FEBRUARY · 1948

electronics

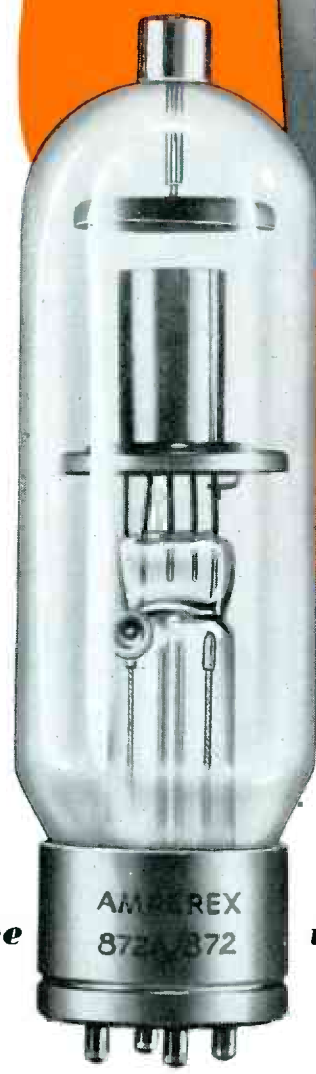
A McGRAW-HILL PUBLICATION

MACHINE-MADE RADIO

"I like Amperex tubes because"...

It takes a lot more than 25 words to sum up all the reasons engineers prefer and specify Amperex tubes. For example: the engineers of Induction Heating Corporation specify Amperex 833-A power tubes and Amperex 872-A rectifiers for their Model 43 induction heater because they find that Amperex

The Model 43 Ther-Monic Induction Heater manufactured by Induction Heating Corporation is factory equipped with Amperex 833-A power tubes and Amperex 872-A rectifier tubes.



tubes have longer life, give a minimum of trouble and help produce satisfied customers. Too, they like that extra engineering that goes with the Amperex name; those little differences that make a big difference . . . and they also like the application engineering of the Amperex staff which is theirs, and yours, to command.

re-tube with Amperex

AMPEREX ELECTRONIC CORPORATION

25 WASHINGTON STREET, BROOKLYN 1, N. Y.
In Canada and Newfoundland: Rogers Majestic Limited
11-19 Brentcliffe Road, Leaside, Toronto, Ontario, Canada

electronics

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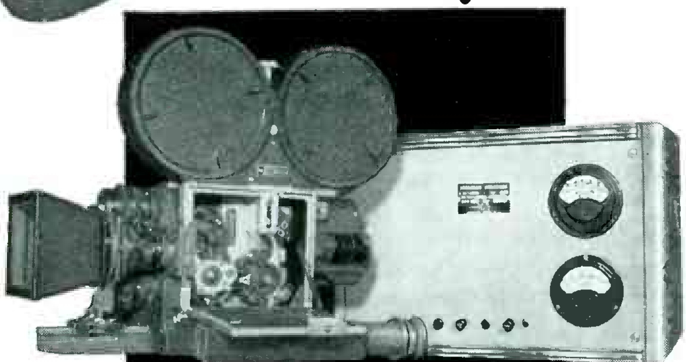
...get out the distortion and variations in your incoming line voltages with SORENSEN ELECTRONIC REGULATORS



● This Nobatron is being used to test battery operated Movietone News cameras. Nobatrons provide a source of DC voltages at high currents previously available only with batteries.

The Nobatron maintains a regulation accuracy of 0.25%, ripple voltage (RMS max) of 1% and has a recovery time of 1/5 of a second.

● *Wherever you use line voltage for precision operations, whether it be in the test laboratory or on the assembly line, a Sorensen unit can provide regulation accuracies to 2/10 of 1% with quick recovery time.*

Arrange to have a Sorensen engineer analyze voltage regulation requirements in your plant. He can select one of the standard units or suggest a special design to handle your unusual applications.

Take a look at this Performance!

