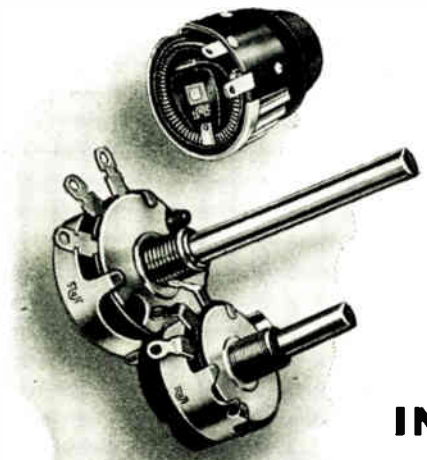
A light source of constant intensity is focused upon a phototube. The phototube operates into an a-c amplifier driving a cathode-ray oscilloscope provided with a 60-cps sinusoidal sweep. An opaque disc or wheel in which there are two apertures directly opposite each other, one aperture containing the filter and the other left open, is placed in the path of the light beam

"KNOW-HOW"

Just as important to many customers as the quality of IRC fixed and variable resistors itself is the "Know-How" of resistor usage that IRC specialized experience makes available.

This "Know-How" is designed into IRC products. It is a big part of IRC customer service. It avoids mistakes in resistor specifications and orders. It simplifies matters of inspection and priorities. It clarifies many special technical problems. Above all, it means invaluable help in selecting the right resistor for the job —chosen without bias as to type from a line sufficiently broad to cover practically every requirement.

For the solution of a large number of the problems confronting the designing engineer, IRC has prepared the Resistor Chart which is yours for the asking. However, many special problems frequently arise requiring the "Know-How" of a trained staff of resistor engineers, which IRC has available.



INTERNATIONAL RESISTANCE COMPANY

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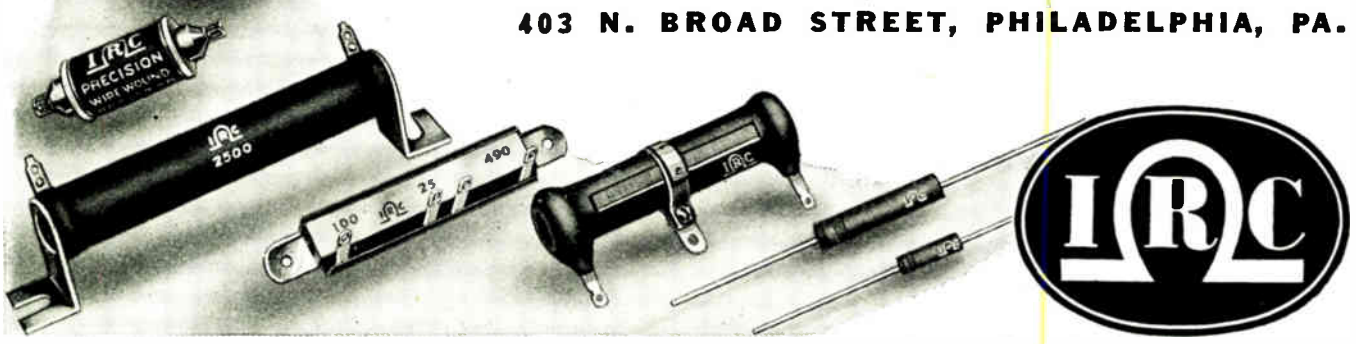
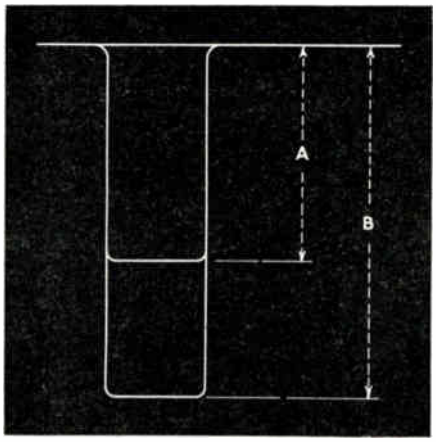


IRC

in such a manner that the light shines alternately through the two apertures when the disc is rotated by a motor running at 1800 r.p.m.

Since such a disc revolves at 30 rps and there are two openings in the disc light will reach the phototube once each 60th second. A pattern similar to the one shown will be observed on the oscilloscope screen, the distance *B* indicating the amount of light reaching the phototube directly and the distance *A* indicating the amount of light reaching the phototube through the filter. Thus the ratio *A/B* represents the percentage light passing through the filter.

If the wavelength of maximum transmission is desired, this may be determined by passing the light from the source through a prism before passing it through the disc apertures. Angular movement of the prism will permit the wavelength of the light transmitted to the phototube to be varied.—Seeley and Anderson, *Review of Scientific Instruments*, August, 1941, p. 392.

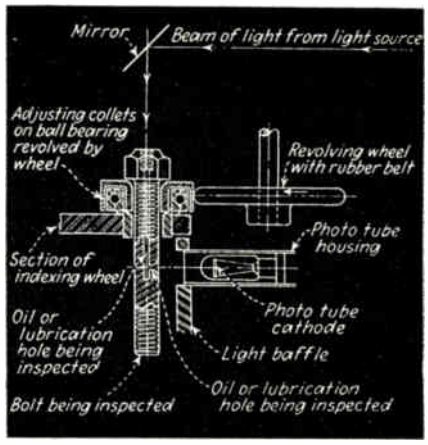


Cathode-ray oscilloscope pattern showing the relationship between light passed directly to a phototube and light passed to the phototube through an optical filter. *B* represent light transmitted directly and *A* light transmitted through the filter

Oil Hole Inspector

AUTOMATICALLY INSPECTING one shackle bolt per second, a photoelectric machine determines that oil holes drilled longitudinally through the bolts exactly meet other oil holes drilled into the bolt centers from the sides.

A beam of light is reflected from a mirror into the longitudinal hole while a bolt is revolved one complete turn by a rubber-tired driving wheel. If the quantity of light at which the device is calibrated fails to reach a phototube mounted adjacent to the side hole during some portion of this cycle, indicating imperfect alignment or a block, the bolt is automatically rejected by an electromechanical mechanism. — Powers, ELECTRONICS, September, 1939, p. 54.



Photoelectric oil-hole inspector

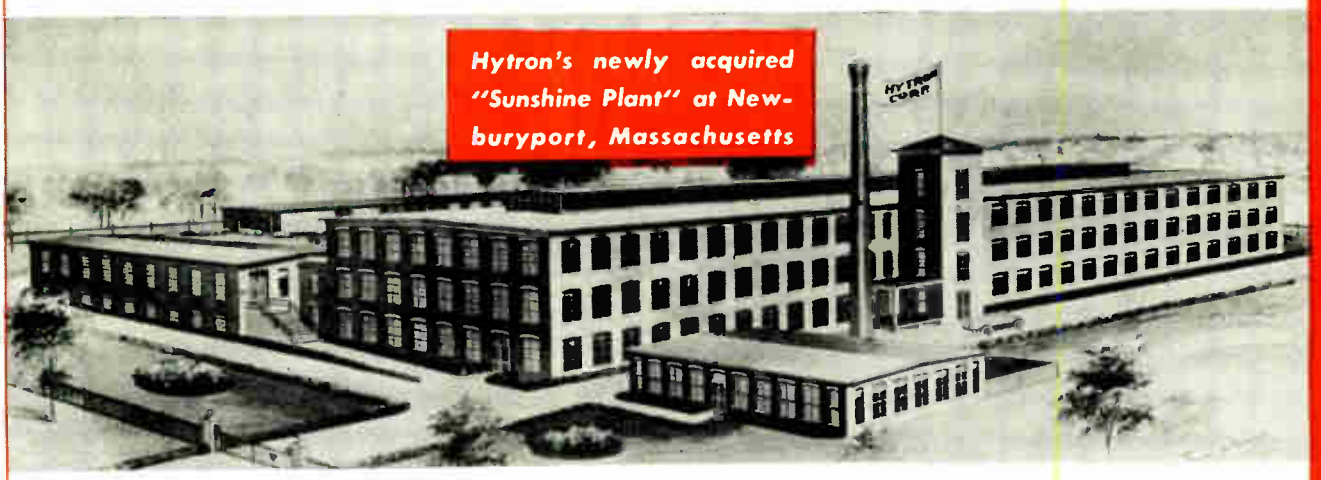
Articulated Weighing Scale

WEIGHING SCALES FREQUENTLY used to indicate one specific weight may be made to actuate an audible or visible signal when that weight is reached.

A small hole is drilled through the face of the scale at a position corresponding to the weight to be indicated. A light source is mounted in front of the hole and a phototube is placed back of the hole in such a manner that the beam of light is interrupted by the pointer or by a flag attached to the pointer when this weight is reached. The output of the phototube is amplified and, when interrupted, operates a relay which energizes the selected signal device.

The advantage of the electronic method of control in this instance is the fact that no error-producing load is introduced in the mechanism of the scale by the articulating device.

Editor's note — This hole-in-the scale device is widely used with phototubes for controlling mechanical or electrical quantities.—Kron Scale Co., ELECTRONICS, January, 1942, p. 60.



Hytron's newly acquired "Sunshine Plant" at Newburyport, Massachusetts

HYTRON now has QUADRUPLED space for war production

Hytron REMEMBERS PEARL HARBOR—Wake Island—Bataan—Corregidor. As its contribution to the swelling tide of production which will equip the nation with an overwhelming flood of war materials to avenge these temporary defeats, Hytron is developing at top speed the productive capacity of its new plant at nearby Newburyport. The new factory is so large that it could easily accommodate on one floor the entire Salem plant. In this appropriately-named radio war, Hytron's quadrupled facilities will play an important part in the production of vital electronic tubes to be used in making the enemy remember with regret his mistake in attacking the United States.

HYTRON CORPORATION

Manufacturers of electronic tubes since 1921

Newburyport . . . MASSACHUSETTS . . . Salem

MORE TUBES FOR VICTORY

RECEIVING — "GT", "G", or "acorns", R.M.A. or Government types, — twenty-two years of experience give you time-tested quality.

TRANSMITTING — Nationally famous u-h-f designs, popular instant-heating tubes for mobile use, standard Hytron triodes and rectifiers, all perform efficiently—dependably.

SPECIAL PURPOSE — From medium power tubes to tiny miniature types, Hytron welcomes the opportunity to manufacture in production quantities the specialized tubes you may need for your war production.

Hytron's Plant at Salem

Measurement of Turbidity in Liquids

THE TURBIDITY OF ALMOST clear solutions can be measured by the extent to which a light beam is dispersed by the suspended particles. By the use of proper filters, colored solutions can also be measured. The method is to pass a collimated light beam through two grids consisting of alternate bars and open spaces with the sample and a lens system between them. The grids must be machined very accurately so that the two units are of the same dimensions and so that the bars and the open spaces are of the same size. After the light beam passes through the first grid it consists of several beams which are rectangular in cross section. A pair of 4-inch objective lenses is mounted in a slide for focussing.

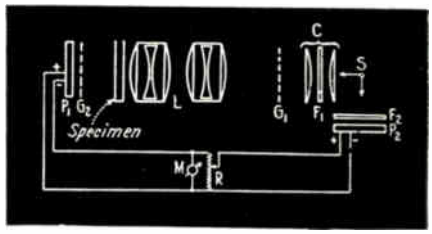


Diagram of the circuit and optical system of the photoelectric turbidimeter

The lens system is adjusted so that the light beam has unity magnification on the second grid. The second grid is positioned so that the rectangular portions of the light beam fall on the bars. Thus, no light gets past the second grid, except that which results from imperfect machining of the grids. Beyond the second grid is a barrier type photocell to detect any light. Another photocell is located near the light source as shown in the diagram and connected to a potentiometer across which are connected the first photocell and a microammeter. This is for the purpose of balancing out any light getting past the second grid.

When a liquid sample is placed between the two grids as shown, any suspended particles cause a dispersal of the light and permits it to pass through the openings of the second grid to the photocell where it is converted into electrical energy for measurement.—Silverman, *Review of Scientific Instruments*, February, 1941 (ELECTRONICS, April, 1941, p. 100).

THE DSD 880 WINCHESTER SYSTEM.

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EXCEPT DIGITAL DOESN'T MAKE IT.

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★ "OEMS: Don't miss the new 700 Series of Multibus Winchesters at NCC booth #A549, Astroarena, Houston."

The people at Digital are a pretty smart bunch. They make some of the finest small computers in the world. So we like to think that if they were to make a new storage system like our 880 Winchester/Floppy, they'd do it the same way we did.

First of all, they'd make it extremely reliable with extensive testing and by using one of the most reliable storage technologies known, the Winchester.

Next, they'd offer it in different capacities, like 7.8, 20.8, and 31.2 megabytes, with a choice of .5 or 1 Mb floppy back-up, or none at all.

These different configurations would, of course, be fully compatible with Digital's LSI-11 and PDP®-11 computers.

And the whole package would be extremely compact, just 5¼ inches high, so it would save space and fit in almost anywhere.

They might even add some on-board self-diagnostics, similar to our exclusive HyperDiagnostics,™ so you could test, exercise, and debug without a CPU. And cut down on your service costs at the same time.

Maybe they'd even institute a module swap program, something like our Rapid Module Exchange,™ which would be designed to get you back up and running within twenty-four hours.

Finally, since this system would be so dependable, they'd be able to offer their extended service at a much lower price—much like we do with our own HyperService,™ which goes into effect when the 90-day warranty expires and covers everything.

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Packaging & production

Machine etches fine metal lines

Reactive ion etching system reduces undercutting to make aluminum lines 0.5 μm wide

With the geometries of very large-scale integrated circuits approaching the submicrometer region, semiconductor manufacturers have turned to dry plasma etching systems, which offer tighter control in oxide, nitride, and polysilicon etching. But the size of many VLSI devices is determined by the metal interconnections, which are wet-etched and must be made wide enough for the acid etching not to completely undercut them.

A new system from Technics West Inc. promises to solve this problem with reactive ion etching [*Electronics*, April 21, p. 33]. With this technique, metal lines can be produced that are 0.5 μm wide on 0.5-μm spacing, with a height of 1 μm.

Reactive ion etching combines the characteristics of two established wafer-processing techniques—plasma etching and ion milling. As in plasma etching, reactive chemicals in a gas plasma are employed, but the plasma's ions are accelerated in a collimated beam, as in ion milling. The beam strikes the bottom of the etch pattern and not the sidewalls, greatly reducing undercutting and allowing narrower metal lines.

The reactive ion etching takes place in a chamber where the cathode is a hexagonal aluminum column on which the wafers are mounted. The anode is a stainless steel bell jar. Four wafers (3, 4, or 5 in. in diameter) are mounted on each of the six surfaces. A complete etching cycle takes 40 minutes, so the system, called the HE-II, has a throughput of 36 wafers per hour.

Technics West has been building plasma etching and ion milling systems for about 10 years. The HE-II, which is based on a process developed and licensed by Western Electric's Bell Laboratories, will be shown for the first time at Semicon/West, the semiconductor production-equipment trade show held in San Mateo, Calif., May 25–28.

The HE-II will sell for about $250,000, depending on configuration. Delivery is in six months.

In addition to the ion etching system, Technics West has developed a wafer loader that automatically takes wafers from standard cassettes and loads them onto the special carriers that mount on each of the six processing surfaces. Pricing for the loader has not yet been set.

Technics West Inc., 2305 Paragon Dr., San Jose, Calif. 95131. Phone (408) 946-8700 [435]

Hybrid aligner exposes fine lines

Mask aligner's critical stage is pneumatically isolated to achieve 1-μm line widths

The key to aligning geometries with dimensions of around 1 μm on thin-film hybrids, flat-screen displays, microwave hybrids, and other fine-line devices is a vibration-free system that enables an operator to view the mask and substrate clearly at high magnifications. Optical Associates Inc. has designed its new series 500 mask aligner so that its mask-to-substrate alignment stage is located on a vibration-free pneumatically isolated exposure platform. The Hybralign 500 system, a successor to the proven 400 series, can accommodate substrates up to 4 in. on a side and rectangular masks with a diagonal dimension of 7 in.

At higher magnifications (up to ×400) it is essential that the substrate surface remain in focus as the microscope is moved along any axis during the alignment phase. To achieve this, the aligner first brings the substrate surface into contact with the mask. When separated, the system keeps the mask and surface parallel, compensating for any substrate-wedge error.

Selection of microscopes. Another key feature of the 500 aligner is its wide microscope adaptability. The user can select from a variety of split-field metallurgical microscopes

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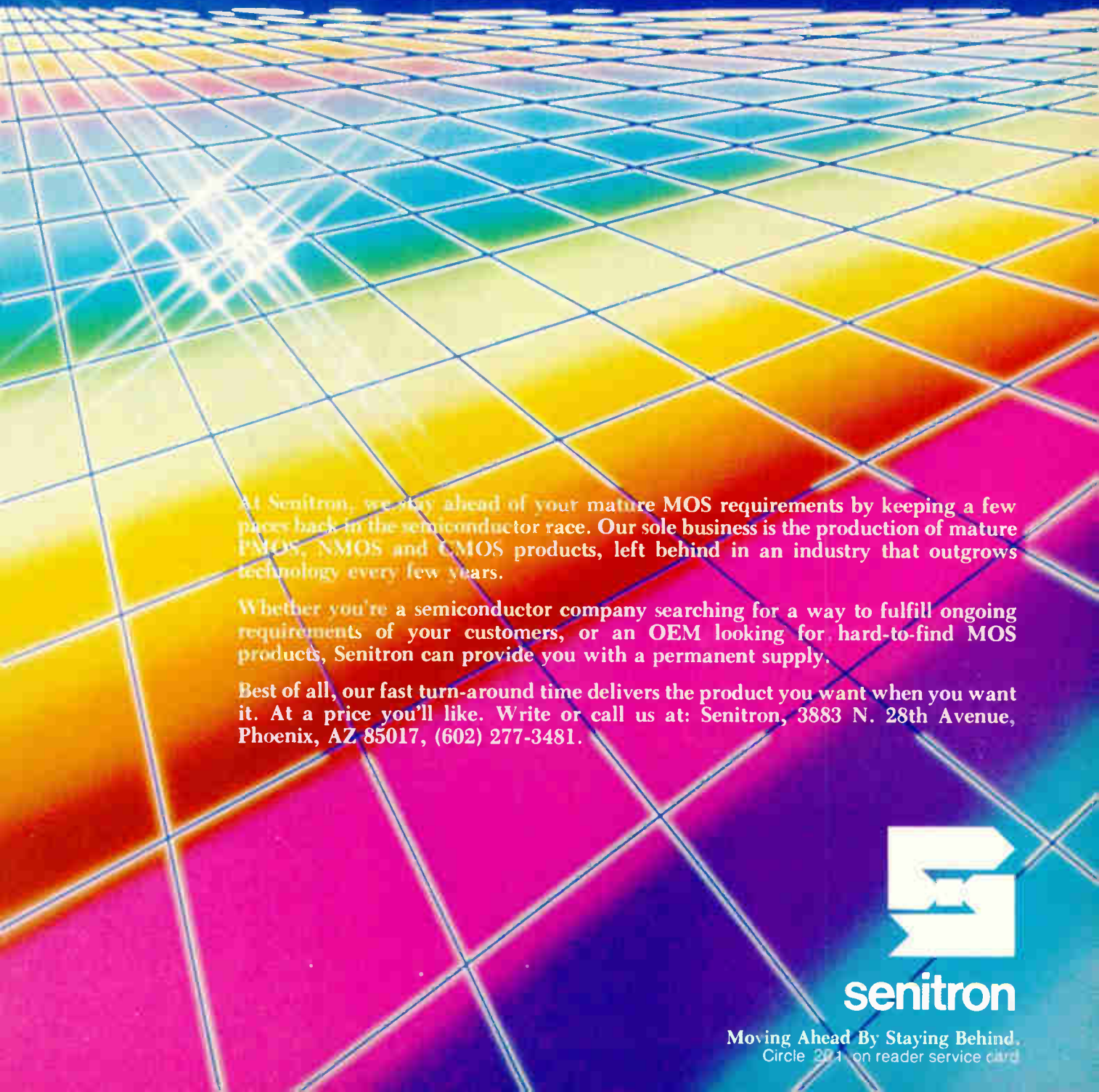

At Senitron, we stay ahead of your mature MOS requirements by keeping a few paces back in the semiconductor race. Our sole business is the production of mature PMOS, NMOS and CMOS products, left behind in an industry that outgrows technology every few years.

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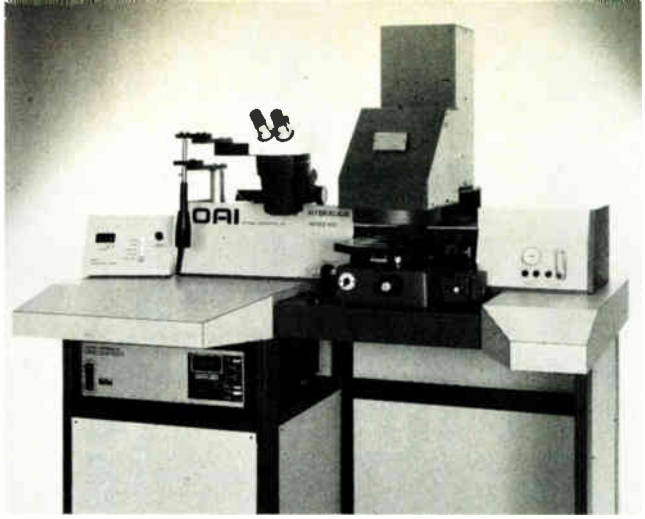
Moving Ahead By Staying Behind.

with a bright- and dark-field capability or units operating on Nomarski interference-contrast principles, which are especially valuable when lining up a feature to a metal edge.

The mask-to-substrate alignment stage is supplied with differential micrometers that provide fine vernier control of X- and Y-axis movements of the substrate holder. In addition, the microscope joystick has finger-tip–operated X- and Y-axis brakes. Another valuable feature is simple, direct operator control of the pneumatically powered stage positioning for the alignment and exposure steps. In the off-load, on-load phase, there is unobstructed access to the entire mask-to-substrate alignment stage.



Other features of the system, which is priced at approximately $25,000, are constant intensity control at the substrate surface and a shutter timer. Light sources for the unit are available with collimating lenses up to 7 in. in diameter and with lamp ratings of up to 500 W.

Optical Associates Inc., 3300 Edward Ave., Santa Clara, Calif. 95050. Phone (408) 988-6900 [436]

Gage controls lapping to 0.5 μm

Quartz crystal is lapped with wafers; its resonance is used to monitor progress

Thickness is a parameter that must be carefully controlled in the process of lapping metals, semiconductors, or insulators. A new piezoelectric gage from Transat Corp. employs a low-cost, disposable quartz sensor disk to monitor the thickness of work pieces during lapping to an accuracy of 0.5 μm and terminate the process automatically when the work pieces reach a preset thickness.

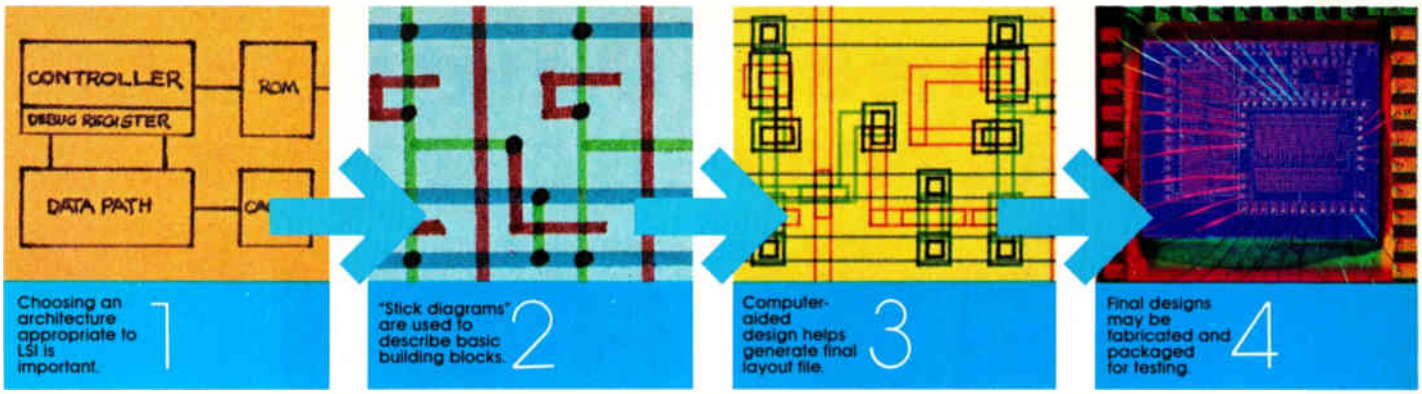
The measurement, twice as accurate as those of existing instruments used for this purpose, is independent of lap-plate wear—it indicates the thickness of the machined pieces, not the distance between the lap plate and a fixed reference surface.

The gage consists of a control unit and a base unit. The control unit contains the thickness display and a key pad for entering the desired control parameters. It can be located near the operator or mounted in the control panel of the lap machine. The base unit contains the main electronics and can be remotely located.

The gage measures the oscillation frequency of the quartz monitor disk in two modes, from 1 to 40 MHz. The control unit translates frequency into thickness. Normally the gage uses the frequency constant of AT-cut quartz monitors ($k = 1.66 \times 10^9$ μm-Hz), but other constants can be entered through the keyboard. The thickness dimension can be read out in micrometers or mils. Furthermore, an offset can be entered to account for the added thickness of a spacer on which the monitor can be mounted. With the standard frequency constant, thickness can be measured from 1,660 down to 41.5 μm. With the addition of a spacer, greater thicknesses can be measured.

In an actual lapping operation, a small quartz monitor blank is inserted into the center of one or more wafer carriers. An electrode is mounted in the lap plate, its face flush with the lap surface and positioned so that it meets the quartz monitor once each revolution. A variable-frequency sweep signal is applied to the electrode from the gage. The signal flows through the quartz monitor and then back to the electrode.

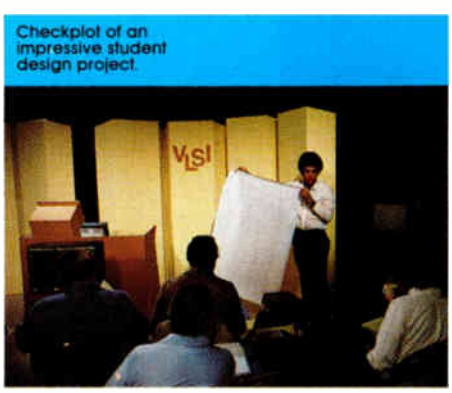
Target resonance. The monitor oscillates, responding strongly when its mechanical resonance frequency coincides with the signal frequency. The resonant frequency is sensed and compared with a target frequency. When the resonant frequency of the monitor equals the target value, the lapping motor is stopped by a relay. Thickness equals the frequen-



LEARN VLSI DESIGN!

If you want to take part in LSI/VLSI design–and understand what this technology means to you, your company, and your career–you can't sit back and watch. **Join the design revolution of the '80's!** Learn VLSI design!

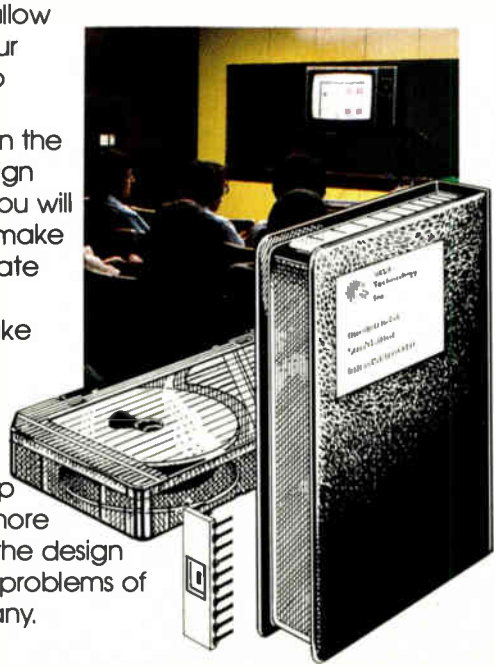
And that's what this new **video tape course** from VLSI Technology, Inc. is all about–actually "doing LSI/VLSI". Filmed before a class of managers, engineers, and CAD specialists from Hewlett-Packard, this 21 hour video



tape series teaches you how to **architect, design, and layout your own proprietary chips.** Homework assignments are provided so you can learn by doing. Some of you may actually fabricate your first designs.

The instructors for this course have debugged the material over the past two years while teaching LSI/VLSI design courses at M.I.T., Caltech, Stanford, and U.C. Berkeley. Similar courses based on the Mead/Conway design methodology are now being taught at **DEC, Xerox, Varian, Bell Labs, and Hewlett-Packard,** as well as at over 30 major universities in the U.S. and Europe.

Now you and your company have the opportunity to take part in this valuable course at your own plant or office. A modest programming or digital design background are the prerequisites. **Managers, engineers, programmers, and CAD specialists** can all benefit. This new course will allow you and your company to become a participant in the LSI/VLSI design revolution. You will be able to make more accurate technology tradeoffs, take part in proprietary chip-design programs, and develop CAD tools more attuned to the design and testing problems of your company.



Learning a new technology is not easy. It takes work–and a lot of it. If you're willing to make that commitment, and **move your career and company forward.** Join the design revolution of the '80's! **Learn VLSI design!**

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cy constant, k, divided by the resonant frequency. For quartz, k is precise within about 1 part per million. The monitor, which costs about 15¢, is lapped down with the lap load and discarded after the process.

The gage has been evaluated by a major lapping-machine manufacturer, and several are currently being installed at integrated-circuit firms. It is priced at about $8,000 and can be delivered in eight weeks.

Transat Corp., 3713 Lee Rd., Shaker Heights, Ohio 44120. Phone (216) 991-7300 [437]

Dense connector takes vibration

Stacking connector uses wires bonded to elastomer to link boards despite knocks

The stacked or board-to-board connector has evolved into an attractive alternative to the backplane. Present metallic-contact board-to-board connectors are adequate for most applications but are limited to relatively low-density interconnections and, in addition, are susceptible to failure due to shock and vibration.

Tecknit has developed a high-density, low-resistance elastomeric connector assembly for board-to-board applications where center-to-center contact spacing is less than 50 mils and where the system must withstand a certain amount of vibration.

The assembly consists of a low-resistance Zebra series 7000 elastomeric connector inserted into the slot of a plastic dielectric holder, which is held in position between a pair of printed-circuit boards with two screws. The holder is designed to align the pc boards and also acts as a controlled deflection stop.

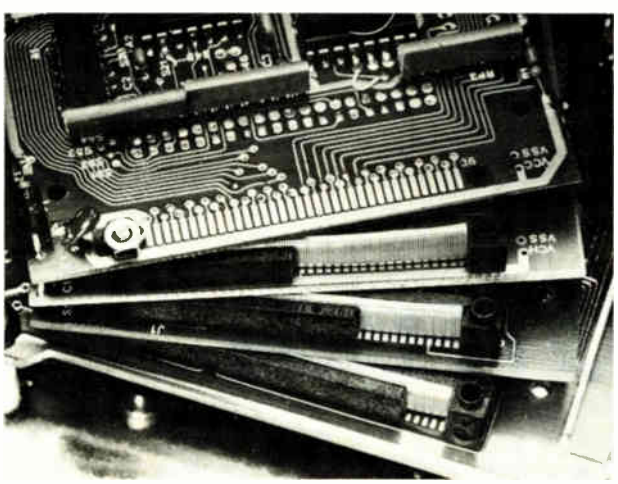
The elastomeric connector element is a D-shaped low-durometer silicone elastomeric core around which run flat metal conductors. Parallel rows of these wires are vulcanized to the surface of the silicone and become part of the composite material.

When the connector is deflected by vibration between the pc boards, there is no danger of the wires coming loose since the bond between the wires and rubber is stronger than the rubber itself. The elastomer also provides excellent shock and vibration damping and forms a gas-tight seal where it contacts the board.

At the extreme top and bottom of the D configuration, the tips of the flat wires flare upwards so point contact can be achieved. This contact penetrates any surface oxides or other contaminants present on the surface of the contact pads, ensuring a reliable electrical connection in addition to the connection through the flat surface of the element. The flat wires of the elastomeric insert are on 15-mil centers and typically have a contact resistance of 20 mΩ when connected to a pad 35 mils wide.

The new connector offers a pressure-type connection that eliminates problems associated with soldering and lead straightening and allows for rapid assembly and disassembly of interconnected boards. A plastic holder and connecting element 2¼ in. long sell for about $3 in lots of over 20,000. Deliveries are in about three weeks.

Tecknit, 129 Dermody St., Cranford, N. J. 07016. Phone (201) 272-5500 [438]



Chip sorter permits chip inspection

A programmable chip sorter enables users to categorize integrated-circuit chips and diodes and simultaneously moves them from film-mounted sawed wafers to waffle packs and from waffle packs to substrates, hybrid circuits, or other packages.

The KTC Placement System can load the chips in up to four separate waffle packs. The operator visually determines the chip's category and then presses the appropriate output button (labeled A through D), causing the chips to be automatically placed in the designated chip tray.

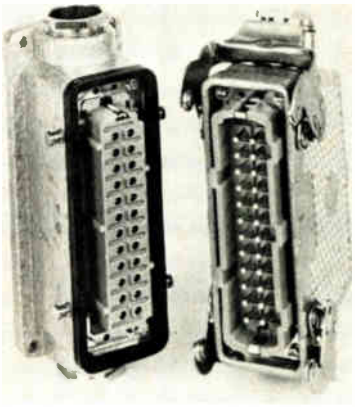
The chips are picked up from the input table by a dual-tip 180° transfer head and transferred to the output table. Both 4-by-4-in. tables are microprocessor-controlled with programmable read-only and random-access memory and have several optional tooling holders.