1. Wide input voltage range: 95 to 125 volts or 190 to 250 volts.
2. Low harmonic distortion: less than 5% in basic models, and 2% in "S" models.
3. Insensitive to input line frequencies between 50 and 60 cycles.
4. Power factor variations from 70% lagging to 90% leading have little effect on regulation accuracy.
5. Recovery time of 0.1 seconds under the most adverse input and load conditions.
6. Regulation accuracies from 0.1% to 0.5% depending upon model chosen.

write today for your copy of the new Sorensen catalog. It contains schematics, curves, application data and a special section on "Principles of Operation."

• Represented in all domestic and foreign principal cities.

Address of Sorensen office in your area furnished on request.

The FIRST line of standard ELECTRONIC AC Voltage Regulators and Nobatrons

SORENSEN

& COMPANY, INC. • STAMFORD, CONNECTICUT

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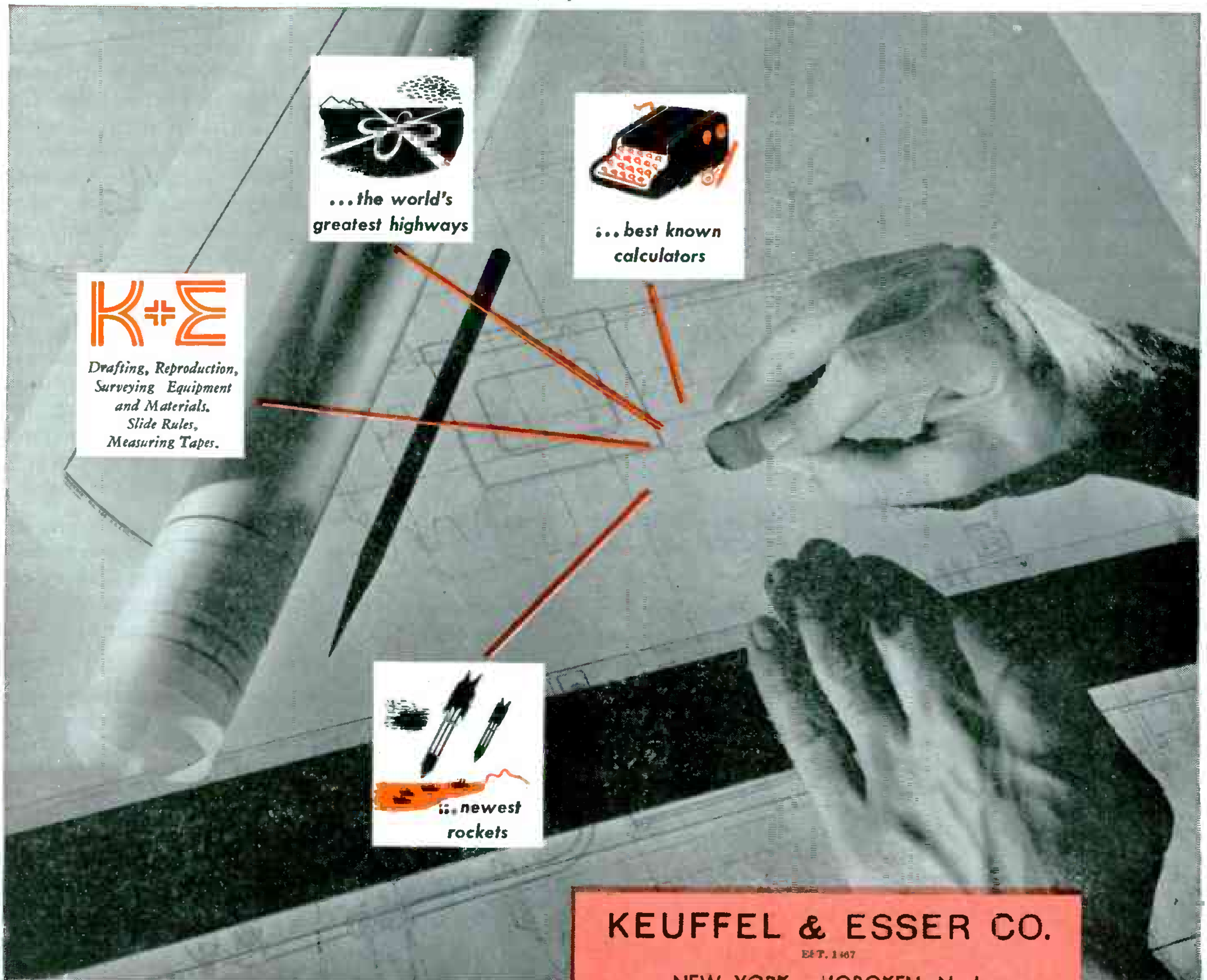
For 80 years Keuffel & Esser Co. drafting equipment and materials have been partners, in this sense, in shaping America, in making possible its swift-moving highway traffic, its speed in conducting business, its victorious might in war ... So universally is K & E equipment used, it is self-evident that every engineering project of any magnitude has materialized with the help of K & E. Could you wish any surer guidance than this in the selection of your own "drafting partners"?