The KTC Placement System is available with a closed-circuit television monitoring system that is used to align and inspect chips transferred from film through a die-elevator device and sells for $34,500. With a stereo microscope monitoring system used for high-quality inspection, it sells for $32,500. Delivery takes eight to ten weeks.

Keller Technology Corp., P. O. Box 103, Buffalo, N. Y. 14217. Phone (716) 693-3840 [393]

Multipole connectors work in hostile environments

A line of multipole connectors with die-cast aluminum housings resists dirt, grease, oil, vibration, and sea water. They are commonly used for heavy-duty machine tools, industrial



machinery and processing equipment, electronic medical equipment, transport and recreational vehicles, and outdoor advertising and communications equipment.

The environmentally protected connectors comply with DIN 40050 standards and are VDE rated. Their positive-locking latch comes in zinc-plated steel or stainless steel, and the neoprene gasket seal is resistant to aging.

Available with either screw-, solder-, or crimp-type terminations, the multipole connectors are priced at $38 each. Delivery takes eight to ten weeks after receipt of order.

Electrovert Inc., Components Division, 399 Executive Blvd., Elmsford, N. Y. 10523. Phone (914) 592-7322 [394]

Desoldering unit removes components from pc boards

In the offing is a desoldering system, the printed-circuit-board reflow module, which can remove bad multi-lead components quickly and easily from printed-circuit boards in about 5 seconds. The component to be removed is positioned so that a predetermined amount of solder flows against the lead pattern of the component. The flowing solder transmits enough heat to cause solder in all lead holes to melt for instant removal of the component. The operator need not be experienced to operate the system because the only thing that touches the board is the flowing solder.

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Propagation Delay	2ns
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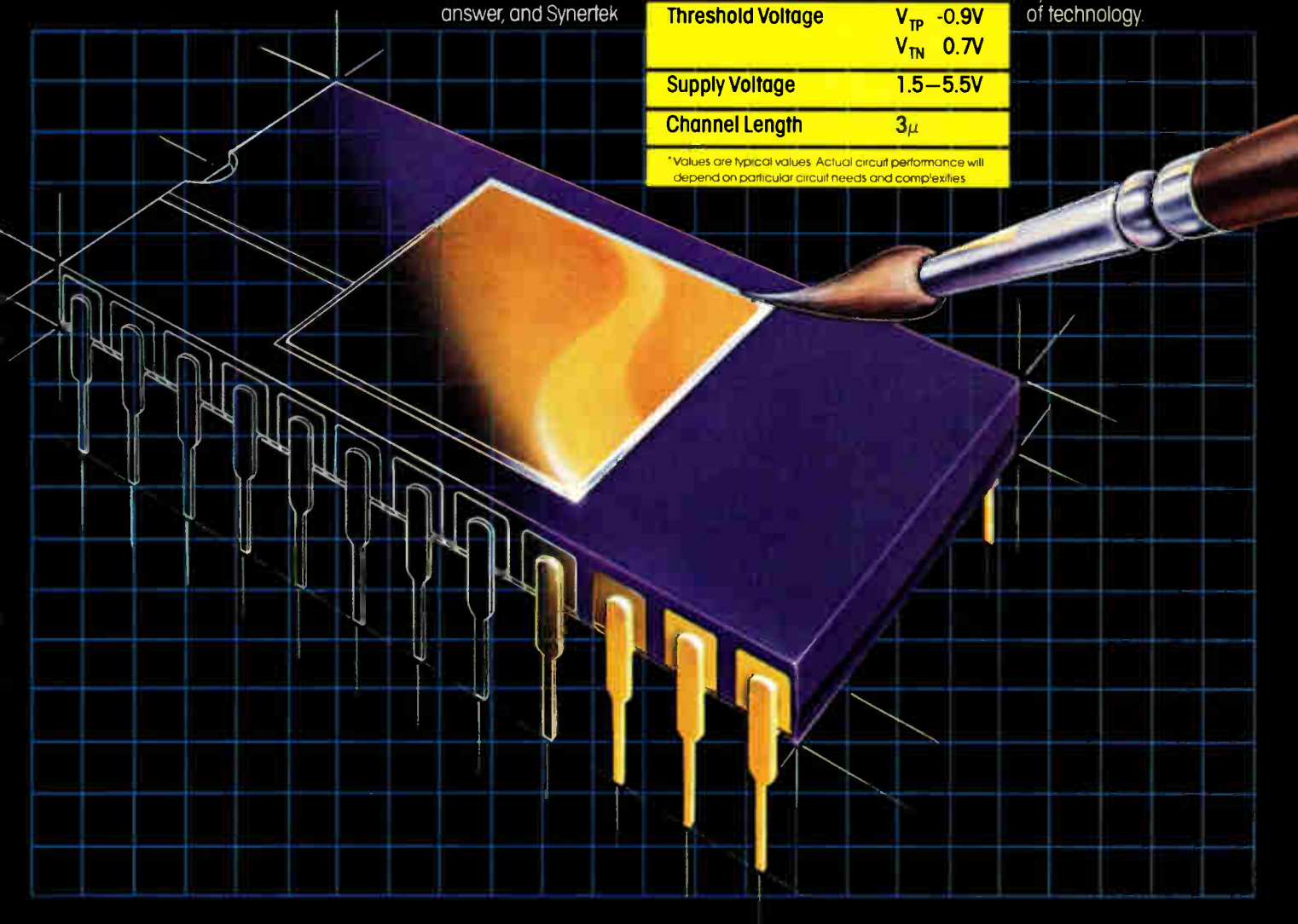
Supply Voltage	1.5–5.5V
Channel Length	3μ

*Values are typical values. Actual circuit performance will depend on particular circuit needs and complexities



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reflow module, faulty assemblies can be economically repaired, and valuable components can be salvaged from nonfunctional boards, thus reducing the cost of replacement, according to its maker.

The desoldering system is available as a table-top model or as a console station with adjustable board carriers, a target locator, and temperature and speed controls. It is framed in an acrylic-polyvinyl-chloride housing and is priced at $3,900. Delivery takes six weeks.

Air-Vac Engineering Co., 100 Gulf St., Milford, Conn. 06450. Phone (203) 874-2541 [395]

Pc-board cleaning systems sell for under $10,000

Two aqueous cleaning systems, the Aquamatic I and II, wash, rinse, and dry printed-circuit boards. They incorporate features normally found in only the much larger systems but have a base price starting at under $10,000—lower than any comparable system in the industry, its maker claims.

The Aquamatic I is a modular system with a series of seven basic modules that can be added or subtracted according to the user's needs. The Aquamatic II is a self-contained unit incorporating three basic stations. Both are available with a variety of options and accessories for custom-designed systems. The Aquamatic I, for example, comes with an optional clear window for inspection of the cleaning operation. A nonpolluting and economical cleaning stage that uses water to eliminate constant dumping and monitoring is common to both systems.

The Aquamatic I and II can handle pc boards up to 12 in. wide and can be used in line with larger systems, including soldering systems, without costly modifications. Delivery is estimated at eight to 10 weeks after receipt of order.

The John Treiber Co., 18120 Mount Washington St., Fountain Valley, Calif. 92708. Phone (714) 557-1821 [398]

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"ELECTRO BOOTH NUMBER 2538"

Circle 209 on reader service card

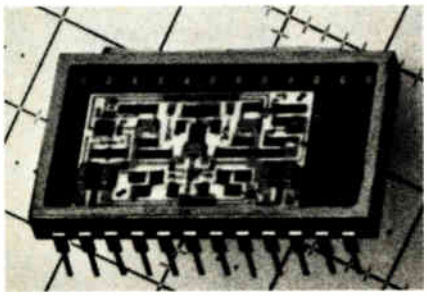
Components

Hybrid op amp runs at 70 MHz

High-speed unit's performance is stable without compensation over gain range of 1 to 40

Comlinear Corp. is offering a hybrid operational amplifier of exceptional performance. It has, says David A. Nelson, president, a gain-phase response that is flat from dc to 100 MHz and an unconditional stability not requiring external components.

The CLC103's typical small-signal 3-dB bandwidth is 150 MHz, and the minimum full-power (an ouput of 20 V peak to peak) 3-dB bandwidth is 70 MHz for noninverting applications or 75 MHz when the input is inverted. These minimums hold over a range of transfer gains (V_{out}/V_{in}) of 1 to 40. The typical slew rate is greater than 6 V/ns.



For a 10-V output step, typical settling time to within 0.4% of final value is 5 ns and to within 0.2% is 10 ns. Maximum settling times at a transfer gain of 20 are 8 ns to within 0.4% of a 10-V step and 15 ns to 0.2%. Phase linearity from dc to half the bandwidth is within 1°.

Stable performance at this high level is maintained by a proprietary design that keeps the op amp's closed-loop gain constant as transfer gain is varied by a single external resistor from 1 to 40, says Nelson. With closed-loop gain held constant, no change in internal compensation is required as transfer gain is varied. Unlike conventional op amp designs where the optimum gain-bandwidth product is achieved at high gain, minimum settling time occurs at a gain of −1, and the minimum slew rate is found at a gain of +1, the year-old-firm's device is consistent in almost all aspects of performance over its entire gain range.

The hybrid's high stability at all gain settings "means that no compensating capacitors or resistors are needed to maintain stable gain and high-fidelity pulse response," says Nelson. "This eliminates the expense of adjustable capacitors and the labor of a trained technician to adjust them."

Uses. Comlinear is targeting the CLC103 for use with 100-MHz flash analog-to-digital and digital-to-analog converters, as preamplifiers for high-speed fiber-optic detectors and photomultiplier tubes, as high-performance low-cost output amplifiers for function and pulse generators, and for baseband video communications in such applications as satellite earth stations.

Group delay for the CLC103 is typically 2.2 ns at a transfer gain of 4, 2.9 ns at a gain of 20, and 3.5 ns at a gain of 40. Overshoot for a 1-ns input rise time and a 20-V output step is typically 3% at gains of 20 and 40 and 12% for a gain of 4. For a 5-V step, overshoot is only 2% at a gain of 20. The part's high linearity is typified by a minimum third-order intermodulation intercept of 40 dBm at 20 MHz. At 50 MHz, 1-dB gain compression occurs at 20 V peak-to-peak output.

Input offset voltage is typically less than 30 mV and drifts less than 50 μV/°C. The unit draws 27 mA from a ±15-V supply—supply levels may range from ±9 to ±16 V. The two bipolar output transistors will put out ±200 mA at 12 V peak.

In a 24-pin ceramic dual in-line package, the CLC103 is priced at $150 each in small quantities. For orders of 1,000 pieces or more, the price is under $100; production quantities will be available this month. The operating temperature range is −25° to +85°C. Comlinear is also offering a version that meets MIL-STD-883B, operating at from −55° to +125°C.

Comlinear Corp., 2468 East Ninth St., Loveland, Colo. 80537. Phone (303) 669-9433 [341]

Instrumentation filter and amplifier eliminate aliasing

The PDF-106 instrumentation amplifier and filter conditions signals and eliminates aliasing by limiting the input-signal bandwidth. The -106 combines a programmable, high-performance instrumentation amplifier and a low-pass, six-pole Butterworth filter that is housed in a thick-film hybrid circuit, hermetically sealed in a 24-pin dual in-line package.

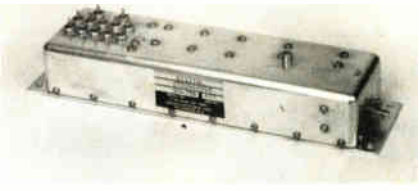
Amplifier gain is from 0.1 to 1,000, amplifier offset is ±100%, and the filter cutoff is between 5 Hz and 5 kHz. All values are determined by external resistors. The amplifier-filter combination has floating differential inputs, an input range of ±10 V, and a high common-mode rejection ratio—110 dB minimum for a gain of 1,000. The device's gain stability is within 2% between −35° and +85°C.

The -106 is approximately $200, with delivery from stock.

Aydin Vector Division, P. O. Box 328, Newtown, Pa. 18940. Phone (215) 968-4271 [343]

Digital attenuators operate over dc-to-400-MHz range

A line of TTL-programmable digital attenuators spans the frequency range of dc to 400 MHz, with a maximum attenuation to 127 dB. These miniature components are capable of providing attenuation with a preci-



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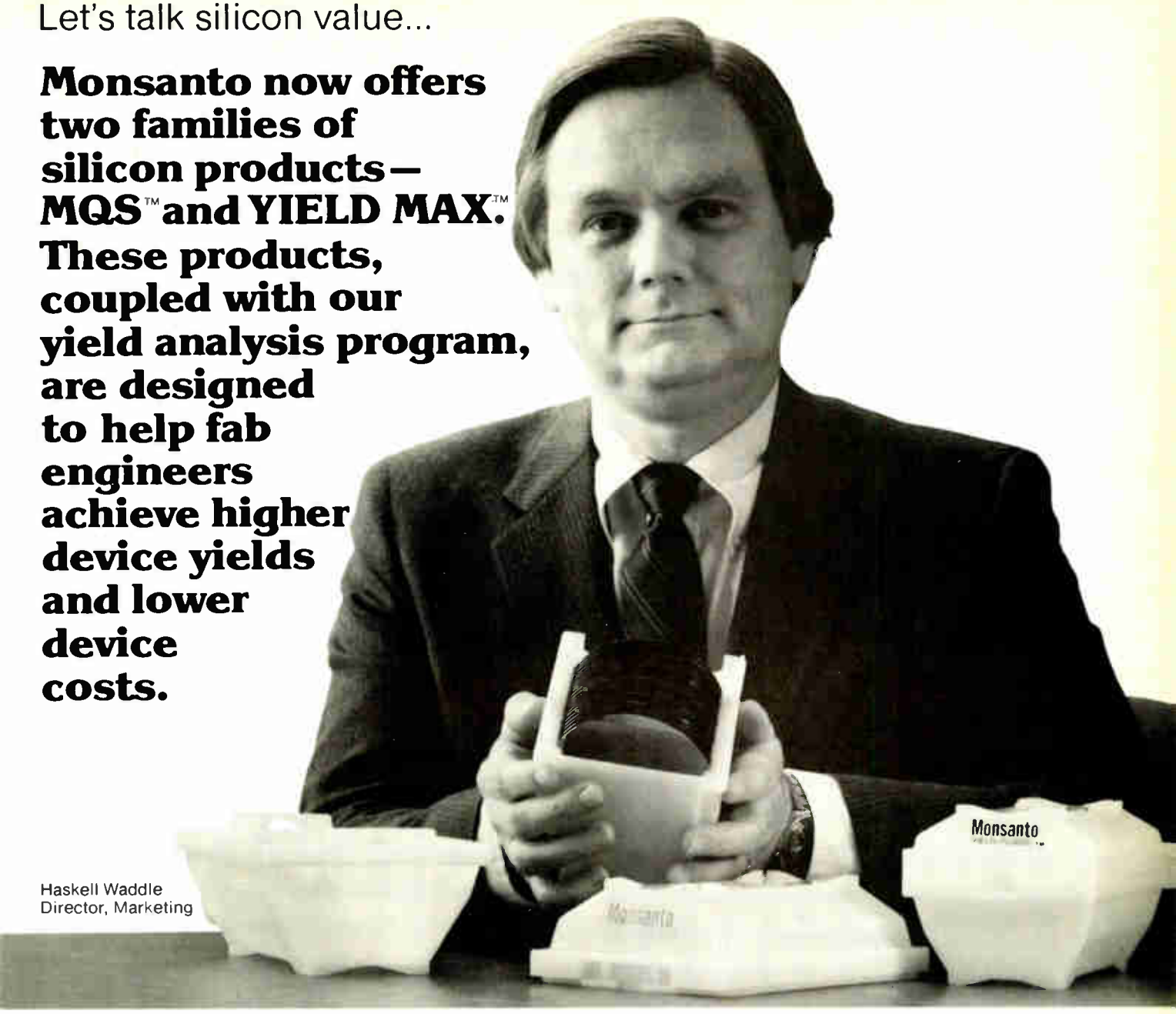

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Circle 211 on reader service card

sion normally associated with mechanical step attenuators.

The DA-600 series covers the 1.0 to-35-MHz range with a balanced configuration that reduces switching transients to extremely low levels, while the -700 series covers the 20-to-400-MHz range with attenuation in 1-dB steps to 127 dB. A third series, the -800, uses miniature electromechanical devices to cover the dc-to-35-MHz range with negligible switching transients and distortion.

The series is available in a variety of binary or binary-coded–decimal sequences, including single-bit units suitable for interspersion in signal paths where gain-attenuation profiles require critical control. Switching times are 200 ns for the -600 series, 2 μs for the -700 series, and 3.0 ms for the -800 series.

The devices range in price from $460 to $1,995 each. Delivery takes 60 days and longer.

Lorch Electronics Corp., 105 Cedar La., Englewood, N. J. 07631. Phone (201) 569-8282 [344]

Pulsed laser diode works at wavelengths of 870 to 904 nm

The PLD-10, a high-performance, military-grade laser diode, is a gallium-aluminum-arsenide laser designed for pulsed operation. The laser has a mirror-coated, multilayer, heterojunction design and operates on a low threshold current. The device's output power is typically 10 W.

The laser diode is available at peak wavelengths of 870 to 904 nm. Each laser is factory tested for 24 continuous hours before shipment. The pulsed laser diode, packaged in an optically centered, hermetically sealed case, can be used in a variety of military systems including laser range finders, proximity devices, and target designators. Available for immediate delivery, the -10 sells for approximately $150 each.

Laseron, 655 Concord St., Suite 1, Framingham, Mass. 01701. Phone (617) 872-9870 [345]

Resistor networks in plastic packages meet military specs

Housed in plastic 8-, 14-, and 16-pin dual in-line packages with a 99.5% alumina substrate and 0.100-in. lead spacings are the F08, F14, and F16 series, respectively, thin-film precision resistor networks that meet the specifications of characteristic V of MIL-R-83401. Automatically insertable, the devices have standard resistor tolerances of $\pm 0.1\%$, $\pm 0.5\%$, and $\pm 1\%$ absolute, respectively. Their temperature coefficient of resistance is 50 ppm/°C, and their operating temperature range checks in at $-55°$ to $+125°$C.

Suitable for replacing discrete precision resistors, the resistor networks' applications include matched pairs, pull-up resistor arrays for unused TTL gates, parallel high-speed circuitry, wire-OR gate configurations, and TTL-MOS interfacing.

In 1,000-unit lots the devices sell for 95¢ each, with delivery taking eight weeks.

Allen-Bradley Co., Electronics Division, 1201 South Second St., Milwaukee, Wis. 53204. Phone (414) 671-2000 [346]

Full-travel keyboard has ergonomic features

A full-travel membrane-type keyboard, called Screened-Contact, for wired-only keyboard requirements is designed to replace more expensive and less reliable gold-contact switches.

The keyboard, which will be exhibited at the National Computer Conference next month, meets all of the new ergonomic standards, including the German DIN requirements. Each switch is 19 mm high and has a lifetime of over 50 million operations.

The board is mounted on a rigid frame, and stepped or sculptured keytops are available—a nonglare keytop finish is standard. The 53-station keyboard with a wired-only, X-Y matrix termination will be delivered from stock for $76.07 each in lots of 1 to 9 and $52.90 each in quantities over 50.

In addition, the firm has introduced an off-the-shelf enclosed keyboard, model P2492, that includes an 83-station microprocessor-encoded capacitance keyboard with serial ASCII output. This keyboard will be available from stock for $149.63 without an enclosure and $212.63 with one for 1 to 9 units.

Key Tronic Corp., P. O. Box 14687, Spokane, Wash. 99214. Phone (509) 928-8000 [347]

Membrane-telephone keypad costs as little as 45¢ each

Added to the Kriket series of silicone elastomer keypads is a standard telephone-array membrane keypad. The units are guaranteed for 3 million cycles and have typical contact resistances of less than 200 Ω. Center-to-center spacing, in both directions, is 17.5 mm.

The keypad is configured in the standard three-by-four-key array, but customers can use multiple pads to make larger arrays. Available from stock, the keypads sell for $1.25 each in the 50-piece minimum order and for as low as 45¢ each in quantities over 10,000.

Conductive Rubber Technology, Olive Mill Plaza, 1230 Coast Village Circle, Santa Barbara, Calif. 93108. Phone (805) 969-5807 [348]

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Circle 213 on reader service card

Cyborg Corporation, 55 Chapel Street, Newton, MA 02158 (617) 964-9020

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RCA's new CD40117B is the industry's first low-current data terminator.

Consisting of two 4-bit terminators, it can be used to terminate a data bus to a high or low logic state. Or to terminate any open or unused CMOS logic input to the last driven logic state with 3-state logic or during power down.

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RCA Solid State headquarters: Somerville, NJ. Brussels. Sao Paulo. Hong Kong.

Circle 214 on reader service card

Computers & peripherals

Q-bus card links to current loop

Communications card also offers RS-232-C link, lets Unibus code run on LSI-11

The world is opening up to Digital Equipment Corp. LSI-11 users who can now choose between current-loop and RS-232-C interfaces, and now Unibus *aficionados* will be able to bring their software to the LSI-11 environment—all because MDB Systems Inc. has expanded its line of DEC-compatible boards with a system communication module that is a multifunction board.

The MLSI-SCM11 offers a variety of features that are not available on the comparable DEC board, the MXV11RC, according to MDB design engineer Sandy Traylor. Foremost among these is the ability to interface with both current-loop and RS-232-C peripherals. The single port on the board accepts either, letting users switch equipment easily without worrying about compatibility, she notes.

Two features permit users to carry over Unibus software. The -SCM11 offers support for four-level interrupt schemes, so Unibus packages can be brought to it without modification. A clock-programmable interrupt capability is another aspect that makes it easy to maintain Unibus software. The board provides for the timed interrupts needed for Unibus programs that are not a feature of the LSI-11. When Unibus software runs, the LSI-11 ignores the interrupts, obviating code rewriting.

A selector on the front of the board lets users manually change transmission rates when devices of different speeds are used. This quick conversion method eliminates special software packages needed on some systems for rate alteration or the powering down of the system for hardware conversions required on others, says Traylor. Rates from 110 b/s to 38.4 kb/s are standard.

As a troubleshooting aid, the -SCM11 has two light-emitting diodes that show whether the board is transmitting or receiving data. This feature, common to many of MDB's recent introductions, makes it simpler to determine whether the terminal or board is malfunctioning by indicating data flow.

The board lists for $450 in single quantities, with the price dropping to $360 in 100-quantity orders. Delivery is 30 days after receipt of order.

MDB Systems Inc. 1995 North Batavia St., Orange, Calif. 92665. Phone (714) 989-6900 [411]

Spate of CAD/CAM hardware heads toward market

Developers of computer-aided–design and –manufacturing systems are aiming at a new level of system integration based on a common data base accessible to both engineering and manufacturing organizations and maintained by a 32-bit computer. This key feature is found on the most recent CAD/CAM entries from Applicon, Sperry Univac, Graftek, and Auto-trol Technology Corp.

Applicon's series 4000 (see photo below) is built around three new Graphics Processing Facilities based on Digital Equipment Corp. minicomputers. The series 4000 features a Distributed Graphics Network package and a data-base management system. The network package allows users to establish graphics data networks. The data-base management package provides the multidisciplinary access to engineering and design data necessary to see a product through the entire development cycle. Says Applicon president Donald W. Fedderson, "The series 4000 provides more than basic documentation and drafting capabilities. It offers engineering, manufacturing, and data-management capabilities not typically found in today's CAD/CAM systems."

Data base with network. The 4275 graphics processing facility offered with the top-of-the-line series 4000 system represents a major innovation for Applicon. Based on a DEC VAX-11/751 processor, this facility is supplied with 1 megabyte of main memory (which can be upgraded to 2 megabytes) and supports as many as four dual-density tape drives and four hard-disk drives. Starting at less than $320,000, this system combines networking and data-base capabilities with the fast number crunching that is necessary for many advanced applications.

The VMS operating system and virtual-memory architecture help to keep data-base management swift and efficient. The data-base manager sees to it that access to data is protected. The system can be set up so that manufacturing personnel cannot change the original design to make it easier to manufacture without notifying the engineers and designers responsible for the original

development of the product.

Besides its top-of-the-line system, Applicon offers entry-level systems based on the 16-bit PDP-11/34 processors. These graphics processing facilities, dubbed the 4225 and 4245, include the RSX-11M operating system. A system including hardware, software, and a work station can be bought for less than $100,000 and is upwardly compatible with other Applicon systems to protect the user's initial investment.

Unifying thread. Joel N. Orr, chairman of Orr Associates Inc. of Danbury, Conn., and a CAD/CAM expert, notes that "the unifying thread running through all the operations of the automated factory is the geometric description of the part." Sperry Univac has designed its UNIS*CAD system with that thought in mind. Seeking to build a system with drafting and design capabilities and analysis software that operates directly on the design model, Sperry included a direct connection with production scheduling and control operations, as well as numerical-control capabilities.

The most recent addition to Sperry Univac's UNIS series of systems executing manufacturing planning, scheduling, and control software, UNIS*CAD (see photo above) uses both a Sperry Univac 1100 series 32-bit mainframe and a Sperry Univac V77 minicomputer in a distributed architecture. The V77 handles design, drafting, numerical control, and mesh generation, freeing the mainframe to run large analysis programs, perform the detailed calculations required for solid modeling, maintain the data base, and perform business functions. The V77 is in turn offloaded by the graphics terminals, which store display lists; zoom, pan, and rotate display figures; and communicate with the designer via the data-tablet interface. The graphics software packages provided by Sperry Univac support the Megatek 7200 and the Adage 4177 terminals.

Graphics Technology Corp., also known as Graftek, is adding to the spectrum of available hardware a high-resolution–color work station to be used with its 32-bit turnkey

CAD/CAM system. The new high-performance display will feature a 19-in. raster-scanning color cathode-ray tube with flicker-free 60-Hz noninterlaced operation. Capable of displaying 1024 by 768 picture elements in eight colors, the terminal has 27 programmable-function keys and screen-overlay capabilities.

But the element that promises to make the new color work station truly unique is its voice-input option. Slated to be available in September, this option recognizes 100 words or phrases up to 1.2 seconds in length. Extra words can be added to the recognizable vocabulary in under 15 seconds.

Full-featured. The color terminal alone will be available in July for $45,000. It is designed to work with Graftek's series 32 CAD/CAM system, which has a relational data base specifically designed to handle engineering and scientific data. The series 32 is a full-featured system including provisions for mechanical design, numerical control, production drafting, electrical-power wiring work, solid-geometric and finite-element modeling, flat-pattern development, and plastic injection molding. Graftek first began shipping the system, which is built around Gould's SEL 32-bit computer, in May of 1981. A complete turnkey system including four work stations is available for $425,000.

Another 32-bit–based system designed to be an integrated product-development tool was recently announced by Auto-trol Technology Corp. Auto-trol's GS-32 engineering and manufacturing system also uses the DEC VAX series of 32-bit minicomputers. The minicomputer supports the user's work stations, with all functions—from tooling design and flat-pattern development to numerical-control and product assembly programs—running on the same computer. Turnkey systems, including the processor, start at $80,000.

Applicon, 32 Second Ave., Burlington, Mass. 01803. Phone (617) 272-7070 [476]

Auto-trol Technology Corp., 12500 North Washington St., Denver, Colo. 80233, Phone (303) 452-4919 [477]

Graphics Technology Corp., 1777 Conestoga St., Boulder, Colo. 80301. Phone (303) 449-1138 [478]

Sperry Corp., Sperry Univac Division, P. O. Box 500, Blue Bell, Pa. 19424. Phone (215) 542-4213 [479]

$895 daisy-wheel printer runs at 12 characters/s

The cost of letter-quality printing for small computer and word-processing systems takes a big step down with the announcement of the TP-I daisy-wheel printer from Smith-Corona. Its suggested retail price is only $895, and glass-reinforced nylon daisy wheels for various type fonts are only $5 each.

The unit prints at speeds between 12 and 15 characters/s on paper up to 13 in. wide. The 10-character/in. version can print 105 characters a line, and the 12-character/in. version 126 a line. The initial unit has a friction paper-feed scheme—a tractor-feed mechanism is due out during the first half of the year, according to the firm.

The TP-I comes with either a Centronics-compatible parallel interface or an RS-232-C serial interface. The latter can be strapped to operate from 50 to 19,200 b/s. Character length and parity can also be strapped. Margins are under program control.

Printing is unidirectional at 6, 4, or 3 lines/in. Impression force is controlled with a five-position switch so that up to five carbon copies may be produced. Print wheels are said to have a 2-million-character life and are easily replaceable. Three types of ribbon are available in convenient

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City State Zip

TRW CAPACITORS
AN OPERATION OF TRW CAPACITORS DIVISION

Circle 217 on reader service card

Daylight Measurement of Cloud Heights

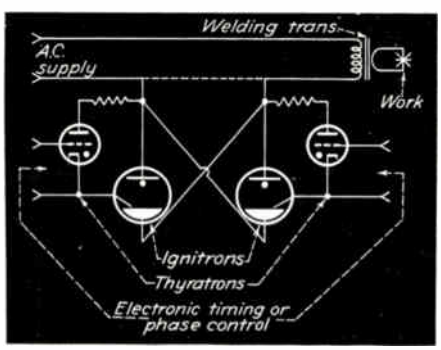
THE HEIGHT OF CLOUDS above ground level is of utmost importance to aircraft operators and can be measured in daylight by means of a modulated light beam pointed vertically at the cloud, and a photoelectric detector unit and amplifier. The light source is an a-c operated high intensity mercury vapor lamp operated on 60-cps power. The modulation of the beam is about 95 percent and has a frequency of 120 cps. The detector system includes a lens system designed to pick up a cloud area no larger than that illuminated by the light beam to reduce the background light to a minimum. A type 929 phototube is used and its current is amplified by a five stage resistance-capacitance amplifier tuned to 120 cps. In practice, the base of the cloud is scanned by the detector until the output meter indicates that the light signal is being received. The computation of cloud height is a simple trigonometric problem making use of a known base line and one angle of a right triangle to determine the vertical leg, or height of the cloud.—*Electrical Engineering*, May 1941.

Stimulus—Electrical

(*Continued from page 74*)

electronic control equipment is inserted in series with this lead. The control comprises two ignitron tubes connected in such a manner that primary current flows through one tube on one half cycle and through the other tube on the other half cycle. When the ignitrons are conducting, circuit operation is precisely the same as outlined above. It will be obvious, however, that welding current may be started and stopped by starting and stopping ignitron conduction, using the ignitrons as an "electronic switch." It will also be apparent that the ignitrons may be used as an "electronic rheostat" if some means of causing them to fire at controllable points along each half cycle of a.c. is employed.

One method of controlling the ignitrons and thus controlling welding time or welding current or both is to connect thyratron tubes between ignitron anodes and igniters as shown. The thyratrons may be controlled by means of any conventional electronic timing circuit or by phase-shift methods described elsewhere in this issue and will, in turn, control the points along each half cycle at which associated ignitrons fire. No special provision for stopping ignitron current flow is required in this circuit as the tubes automatically cease conduction on half cycles of a.c. during which their anodes are negative with respect to their cathodes.—GENERAL ELECTRIC COMPANY, Instruction Manual.



Resistance welding control circuit using ignitrons to control primary current and thyratrons to control the ignitrons

Motor Reversal and Speed Control

THE DIRECTION OF rotation and the speed of d-c motors may be controlled by means of the circuit shown. The motor field is operated from any suitable d-c source. Alternating current is applied to the motor field in series with two thyratron rectifiers connected "back to back." The thyratrons employed here are cut off unless their grids are made positive with respect to their cathodes. Throwing the control switch to the left makes the grid of thyratron *A* positive and that tube conducts. Half waves of current pass through the motor armature in one direction and the motor operates. Throwing the control switch to the right causes tube *B* to fire and the motor direction reverses.

If a variable inductance is included in the center arm of the control switch, as drawn, it will be possible to control motor speed as well as the direction of motor rotation. Varying the inductance shifts the phase of voltage applied to the thy-

The challenge: conformance to VDE and international standards

The solution: AIRPAX IPG and SNAPAK® magnetic circuit breakers.

For the export market, your product must conform to international and VDE specifications. AIRPAX engineers designed the IPG and SNAPAK to comply with the spacing requirements of VDE 0730, IEC 380, and IEC 435 standards.

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Specifications are in our new catalog. Write or call AIRPAX/North American Philips Controls Corp., Cambridge Division, Woods Road, Cambridge, MD 21613, telephone (301) 228-4600.

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NORTH AMERICAN PHILIPS CONTROLS CORP.