partners in creating

You will find special advantages, for example, in PHOENIX* Tracing Cloth, which K & E has made almost "ghost-proof." Here is a cloth from which you can erase either pencil or ink lines without risking untidy "ghosts" on the prints, a cloth practically immune to stains from perspiration and water. You can even soak it in water for ten minutes at a time without harm! For further details about PHOENIX* Tracing Cloth, write on your letterhead to Keuffel & Esser Co., Hoboken, N. J.

*REG. U. S. PAT. OFF.



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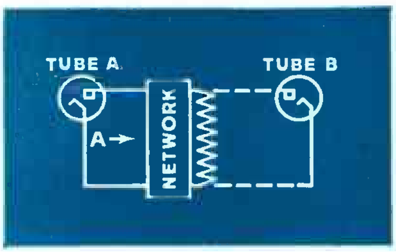
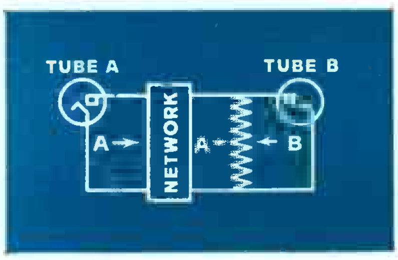
How the Doherty Circuit pays off for Broadcasters

DOHERTY CIRCUIT



CONDITION 1: **Nearly zero modulation, so amplifier has to handle carrier wave alone. Tube A is sufficient and—seeing just the right impedance in network—operates at maximum efficiency. Tube B, not needed, lies idle.**



CONDITION 2: **Carrier being modulated. Tube B, now needed, kicks in, adding its quota of power to handle the increased load and changing the impedance so that Tube A also steps up its output. Both tubes work to full capacity and at high efficiency.**

The Doherty Circuit for AM broadcast transmitters was the first to achieve *high efficiency and economy* and still retain the following important advantages of *linear* and *grid bias modulated* power amplifiers:

(1) A simple tube complement—no high-power audio tubes required

(2) No modulation transformer required—savings in space and apparatus

(3) Freedom from transient or overmodulation surges—can be heavily overmodulated at any audio frequency for long periods without damage

(4) Adaptability to large amounts of feedback derived from the final output envelope, resulting in low noise, low harmonic distortion, and low intermodulation distortion over wide variations in tube characteristics and circuit adjustment

(5) Negligible carrier shift, assuring full utilization of the assigned carrier power of the station

Gearing tubes to circuits

How a tube acts in a circuit depends, of course, upon the *impedances* which face it in the circuit. So getting the most out of tubes is a matter of getting the right impedances.