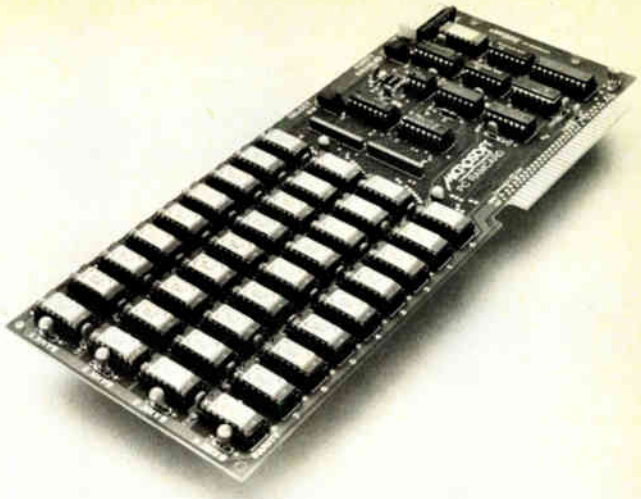
Cambridge Division

Circle 220 on reader service card

Microcomputers & systems

Enhanced OS lets RAM emulate disk

Version of operating system for IBM Personal Computer speeds I/O-intensive tasks



Microsoft, the company that developed the primary disk operating system for IBM's Personal Computer, has come up with an expandable random-access-memory card with a difference: it comes with a modified version of the PC-DOS that allows a portion of main memory to be used as if it were a disk drive. Because programs written in the Personal Computer's Basic language can only use 64-K bytes of the potentially large semiconductor memory as work space, long programs may be forced to keep subroutines and data on disk. Transferring them to and from floppy-disk storage can slow execution down radically, and this is where the RAMDrive feature of the RAMcard, as it is called, steps in.

"Programs aren't bottlenecked while the disk drive is clicking and whirring," says David Woodruff, product marketing manager. Emulating the disk with the RAMcard achieves much higher input/output rates and is particularly valuable to programs requiring repeated disk access. Large-scale business programs, sophisticated graphics programs, and major development tasks are made feasible.

The card comes in 64-, 128-, 192-, and 256-K-byte configurations ranging in price from $495 to $1,095. The smaller versions can be upgraded in $200 64-K-byte increments. Three cards, placed in any available expansion slots, add up to 576-K bytes of usable memory. Address-decoding switches let the user assemble programs anywhere in the user memory map.

With a utility called Config, the user may assign a disk-drive letter to a portion of the main memory. Another utility, Memtest, can isolate bad memory to the chip level.

The card has odd parity checking and two light-emitting diodes, one indicating that parity checking has been disabled and the other that the board has been selected. The fully loaded card draws 600 mA from the 5-V supply when accessed, 525 mA when idle. It will be available this month at retail stores.

Microsoft Corp., 10700 Northup Way, Bellevue, Wash. 98004. Phone (206) 828-8080 [371]

68000-based unit runs in-house OS

Proprietary operating system is user-friendly, supports body of tested application programs

The Motorola 68000 is fast growing in popularity for small-business systems, and most of the recent 68000-based entries offer system software employing *de facto* industry standards, such as Bell Laboratories' Unix. Alpha Microsystems is taking a different tack with its AM 1000 entry-level system: it has designed the hardware around the 68000 specifically to run the firm's user-friendly AMOS (for Alpha Microsystems operating system).

Implementing the multiuser multitasking operating system and revising the Alphabasic compiler for the generation of 68000 code allows the AM 1000 to run tested application software written during the last five years with a minimum of code modification, says Robert Currier, director, future systems. In addition, users who develop programs on the AM 1000 will be able to maintain them as they move to larger systems. Alpha Microsystems will continue to support the custom central processing unit that it first made available in 1977 even though it is currently updating all its hardware to 68000-based units.

The system is designed for first-time users and comes with a variety of built-in mass-storage options that use the Shugart Associates standard interface. A low-end version will have two 5¼-in. double-density floppy-disk drives, each with an unformatted capacity of 1 megabyte. Another model substitutes a 10-megabyte Winchester disk drive for one of the floppy-disk drives. A third version includes the Winchester drive and an interface that allows the hard disk to be backed up with a video cassette recorder, using a technique unveiled last year [*Electronics*, Nov. 17, 1981, p. 40].

The AM 1000 comes with a maximum of 16-K bytes of read-only memory and a main memory 128- to 512-K bytes in size. Three RS-232-C ports are provided.

Distributor pricing is not yet set

for the AM 1000, but the system will sell to the end user for under $10,000, the company says. Deliveries are in 30 days.

Alpha Microsystems, 17881 Sky Park North, Irvine, Calif. 92713. Phone (714) 957-1404 [372]

S-100 voice unit lets users vary quality of speech

With its selectable bit rates of 1.25-, 2-, 3-, and 4-K bytes per second of speech, the CompuCorder, an S-100-bus–compatible speech-storage circuit card, lets the user determine the tradeoff between computer memory requirements and speech quality to suit individual applications.

The unit can produce high-quality speech in any language, from any voice, male or female. Vocabulary for the CompuCorder is prepared by the user by simply speaking into a microphone. The voice is digitized using a hardware-based data-compression technique. The resulting speech data is stored in computer memory, then replayed under software control.

When combined with a disk, the unit becomes a high-speed, random-access tape recorder, suitable for applications such as voice store-and-forward systems, paging systems, automatic announcement systems, ham-radio repeaters, and computer-aided instruction.

Available now, the CompuCorder is priced at $295.

Computalker Consultants, 1730 21st St., Santa Monica, Calif. 90404. Phone (213) 828-6546 [373]

Low-cost video controller is aimed at smart terminals

Built on a 3-by-7-in. iSBX Multimodule board, the iSBX 270 video display controller provides low-cost, eight-color display-terminal control for all 8- or 16-bit Multibus and iSBX-compatible systems.

The board can interface with either color or black and white display monitors at a 50- or 60-Hz frame rate. Up to 256 characters are contained in erasable programmable read-only memory, reprogrammable by the user for custom applications.

Three types of character font displays are supported by the iSBX 270 in matrixes of seven by nine, five by seven, or six by eight dots. A keyboard and light-pen interface are also on board to simplify the design of intelligent terminals. Rounding out the controller's features are cursor control, reverse video, blinking and underline, and scrolling.

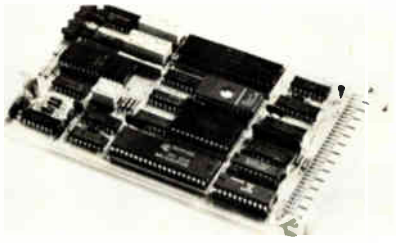
The iSBX 270 contains a software package in its on-board 8741A microcomputer that initializes and monitors the various on-board very large-scale integrated circuits, maintaining constant video display without the intervention of the system's central processing unit. The device is available now for $750.

Intel Corp., 5200 N. E. Elam Young Parkway, Hillsboro, Ore. 97123. Phone (503) 640-7147 [374]

Boards make IEEE-488 bus respond to serial, parallel data

The models 4825 and 4828 interface cards allow IEEE-488 bus control from any standard serial or 8-bit parallel data source, respectively. Both are Eurocard-sized plug-in boards intended for the original-equipment-manufacturer market.

The 4825 accepts command data in serial format from any RS-232-C or RS-422 serial-data source computer input/output port or modem and interprets it to control IEEE-488 bus operations. The 4828, on the other hand, accepts command data in parallel format from any standard 8-bit Z80- or 8080-type microprocessor bus and interprets that data for bus control.



No special interface software need be written. Each board contains all the logic and intelligence necessary to let it operate as a full-featured controller, and each accepts high-level commands, generating all the control signals and character codes necessary to command bus operations. Each card can address any device connected to the bus as well as transfer data from devices on the bus back to the command source.

In small quantities, the 4825 sells for $550 each, the 4828 for $525. Delivery takes 45 days.

ICS Electronics Corp., 1620 Zanker Rd., San Jose, Calif. 95122. Phone (408) 298-4844 [378]

Package brings CP/M to SS50-bus computers

A combination hardware and software package called the Z809 Softboard System enables users of SS50-bus computers to run commercial CP/M application programs. In addition, a large quantity of public-domain software is available from the CP/M User Group.

The Z809 board contains a Z80A microprocessor that runs at 4 MHz when installed on a 2-MHz SS50 system. It will execute Z80 and 8080 object code. Minimum memory requirements are 25-K bytes, but the system can accommodate as much as 56-K bytes. It also supports up to four disk controller boards and up to 16 disk drives.

Included with the Z809 are the CP/M 2.2 operating system, the console command processor, the file manager, and a collection of nonresident commands and utility programs. The Z809 Softboard System, which is to sell for $595, will be demonstrated at the National Computer Conference next month. In addition to the 50-pin processor board and CP/M, it includes an editor, assembler, and debugger.

Meta Lab, 2888 Bluff St., Suite 106, Box 1559, Boulder, Colo. 80306. Phone (303) 499-4236 [376]

Here's a new line of Miniature ROTARIES PLUS a whole lot more...

Make ALCOSWITCH your one stop supply source for all miniature rotary switch requirements. The brief list shown will provide an idea as to the extent of our current line. In the works are also many options and custom modifications to meet many of your exact requirements.

You can start by calling ALCOSWITCH and ask for additional information on one or more specific series. Or, simply request a copy of our new catalog which includes other miniature switch products. ALCOSWITCH is prepared to quote on any custom design switch products. Our engineering department is trained to work with your designers to overcome any technical problems or space limitations.

MRS-RA Series right angle mounting on std. 0.1" centers.

MRS Series miniature rotary switches with solder lug or PC terminals. Choice of two shaft lengths, with adjustable stop feature.

MRSB Series is a programmable rotary for PC applications. Terminals are molded in DAP base. Features full environmental seals. Excellent for flow soldering & auto-cleaning.

MRSE Series is splash-proof. Internal & external "O" Ring Seal shaft & or bushing.

Command Series selector switch offers 1 amp rating @ 125 VAC. 2 or 3 positions.

MRC Series have adjustable-stops with molded-in terminals.

MRJ Series are PC rotaries with maximum positions in minimum space. 30° index.

MRJE Series have splashproof seal on shaft & bushing for added protection.

MRCE Series feature splashproof "O" Ring Seals between the bushing, shaft & panel.

DRS Series dual-in-line mounting. Available as BCD or 1,2 or 3 pole 4,6, or 12 positions.

MRJB Series has screwdriver slot adjustment. All MRJ versions are break-before-make.

AUGAT® ALCOSWITCH®

QUALITY AND INNOVATION

ALCO ELECTRONIC PRODUCTS, INC.
1551 Osgood Street, North Andover, MA 01845 USA Tel: 617/685-4371

Canada: Augat Electronics Inc., Suite 103, 6205 Airport Rd., Mississauga, Ontario, Canada, L4V 1E1
Europe: Augat France SA (Z.I Sofilic) B P. 440-CEDEX 94263 Fresnes, France

Electro Show Booth number: 1334-1336

Circle 223 on reader service card

"Of course we advertise...

Many electronics executives do not have good, sharply-focused, measurable objectives for their advertising. This general aimlessness is perhaps the biggest single cause of wasted advertising dollars.

The purpose of this ad is to remind you that advertising is too efficient and powerful to be thrown away on vague objectives. Only you can set the specific tasks that will make your advertising investments pay off, but we hope this ad will serve you as a general checklist of possibilities.

1. Market coverage and brand recognition.

They can't buy from you if they don't know about you. Conversely, the more people who recognize you as a competent supplier, the more companies you will be able to sell to. It is beyond controversy that brand recognition and brand preference are the essential predecessors of sales. It is also beyond controversy that the only efficient tool for establishing broad market recognition is publication advertising. The Electronics Technology Market is getting bigger and broader, and the only way to cover it is to advertise. Don't fall into the trap of believing that the market knows you and is thinking about you. Research will tell you how much recognition you have now. Decide how much more you want, set that increase as the objective for your advertising, invest to achieve it, and measure the return on that investment.

2. Positioning.

Positioning is simply deciding what you most want the market to remember about your company and its products, and then saying those things in your advertising. Do you want to be remembered most for quality, value, low price, service, dependability, research, technology, software support, delivery, or something else? Whatever you select, a good positioning statement can be very powerful. It can make your company easy or safe to buy from. It can preempt your competitors, forcing them into a "me too" position. Research can help guide you to the selection of the optimum available "position" and can measure your progress through the years as you advertise to make that position stick in the marketplace.

3. Ride the trends.

This is a flexible form of positioning. You figure out how your product or service offerings tie in with current market trends and then advertise to put those tie-ins into the prospect's mind. For example, you advertise to show how your products can contribute to microprocessor-based systems, or how they can increase productivity, or how reliable they are in under-the-hood environments. The important technology and market trends are there for all to see.

4. Reach unknown or inaccessible buying influences.

Traditionally, advertising has been seen as a sales support function — "calling on" customers when the salesman is calling someplace else. Electronics technology purchases have become more complex and more critical. The buying decisions have moved up in the organizational hierarchy where the salesman has difficulty making calls. As you define your market coverage objectives,

but I'm not sure why."

make sure your advertising is reaching the important people your salesmen cannot see. Make sure your message is of interest to these kinds of people. If it is, *they will reach you*—even if your salesmen cannot reach them.

5. Product differentiation.

When your products are viewed as commodities, price and availability become your only real competitive weapons. And your profit margins are under constant pressure. The only way out of this "commodity trap" is to differentiate your products from those of your competitors. Pick some product differences and drive them home in your advertising. There almost always are saleable differences in apparently identical products. If there aren't any in yours, *don't advertise.* Save the money and put it into price and inventory for quick delivery.

6. Increase or maintain market share.

If you already have a good share of market and are willing to keep building brand recognition and preference, advertising will make it awfully tough for your competitors to make a run at you. The important thing is to do the research to learn what your share of recognition and share of preference are. Then invest whatever advertising is required to maintain or increase the lead over your competitors. There's also a message here for market trailers: If old number one in your market is letting his advertising slip, your advertising will help you close that gap faster than any other investment you can make.

7. Increase market size.

Suppose you already have the lion's share of a product market? Your strategy as the dominant supplier should be to increase the market size. Maybe this means going into new geographical areas where you have not competed before, like Japan, South America, Eastern and Western Europe, Australia, or Israel. Or maybe it means creating new applications for your products. Advertising worldwide in an international magazine will pave the way.

The surest way to expand a market is to educate potential customers. The surest medium of product education is advertising.

8. Sponsor change.

Change is what creates sales opportunity—change gives you the chance to get business you don't presently have.

Use your advertising to sponsor change. Show the prospect how your product will improve his system, cut his costs, increase his own sales, lower his inventories, let him extend his warranties. Become known as the supplier who can deal with change. Then, when your customers need a change, they'll come to you.

9. Control your message.

Good publications won't let you manage or control the news in their editorial columns, but you can do it in your advertising pages. Advertising is an ideal "announcement" medium. You can tell your story to the whole worldwide market, at one time, and in your own words, for very modest expense. When you have something to announce, advertise. Then set up a system to measure how the message got across.

10. Make the customer ask.

How many times have you seen a salesman hand a prospect a sample, or a brochure, or something else that the prospect had not yet requested? This is a faulty selling technique. The sample will only be meaningful to the prospect if the prospect wants it. The salesman should make the prospect ask for something. Your advertising can make the prospect ask. Use advertising to get the prospect to request a sample or demonstration. Then the sample or demo will mean something to him and will be more likely to lead to a sale.

11. What about media?

Now that you have good advertisements based on objectives that you can measure—run them in Electronics. It's read by important people all around the world, and most read only Electronics. In fact, more important people keep ahead of technology and business developments with Electronics than any other magazine —331,072 to be exact. Your share of market will grow with your advertising in Electronics.

Electronics
Where important people read important editorial

This is the second in a series of advertisements on important marketing and advertising objectives for the 1980's. Your comments are welcome.
Electronics Magazine, 1221 Avenue of the Americas, New York, N.Y. 10020

The TRE 800SLR wafer stepper™ has proven that there are no alternatives to its superiority! Here's why...

Industry's highest wafer throughput

The TRE 800SLR Wafer Stepper has the highest demonstrable throughput of any stepper on a production floor today. At 0.2 micron and 2σ registration, the 800SLR provides a guaranteed global throughput of 55 wafers per hour on 4" wafers, on a 10X configuration. The 5X provides a guaranteed global throughput of 90 wafers per hour on 4" wafers.

Ask the competition to demonstrate comparable figures; TRE's throughput can't be beaten.

Machine interchangeability—a new industry standard

TRE Semi manufactures all their steppers to a factory standard of $\pm 0.3\ \mu m$ and uses system characterization software to monitor their performance.

There's nothing else like it. In less than 20 minutes, 484 location points per wafer are calibrated and the data reduced and presented in a numerical and graphic printout.

This production line characterization technique has set the standard for the industry. It should be setting the standards for your production floor.

Industry's most advanced stepper

The TRE 800SLR Stepper is the technological leader; the industry's most advanced, fully-automated system. It's features include:

- automatic field-by-field alignment
- automatic reticle changing, alignment and masking
- automatic wafer handling (3", 4" and 5")
- automatic reticle-to-wafer alignment
- automatic wafer alignment in less than 0.25 second with 0.2 micron precision at 2σ
- built-in environmental control

Maximum yields through automatic alignment

The TRE 800SLR stepper system uses the industry's state-of-the-art automatic wafer-to-reticle alignment system which eliminates the effects of wafer distortion and continental drift errors introduced through the IC manufacturing process.

This results in increased yield, providing more net good die per hour than any other system.

The sensitivity of the system guarantees fast precision overlays on each chip level within $0.2\ \mu m$ at 2σ and is capable of aligning to a target in the first level oxide through all subsequent layers. This is not compromised by different resists, surfaces, or topographies. The benefits are substantially increased yield, chip reliability and tighter design rules.

TRE technology—your competitive edge in IC production

TRE Semi has pioneered many firsts in microlithography. Like vacuum air bearings. And the laser-controlled stage. Environmental chambers. Computer control. Automatic air gauge focus. Automatic reticle align. Criss cross. Automatic reticle and wafer handling. And automatic die-by-die alignment.

And we originated the concept of interchangeable lens systems which permit the user to alter his machine configuration to address his product mix without additional capital expenditures. TRE Semi's present 24-hour-interchangeable 5X/10X system configurations are the continuation of this company philosophy... and the prelude of technologies to come.

What other stepper companies have only been promising for the last two years, TRE Semi delivers. Today.

Industry's highest uptime record

With TRE 800SLR steppers, it's a field-proven fact that when our systems come up, they stay up, consistently registering 95+% uptime.

And they're up, because we build them that way. TRE Semi is the only stepper manufacturer who does a full three weeks of reliability testing prior to source inspection. So any problems are found in our factory, not on your production floor.

Plus, we ship fully-assembled systems. So they're shooting wafers within 8 hours of applying power in 90% of the installations. Shipping sub-assemblies in boxes like some manufacturers do, virtually guarantees problems.

Cost-effective production requires reliability. Our reliability is built in, not serviced in.

TRE worldwide service and support

TRE Semi has the industry's highest commitment to service and support. No other stepper manufacturer can top the breadth of experience or manpower put behind every system we build.

- 4-Hour Response Time—Internationally, within 24 hours.
- 24-Hour Hotline—(800) 423-5327; in CA, (800) 382-3373.
- 14 Service Centers—on three continents with fully-trained, experienced field engineers.
- Process Engineers—with extensive resist background and fab line experience.
- Development Lab—supports production and is open to customers.

We'll demonstrate the difference!

TRE Semiconductor Equipment Corporation

6109 De Soto Ave., Woodland Hills, CA 91367 (213) 884-5050

2 and 4 Avenue de l'Europe, 78140 Velizy, France 946-59-58
Radix House, Central Trading Estate, Staines, Middlesex, England 44-784-51444
TEL, 1-26-2 Nishi-Shinjuku, Shinjuku-ku, Tokyo 160, Japan 03-343-4411

Industrial

STD-bus chassis holds disk drives

13-slot chassis carries four-output switching supply, two 1.6-megabyte drives

More than 50 manufacturers are now creating function cards for the STD bus, but the original-equipment manufacturer who wishes to integrate all this functionality into systems has had to supply his own chassis or select Pro-Log's model 701, a 12- or 21-slot card cage with a linear power supply. Pro-Log's latest addition to the STD-bus effort goes the model 701 one better in making systems easier to integrate.

Model 702 improves upon model 701 by using a four-voltage switching power supply and adding two thin-line 8-in. double-sided double-density floppy-disk drives to a chassis with 13 slots on ⅝-in centers. "Users previously either had to buy two separate boxes to get a mass-storage STD-bus system, or they had to design their own package," notes Charles Cech, Pro-Log's director of product marketing.

The thin-line floppy drives have capacities of 1.6 megabytes each and are made by Tandon Magnetics and an as-yet unnamed second source. The drives are guaranteed for one year, and the remainder of the 702 carries a two-year guarantee. The all-metal model 702 uses forced-air cooling and meets Federal Communications Commission and Underwriters' Laboratories requirements. It fits into a standard 19-in. rack, with optional side and top panels for forming a tabletop unit. The 702 will be priced at about $5,000, and it will be available in September.

A full deck. According to Pro-Log president Edward Lee, the total market for STD cards alone is now about $50 million. "That figure doesn't include the STD cards that users have manufactured for themselves," notes Lee. The STD bus has caught on primarily in industrial control and instrumentation applications. Such systems are also used in telecommunications, medical applications, traffic control, oil exploration and logging, and elevator control.

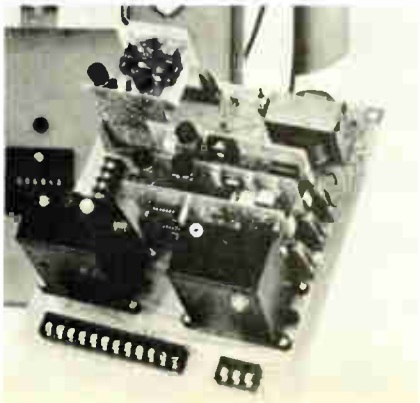
"The STD bus is now over 20% of the industrial pc-card marketplace," observes Lee. It is basically an 8-bit microcomputer bus, as evidenced by the availability of STD central-processing-unit cards containing all 6800 family members, as well as the Z80, 8080, 8085, 8088, RCA's 1802, and National Semiconductor's NSC 800. The STD function cards also include disk controllers, random-access memory, and input/output cards among the primary functions.

The three types of dc power made available to bus cards by the 702's switching power supply include +5 V at 15 A, +12 V at 5 A, and −12 V at 1.5 A. Its rear-panel controls include an ac power switch, two switched auxiliary outlets and a power-line filter. The dimensions of the system, either rack-mounting or tabletop, are 22 by 19 by 7 in., and the unit weighs 46 lb. The front panel can tilt down 180°, or it can be removed by activating two spring-loaded pins. A 3-in. space between the front panel and card cage allows components to be mounted on the panel and cables to be connected to the front of the STD-bus cards.

Pro-Log Corp., 2411 Garden Rd., Monterey, Calif. 93940. Phone (408) 372-4593 [411]

Meter measures fluid flow using ultrasonic transducers

The Sonic-1010 velocity-averaging ultrasonic flowmeter uses the Doppler effect to measure the flow of a fluid in a pipe. A transmitting transducer injects an ultrasonic signal into the pipe; shifts in the frequency of the signal reaching the receiving transducer are translated into a flow rate indicated on a meter and by a linear 4-to-20-mA current-loop output. Measurement repeatability is better than 1% of full scale.



The non-invasive twin-transducer design works with most pipe materials and measures the flow of slurry-like fluids, among others. The unit's nickel-plated aluminum sensors operate at −20° to +130°C, and the instrument itself operates at 0° to 70°C. Its electronics are on epoxy-coated modules with gold-plated contacts. Dual-alarm and integrating totalizing modules can be installed in the field.

The Sonic-1010 flowmeter comes in a 12-by-10-by-5-in. steel case and runs from a 120-V 60-Hz line. The basic unit is warranteed for five years and priced at $2,400. Quantity discounts are available, and delivery is immediate.

Pacific Meter Inc., P. O. Box 1011, Station A, Delta, B. C. V4M 3T2, Canada. Phone (604) 943-8315 [416]

P. O. Box 145, Point Roberts, Wash. 98281 [417]

Solar panel produces power for remote installations

Photowatt International has introduced the largest silicon cell in a solar panel to date. Designed to produce electricity economically for remote industrial applications, the model ML7010 solar panel consists of 36 5-in.-diameter silicon cells that will produce 55 W peak under optimum conditions (3.3 A at 16.5 V).

The cells can be wired in either series or parallel to meet specific voltage requirements. Some of the applications powered by the panel include navigational aids for offshore platforms and buoys, railroad signaling, remote communications, telemetry, and pumping stations.

The ML7010 sells from stock for $575 in small lots.

Photowatt International Inc., 2414 West 14th St., Tempe, Ariz. 85281 [415]

Software

Spread sheet is large, versatile

Financial modeling package for Prime computers accepts initial input from data base

A versatile financial-modeling package called Cybil is available from Software Management Systems to run on Prime Information systems. It is a spread sheet program set up to perform profit and loss analysis and forecasting, cost studies, market planning and sales forecasting, tax planning, and cash-flow management. Up to 702 columns and any number of rows can be maintained.

Paging, scrolling, and moves to a specific location are possible with positioning commands. Columns and rows can be inserted, copied, and deleted; column width and the number of decimal places displayed can be changed. A spread sheet can be initialized from a data base using English-like sentence fragments that invoke any number of files and attributes. Status lines display the current location's definition and position, calculation mode, and whether recalculation is required.

Cybil prints out a report using any number of columns or rows. A spread sheet may be saved on disk under a user-assigned name. Time, date, and the name of the user saving it are recorded, and it can be protected against overwriting

Calculations can be done automatically, or external Basic subroutines can be called for complex custom calculations. In addition to standard arithmetic, transcendental algebraic and trigonometric functions are included; the program computes averages, maximums and minimums, and the results of relational expressions. Cybil's price is $5,000; the program is available now.

Software Management Systems, 84 Inverness Circle East, Englewood, Colo. 80122. Phone (303) 741-3179 [361]

UCSD p-System runs on Altos hardware

A multiuser UCSD p-System, a program-development and execution-environment aid, is now available for the Altos 5¼-, 8-, and 14-in. Winchester-disk microcomputer systems. This package is compatible with the UCSD p-System and provides it with full output support, including a high-speed interpreter, buffered disk, and input/output terminal.

The USCD p-System can handle up to four terminals and three printers simultaneously and will also run existing single-user programs without modifications. Full memory is available for each user with a random-access-memory disk. In addition, the system offers hard-disk mapping and user privacy protection with interuser communication and resource sharing. With an automatic-start utility, the system can be easily installed.

Future enhancements for the version IV.0 package include networking, data communication, extended memory support for large code pools, and extended filing systems. Single system costs are $495 for a turnkey implementation and $925 for full-system implementation.

Dynamic Control Systems, 13662 104A Ave., Surrey, B. C. V3T 1Y8, Canada. Phone (604) 585-0655 [363]

Spelling checker proofs 10,000 words in under 2 min

A tool appreciated by writers, editors, and business people that can not only proofread 10,000 words of text in less than 2 minutes but can automatically correct any errors found throughout the entire document is Word Plus. In addition, Word Plus will visually display the misspelled word and will look up possible correct spellings of the word it has found in its 45,000-word literal vocabulary.

An enhanced version of a spelling checker called the Word, Word Plus includes programs that will automatically hyphenate words within the text, tell not only how many words there are in a given text, but also how many different words there are, what they are, and how many times each was used. Also, it will help locate rhyming words and solves crossword puzzles and anagrams.

Word Plus is compatible with almost every CP/M editor commercially available and will run under CP/M 1.4 and 2.2, CDOS, and others. It comes in a variety of formats including 8-in. single-density; 5¼-in. double-density for North Star, Superbrain, and Osborne; and 5¼-in. single-density for Apple CP/M and Osborne. Complete with a 50-page instruction manual, Word Plus is available for immediate delivery at a price of $150.

Oasis Systems, 2765 Reynard Way, San Diego, Calif. 92103. Phone (714) 291-9489 [368]

Ada-to-Pascal translator aids in learning Ada

Available now from SofTech is an Ada-to-Pascal source-to-source translation tool that also enables the programmer to gain experience with Ada. Designed to be used in the interim until production of the company's Ada compilers and related tools are available, the translation tool recognizes and translates features from the Pascal subset of Ada into the VAX/VMS version of standard Pascal.

The translator includes a standard 9-track tape with the translator's Digital Equipment Corp. Pascal source code, VMS command files for compiling and using the translator, and an installation verification program. It is currently available for the VAX-11/780 and -11/750.

This package is available for a one-time license fee of $4,000 for each central processing unit. Delivery takes 15 days after receipt of a completed license agreement.

SofTech Inc., Ada Products Manager, 460 Totten Pond Rd., Waltham, Mass. 02154. Phone (617) 890-6900 [366]

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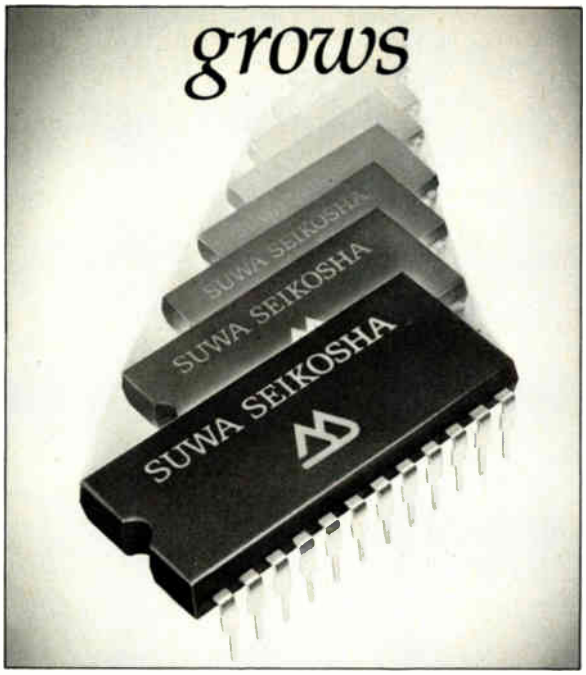

Suwa Seikosha, a major manufacturer of the famous SEIKO watches, is now producing new Static RAMs, Mask ROMS, Microcomputers, Voice Synthesizers and a host of other new products not yet released. As a pioneer of quartz watch technology, the company consistently developed and manufactured its own miniature electronic parts and IC's. Now a recognized specialist in the broad field of CMOS LSI, Suwa Seikosha is working aggressively to extend its position as a major-source supplier of Microcomputer Chips, Memories, Time Standard ICs, Voice Synthesizers, LCD Drivers, CMOS LSIs for Watches and Clocks, and Custom LSIs. OEMs are invited to contact Suwa Seikosha regarding new or existing products in these fields. Furthermore, inquiries are solicited regarding requirements in other fields that might benefit from Suwa Seikosha's most-advanced CMOS LSI technology. *Suwa Seikosha is a* growing *specialist in CMOS LSI.*

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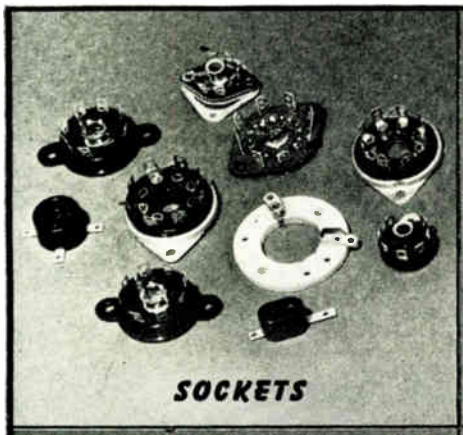
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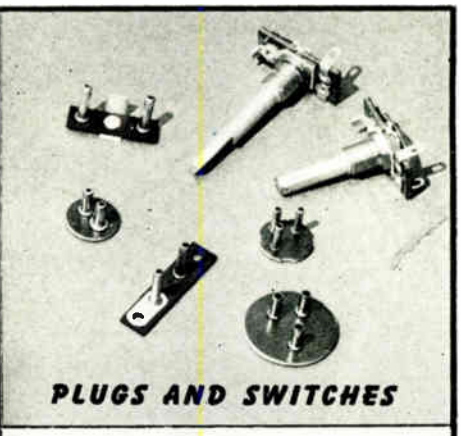
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Instruments

Smart recorder calibrates itself

Microprocessor in recorder equalizes and calibrates it for a wide range of tasks

For its reentry into the market of wideband instrumentation recorders, Racal Recorders Ltd. is introducing a high-performance 42-track tape recorder that sets itself up. Calibration and equalization tasks are assigned to a microprocessor, thus reducing an operation that can take several hours to about three minutes. The microprocessor also drives a small built-in cathode-ray-tube display through which matching characteristics and recorder performance can be monitored.

Racal has set out to cover the widest market spectrum possible with a single multipurpose chassis. It is useful in applications representing 28% of the total world recorder market, says David Kempson, managing director of Racal. Storehorse, as it is called, can be used in any combination of the three standard data record-replay formats: direct recording, frequency modulation, and high-density digital-data recording.

The machine works with ½- or 1-in. tapes. A user can start small with a 14-track intermediate-frequency-band recorder. Subsequently he can change heads and add a signal board for a 28-track wideband recorder. Expanding to a full 42 tracks, however, requires the addition of an external clip-on housing.

Marketing gamble. The firm's bid to squeeze a laboratory-style data recorder into a portable package is a marketing gamble. Usually laboratory-performance instruments are large rack-mounted affairs with coplanar tape transports. But the company has managed to keep Storehorse lean—it weighs around 100 lb and can be transported by a car.

For compactness, a coaxial-spool layout has been adopted. This arrangement puts one 15-in. spool behind another but may be harder on the tape than the usual coplanar feed, argue competitors. Users, they claim, may wish to use a lighter 14-track recorder, playing the tape back later on a laboratory machine.

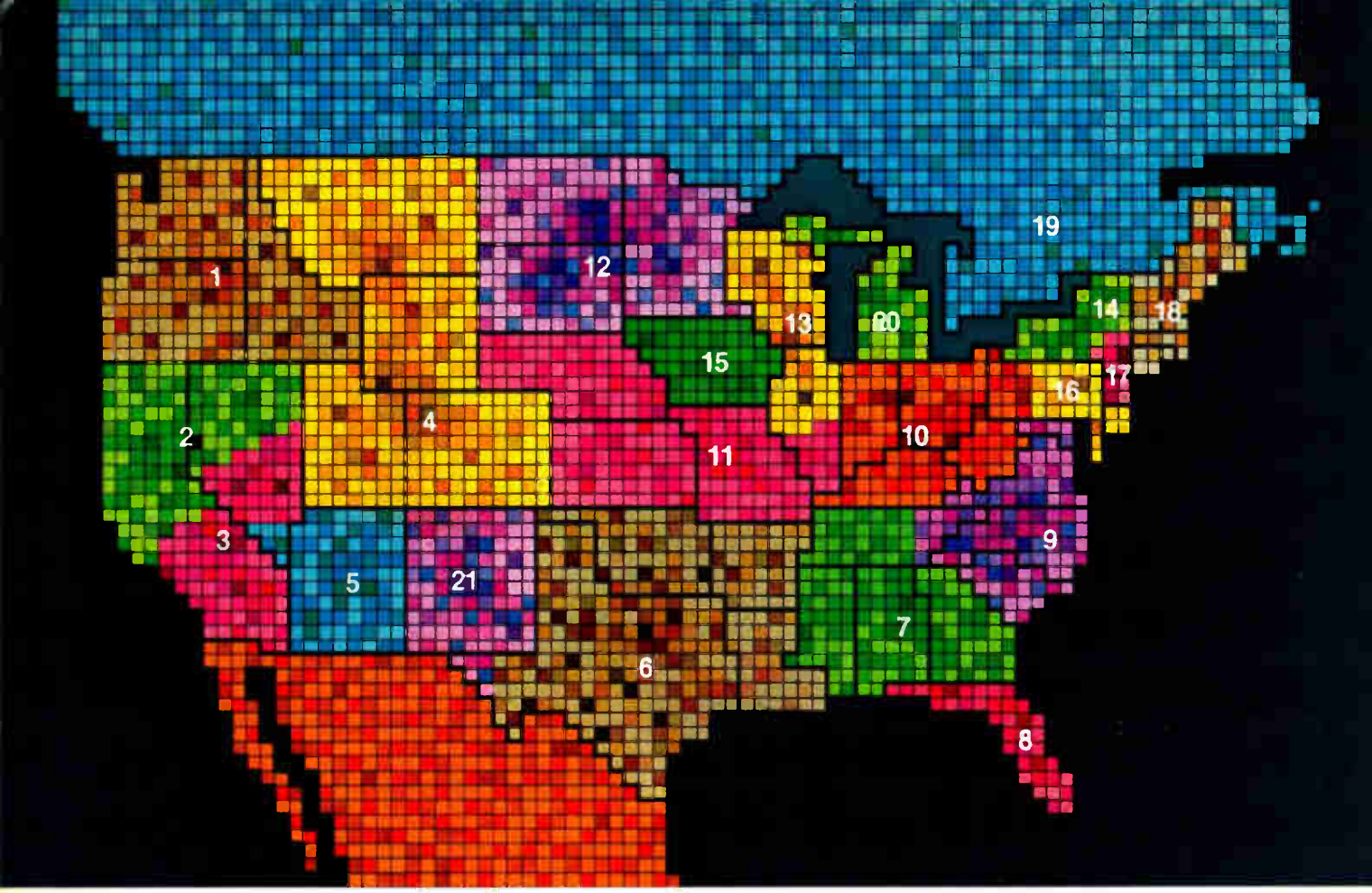
The extensive use of microprocessor technology eases the construction and increases the reliability of recorders by permitting the elimination of the usual arrays of potentiometers. Also new is the use of a digital tracking filter. Changing tape playback speed can alter the apparent signal frequency, so ideally any filter in the playback chain should track the tape speed, adjusting its filter characteristics accordingly.

Use of such a tracking filter allows Racal to offer many tape speeds without additional complexity or compromise in performance. For example, the tape speed is adjustable from $^{15}/_{32}$ in./s to 120 in./s. In many recorders, speeds can be incremented by a factor of two, but in the Racal recorder there is also a facility for dividing tape speed by 6, 10, or 60. This feature is extremely valuable for minutes-to-seconds time compression or expansion.

Racal uses a microprocessor to calibrate the recording circuitry for biasing and recording level and to equalize the replay circuitry across its full bandwidth. Equalization of the replay circuitry is performed using test signals laid down as a preamble when the tape is recorded. Storehorse records these signals automatically. When used as a playback machine for tapes recorded on other machines, these signals are not available, but the company is also offering an accessory that will allow any of its instrumentation recording systems to lay down the necessary preamble signals.

The microprocessor and cathode-ray-tube display monitors the system for fault analysis or diagnosis. For example, all input or output channels can be monitored simultaneously on a bar-graph display. By switching between inputs and outputs, the user can look for any channel that is not functioning correctly. Signal overload is indicated whenever the input or output channel exceeds defined limits.

Other display pages indicate tape position as well as attenuator settings, machine status, trace sequence, tape shuttle, and an index of stored calibration settings. In the event of a system fault during power up or tape loading, a full page will interrupt the display to indicate the



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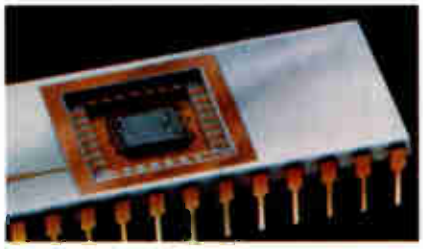

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NCR—NV MEMORY GUIDE

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7033	21x16	WAROM
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3400	1024x4	WAROM
2811	2048x4	EAROM
2168	2048x8	EAROM
2161	2048x8	WAROM
4485	512x8	NVRAM
52801*	**16x16**	**E²PROM**
52817*	**2048x8**	**E²PROM**
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For more information, call your local NCR Microelectronics representative. Or contact Dave Major at NCR Microelectronics Division, Box 606, Dayton, Ohio 45401. Our toll free number is (800) 543-5618, in Ohio (513) 866-7217.

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New products

type of fault and its location.

In the direct-recording mode, Storehorse can operate in an intermediate frequency band to 600 kHz and in the wideband mode to 2 MHz. Fm recording covers an intermediate frequency band to 40 kHz and wideband to either 80 or 500 kHz. High-density digital-data recording is at up to 36,000 b/in. using delay modulation, biphase L or nonreturn-to-zero codes.

Racal Recorders Ltd., Hythe, Southampton, Hants. S04 6ZH, England. Phone 0703-843265 [359]

Racal Recorders Inc., 3830 Bee Ridge Rd., Suite 100, Sarasota, Fla. 33583. Phone (813) 921-6662 [360]

Four-channel analyzer superimposes waveforms

Contained in a 25-lb package, the Smartscope II is an integrated hardware-software system with built-in disk storage for waveform analysis of time- and frequency-domain data. The unit uses a 16-bit microprocessor and is a complete system for the acquisition, storage, analysis, processing, and display of waveforms.

For ease of use, front-panel knobs,

controls, and switches have been replaced by a calculator-style keypad. Menu selections and screen prompts aid in the unit's use. Every function is programmable and the test setups and programs can be stored on disk.

Models come with two or four independent channels of acquisition, with or without signal averaging, with up to a 500,000 Hz sampling rate, a 12-bit resolution, and sweep times as slow as 1,500 s/point. Users can display up to four channels on the screen with up to four waveforms superimposed per channel. Included are IEEE-488 and RS-232-C interface ports.

Prices start at $10,500, with delivery taking 30 days.

T. G. Branden Corp., 5565 Southeast International Way, Portland, Ore. 97222. Phone (503) 659-9366 [354]

VLSI test system operates at up to 60 MHz

Production testing, inspection, and quality assurance may be had with the series 21, a general-purpose very large-scale integrated-circuit test system. It has an accuracy of 1 ns (500 ps for inputs and 500 ps for outputs), offers test rates of up to 40 MHz in a variety of pin counts, and has automatic timing deskewing and calibration.

The system's automatic deskew feature uses programmable hybrid delay lines for automatic adjustment for any combination of timing generators and pins. A deskew load board, containing a 50-Ω matrix, allows the series 21 to be automatically calibrated in less than 15 minutes. It is available with high-speed or -voltage test heads with 60, 90, or 120 pins and uses 10K and 100K emitter-coupled logic throughout all formats, timing paths, pipelines, and local memory sections.

The series 21 has a free-running clock that is used for asynchronous testing and allows the user to force clock bursts out to the device under test at frequencies up to 60 MHz. Because it uses the same operating system as the rest of Fairchild's general-purpose LSI testers, the operator can use the company's library of utility and device programs. It is available with a variety of options to further enhance its capabilities.

The series 21 base configuration is priced around $450,000 with delivery taking 120 days.

Fairchild, Test Systems Group, 1601 Technology Dr., San Jose, Calif. 95110. Phone (408) 998-0213 [356]

New literature

Thin-film primer. The 1982 "Book of Basics," an expanded second edition, serves as a primer on the fundamental sciences required for thin-film technology. It contains five technical papers covering the basics of plasmas, materials, thin films, sputtering, and plasma etching. Illustrated with photos, graphs, and charts, the 214-page book is available for $50 a copy from Materials Research Corp., Route 303, Orangeburg, N. Y. 10962 at (914) 359-4200. Circle reader service number 421.

VIC-20 aid. Designed for use by computer novices as well as experienced programmers, the "VIC-20 Programmers Reference Guide" provides complete information about the programming of Commodore Business Machines' popular low-cost VIC-20 computer. Nearly 300 pages long, the $16.95 guide includes illustrations, instructions, charts, and programs as well as a schematic diagram of the computer. For a copy, write to Commodore Business Machines Inc., 681 Moore Rd., King of Prussia, Pa. 19406 or call (215) 337-7100. [422]

Phosphors and filters. For use as a design guide by manufacturers of equipment with visual displays, an engineering bulletin provides design data and specifications for nonglare, contrast-enhancement cathode-ray-tube display filters. The bulletin lists the most commonly used phosphors and the Homalite shade that meets specific light-transmission requirements for those phosphors. The publication is available free from SGL Homalite, 11 Brookside Dr., Wilmington, Del. 19804 at (302) 652-3686. [423]

Software plus service. Lifeboat Associates' catalog No. 22, called the "Software Desk Reference," includes listings for 26 new products; a special section detailing the company's original-equipment-manufacturer services and products; a new minicomputer systems section; and for the first time, a list of 16-bit software programs including information about the IBM Personal

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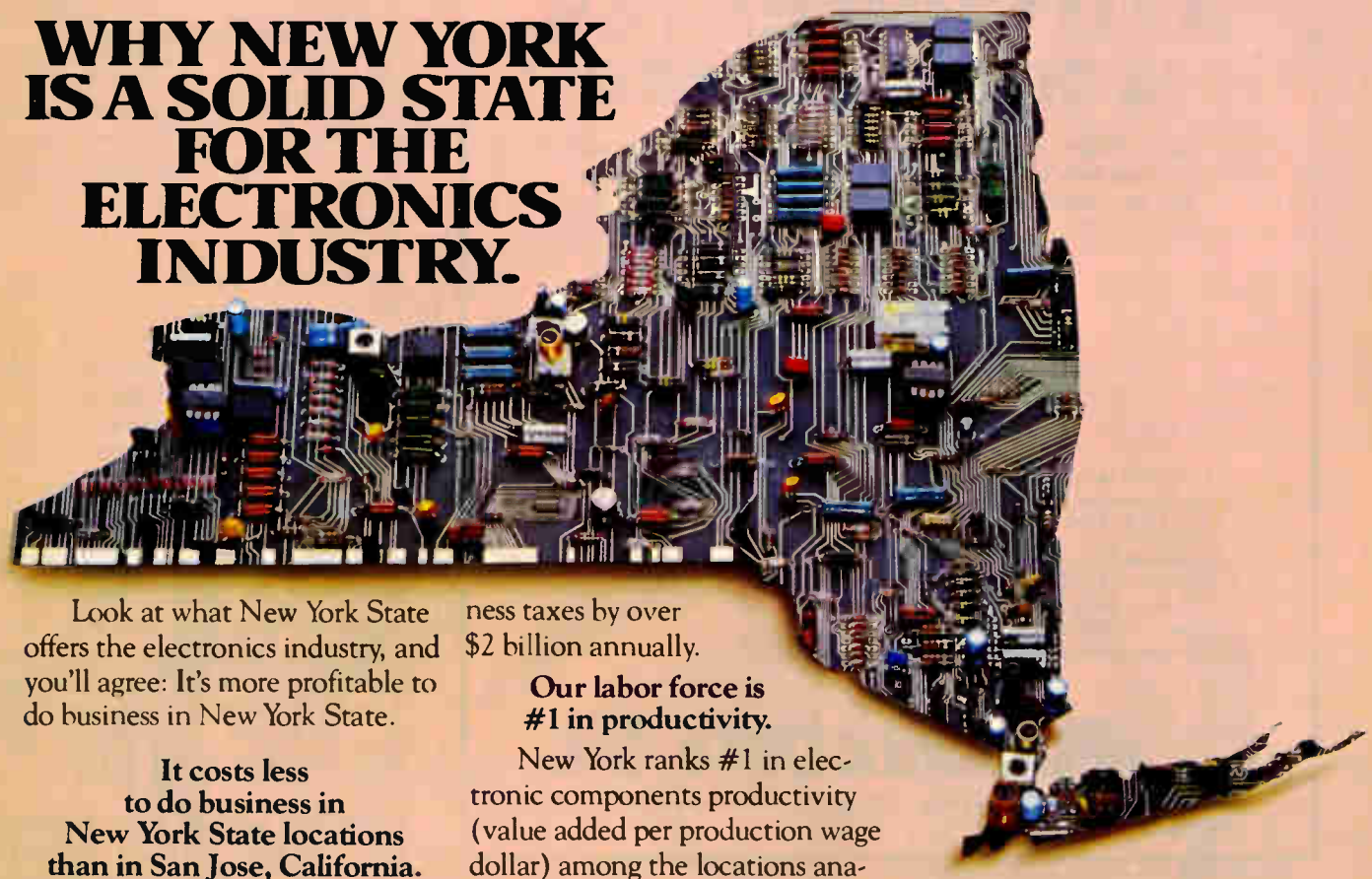

Look at what New York State offers the electronics industry, and you'll agree: It's more profitable to do business in New York State.

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An independent study analyzed the four critical costs of taxes, wages, power and construction for a model new electronics firm. It showed that New York State offers locations where these costs are less than they are for choice electronics industry locations around the country.

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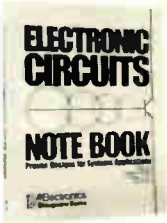

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Products Newsletter

Full-duplex modem has 2,400-b/s channel

Racal-Vadic of Sunnyvale, Calif., will introduce a four-channel originate-and-answer modem at the National Computer Conference to be held in Houston, Texas, June 7–10. The unit is the first available of its kind: its full-duplex 2,400-b/s channel communicates over telephone lines in synchronous or asynchronous modes, implementing 16-level phase-shift-keying quadrature amplitude modulation. The only other 2,400-b/s equipment available is a large box geared to cryptographic applications made by Motorola's Codex Corp. In contrast, **eight of the Quadruple modems, as they are called, will fit into a 7-in.-high rack-mountable enclosure.** Each modem consists of two printed-circuit boards.

A microprocessor in the modem acts as a signal processor to do digitally what is generally done with analog filters and discriminators. The modem also has equalizers that adapt it automatically to a variety of telephone-line conditions. The direct-connect unit includes a 300-b/s asynchronous channel and two 1,200-b/s channels for synchronous or asynchronous operation. One possible market for the modem is computer installations, such as those of Telenet's time-sharing service, with 2,400-b/s ports that are not used because of the lack of suitable hardware.

Finnish supermini executes Ada code

Nokia Electronics of Helsinki, Finland (the U.S. arm, Nokia Inc., is in Sunnyvale, Calif.), is soon to introduce a very compact 32-bit superminicomputer, the MPS 10. **It has an object-oriented architecture with extended stack organization** and is designed to execute Ada programs. The initial compiler is a nearly complete subset, and a full version of Ada is due out next year.

The fault-tolerant machine has **a 40-bit virtual-memory address space and built-in relational data-base management.** The bit-slice TTL central processing unit will come with 0.5 to 4 megabytes of main memory; it is said to perform in the range of a VAX-11/780 from Digital Equipment Corp. Its local network, which links it to intelligent workstations and a gateway processor for interfacing with other networks, will at first be a 500-kb/s subset of Ethernet supporting up to 30 nodes but will later be a full Ethernet implementation. An entry-level system with a ½-megabyte main memory and a Winchester drive and streaming-tape backup each of 45-megabyte capacity will sell for under $30,000 in the U. S.

64-K RAM chip is redesigned

Motorola is placing its redesigned 64-K dynamic random-access memory, the MC6664A, on the market in 150- and 200-ns versions. **Changes in the RAM [*Electronics*, Oct. 20, 1981, p. 39] increase speeds and are transparent to users of the earlier design.** Available now in sample form in ceramic dual in-line packages, the 150-ns chip is priced at $17 each in lots of 100. The 200-ns part sells for $13.60 each, also in lots of 100.

Interface with IBM channel is modified to speed transfers

Auscom Inc. is upgrading its 8900 series of programmable IBM-channel interfaces to increase the throughput rate during data transfers. The Auscom series **gives non-IBM peripherals a direct interface with the mainframe channels.** To enhance the performance of the interfaces, the Austin, Texas, firm has reconfigured the input/output registers. The new series is priced the same as existing models: $4,995 each in single quantities for the model 8900A card set and $14,995 for the 8911A box configuration. Auscom is also offering upgrade kits for the earlier version.

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Career outlook

Educators get together

In the continuing controversy, a growing number of observers now trace whatever shortage of electronics engineers may exist to a shortage of engineering faculty in the colleges. It is against that background—and that challenge—that the American Society for Engineering Education is preparing for its 90th annual conference. Thus it seems entirely appropriate that the ASEE will gather from June 20 through 24 at the country's largest engineering school, Texas A&M University in College Station.

For the educators finding their way to the central Texas campus of Texas A&M, which is an hour by air from Dallas–Fort Worth and 30 minutes from Houston, the program for the meeting offers such a dizzying array of mini-plenaries, workshops, and meetings of boards, councils, and divisions that only one steeped in the arcana of academia could feel comfortable. No detail is overlooked—the program, some 98 pages of listings, directions, and ads, even explains that the native greeting is "Howdy."

In any case, what will the instructors, working the kinks of a just-completed teaching year out of their muscles, seek to accomplish that affects the working EE? At first glance, the conference is top heavy with subjects concerning teaching itself. But for today's engineering faculty, the campus is no ivory-towered sanctuary: scattered throughout the week at Texas A&M are forums and discussions—the mini-plenaries—that will grapple with the realities of shortage versus surplus in these days of an uncertain economy.

In the areas of interest to the EE, there is evidence that help is on the way—although that will be cold comfort to the out-of-work engineer. Still, the educators are worried about catching up with the state of the art, as evidenced by sessions like "Electronics in the '80s." There, guided by C. R. Visvanathan, professor and chairman of the EE department of the University of California, Los Angeles, three panelists will wonder out loud about who will teach electronics, what the curriculum should contain, a philosophy of education for very large-scale integration, computer architecture, and the like. The panelists will be Rajinder Khotla, who heads the solid-state laboratory at Eastman Kodak Co. in Rochester, N. Y.; Dennis McGreivy of Gnostic Concepts Inc. in Menlo Park, Calif.; and Edward Kinnen of the University of Rochester (N. Y.).

Another discussion, or mini-plenary session, that deals directly with the faculty shortage is "Status Report on the Engineering Faculty Shortage Project." Robert P. Stambaugh of Union Carbide Corp., New York, will moderate a panel of experts including John W. Geils, who heads the industry-funded ASEE study and will describe the accomplishments of the first year of the project; Paul E. Torgersen of Virginia Polytechnic Institute, Blacksburg, who will view the project from the university's vantage point; and Robert K. Armstrong of Du Pont, who will describe how it looks from the industry side.

Nitty gritty. On the more basic level, J. J. Jonsson of Brigham Young University, Provo, Utah, who is program chairman for electrical engineering, points out that a lecture on the first day will look at the role of electromagnetic fields in "Field Theory—a Bushel or a Peck?" Gayle Miner of Brigham Young will ask "Who Needs Electro- and Magneto-Statics?" Alexander B. Bereskin of the University of Cincinnati will cover "Microwave Course Content." And Fred J. Young and C. John Mole of Westinghouse Corp.'s Research Laboratories in Pittsburgh will discuss the role of "Electronic Fields and Industrial Research."

The conference, whose theme is "Productivity through engineering," is a big, sprawling affair—much like the state in which it will take place—and will provide proof that the academic community is working hard to keep pace with technological progress. **-Howard Wolff**

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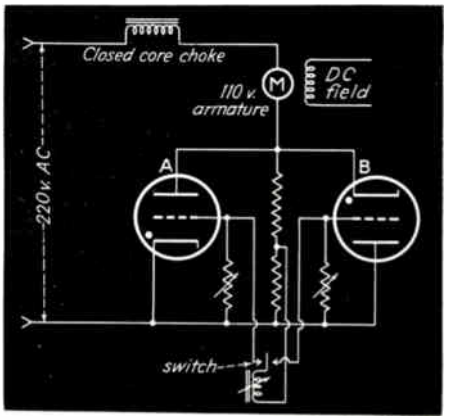

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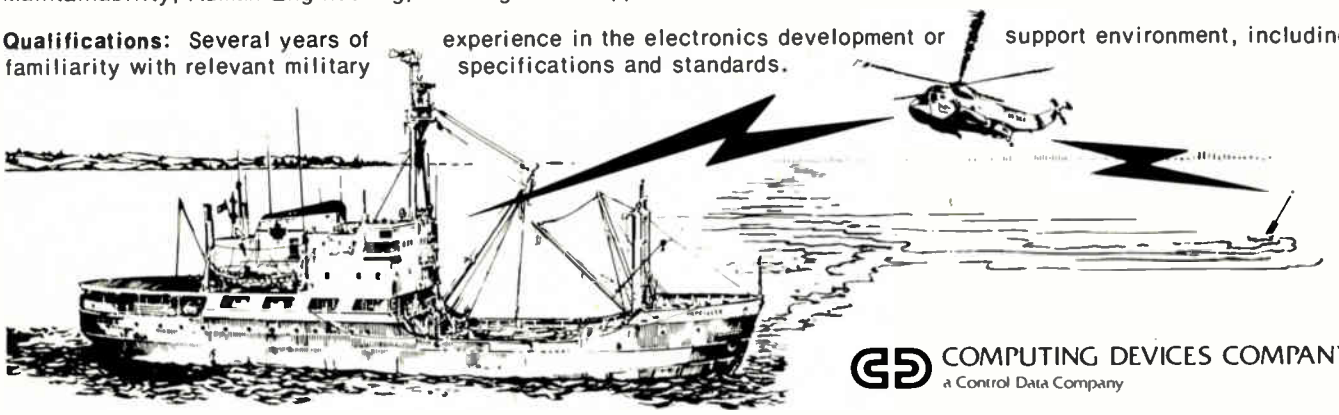

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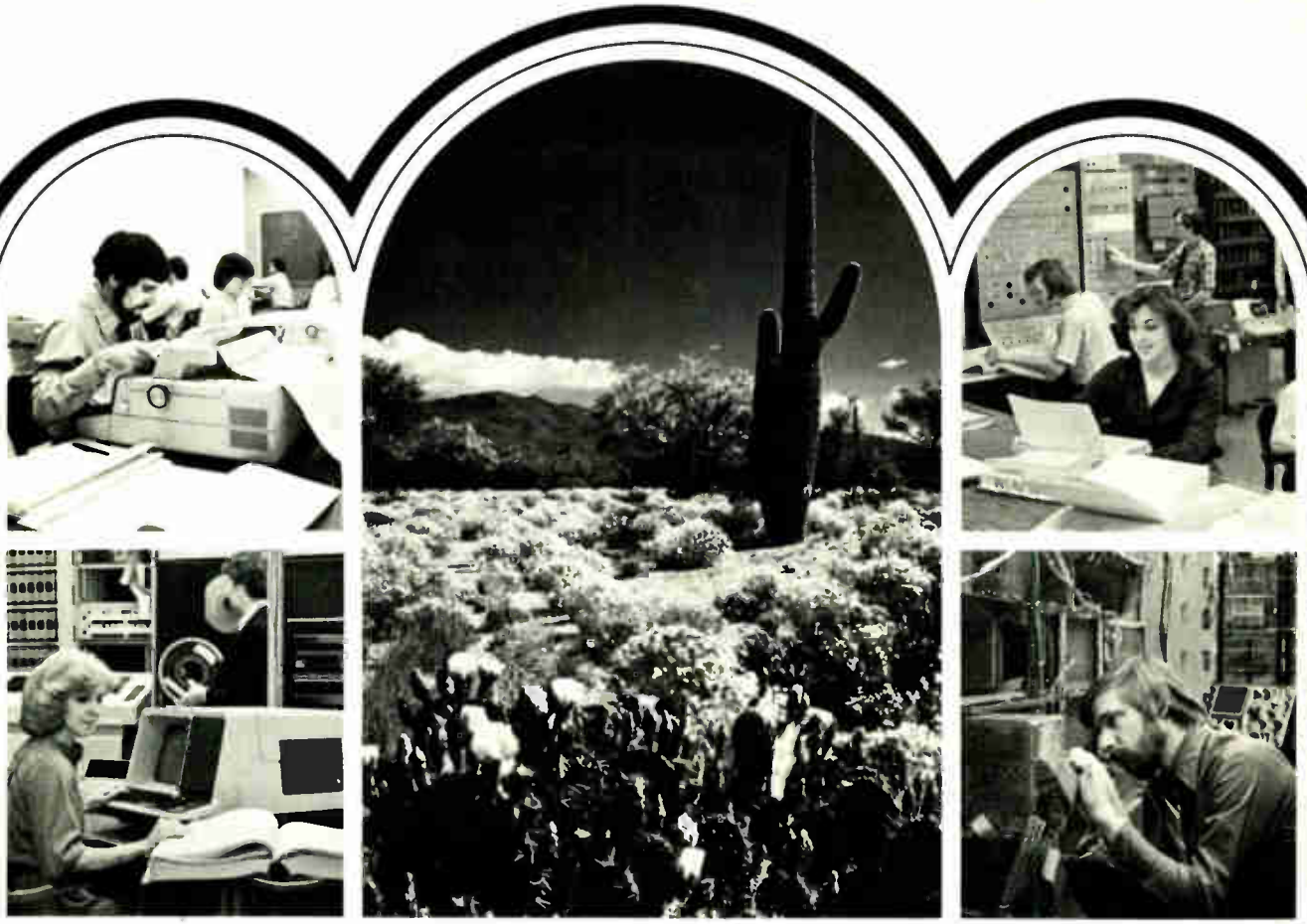

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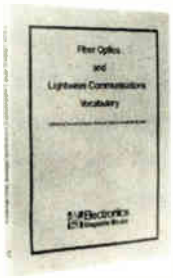

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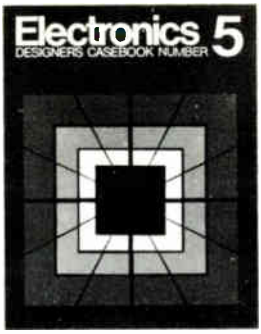

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G. Semiconductor production equipment (component insertion, coil winding, etc.)
H. Electronic sub-assemblies, components and materials (passive, active components, IC's, discretes, hybrids, power supplies)
I. Other manufacturers using electronics equipment as part of their product (machine tools, chemicals, metals, plastics, pharmaceuticals, etc.)
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K. Independent research and development laboratory or consultant
L. Research and development organizations which are part of an educational institution
M. Independent software developers
N. Operators of communications equipment (utilities, railroads, police and airlines, broadcasting, etc.)
O. Educational: 2-4 year college, university
P. Other _____

4. ☐ Indicate your principal job function, occupation and/or title (place applicable letter in box. If letters O, P, or Q are used, fill in name of college or university).

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B. Operating Management (General Managers, Group Managers, Division Heads, etc.)
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E Systems Engineering Integration
F Quality Control Engineering (Reliability and Standards)
G Design Engineering
H Engineering Support (Lab Assistants, etc.)
I Test Engineering (Materials, Test, Evaluation)
J Field Service Engineering
K Research and Development (Scientists, Chemists, Physicists)
L. Manufacturing and Production
M. Purchasing and Procurement
N. Marketing and Sales
O Professor/Instructor at _____
P Senior Student at _____
Q Graduate Student at _____

5. ☐ Indicate your principal job responsibility (place the appropriate number in box)

1 Management
2 Engineering Management
3 Engineering

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☐ 1 to 49
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☐ 250 to 999
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Your design function (check each letter that applies):

x ☐ I do electronic design or development engineering work.
y ☐ I supervise electronic design or development engineering work.
z ☐ I set standards for, or evaluate electronic components, systems and materials.

Your principal job responsibility (check one)

t ☐ Management
v ☐ Engineering Management
r ☐ Engineering

Estimate number of employees (at this location): **1.** ☐ under 20 **2.** ☐ 20-99 **3.** ☐ 100-999 **4.** ☐ over 1000

1	16	31	46	61	76	91	106	121	136	151	166	181	196	211	226	241	256	271	348	363	378	393	408	423	438	453	468	483	498	703	718
2	17	32	47	62	77	92	107	122	137	152	167	182	197	212	227	242	257	272	349	364	379	394	409	424	439	454	469	484	499	704	719
3	18	33	48	63	78	93	108	123	138	153	168	183	198	213	228	243	258	273	350	365	380	395	410	425	440	455	470	485	500	705	720
4	19	34	49	64	79	94	109	124	139	154	169	184	199	214	229	244	259	274	351	366	381	396	411	426	441	456	471	486	501	706	900
5	20	35	50	65	80	95	110	125	140	155	170	185	200	215	230	245	260	275	352	367	382	397	412	427	442	457	472	487	502	707	901
6	21	36	51	66	81	96	111	126	141	156	171	186	201	216	231	246	261	338	353	368	383	398	413	428	443	458	473	488	503	708	902
7	22	37	52	67	82	97	112	127	142	157	172	187	202	217	232	247	262	339	354	369	384	399	414	429	444	459	474	489	504	709	951
8	23	38	53	68	83	98	113	128	143	158	173	188	203	218	233	248	263	340	355	370	385	400	415	430	445	460	475	490	505	710	952
9	24	39	54	69	84	99	114	129	144	159	174	189	204	219	234	249	264	341	356	371	386	401	416	431	446	461	476	491	506	711	953
10	25	40	55	70	85	100	115	130	145	160	175	190	205	220	235	250	265	342	357	372	387	402	417	432	447	462	477	492	507	712	954
11	26	41	56	71	86	101	116	131	146	161	176	191	206	221	236	251	266	343	358	373	388	403	418	433	448	463	478	493	508	713	956
12	27	42	57	72	87	102	117	132	147	162	177	192	207	222	237	252	267	344	359	374	389	404	419	434	449	464	479	494	509	714	957
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14	29	44	59	74	89	104	119	134	149	164	179	194	209	224	239	254	269	346	361	376	391	406	421	436	451	466	481	496	701	716	959
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The fork is then ready for final adjustment and calibration. A hole is drilled and tapped in the end of each tine to receive two adjustable loading screws. The frequency is measured to within one millicycle with both tine holes empty, with an inner tine screw in each hole and then with an outer tine screw set up tightly against the first screw. From these measurements the approximate amount of material to be cut from the tine screws to bring the frequency very close to its nominal value is ascertained.

The fork is then allowed to run for a half-hour at a controlled temperature of 77 degrees F. after which the final frequency measurement is made. Appropriate adjustments of the tine screws set the frequency to within 0.001% of the nominal value. The voltage coefficient of frequency is now obtained. This is approximately 0.005% per volt. The output voltage and harmonic content are then measured.

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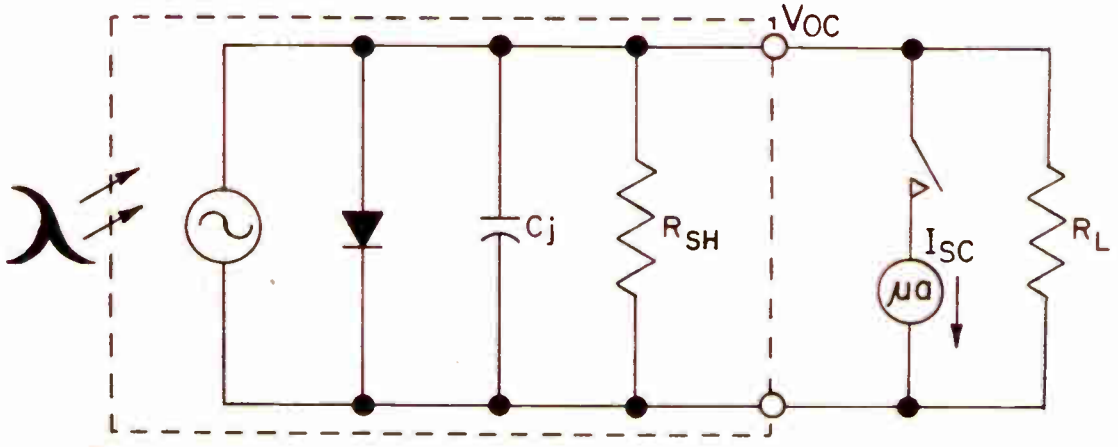

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