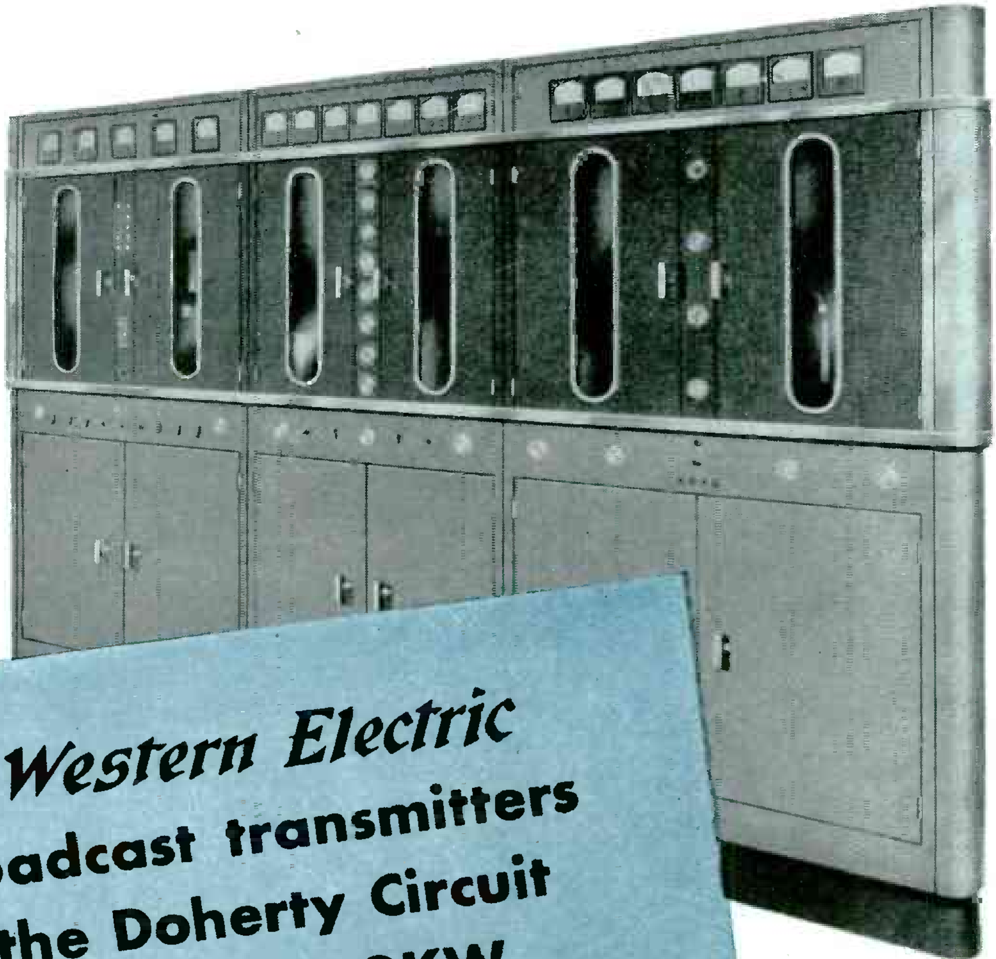
Like pre-Doherty linear amplifiers, the Doherty *High Efficiency* Amplifier Circuit has two tubes. *Unlike* them, it has a network which automatically changes impedances to best meet changing needs. Both tubes receive the signal, but—when the carrier alone is on—only *one* tube is operative. The second tube uses no power. Not until modulation is applied, raising the input voltages on both tubes, does the second tube start up. It then does two things: it contributes more power to meet the added load, and it automatically changes the impedance faced by the first tube so as to throttle it up to full output, too.

For the Broadcaster, this means that the Doherty Circuit consumes only *half the power* required by old style linear amplifiers—a real triumph in circuit engineering.

It is just one of many Bell Telephone Laboratories developments which have contributed to improved efficiency, greater economy and higher quality in communications.

BELL TELEPHONE LABORATORIES

World's largest organization devoted exclusively to research and development in all phases of electrical communications.



The 5 KW AM transmitter, like the 1KW and 50 KW, has the famous Doherty Circuit. Eleven years of experience proves this *High Efficiency* amplifier operates continuously for long periods with no need for retuning.

ONLY Western Electric AM broadcast transmitters have the Doherty Circuit 1KW...5KW...50KW

Today the Doherty Circuit is being used by hundreds of broadcast stations—making possible the use of smaller circuit elements, saving space, giving increased stability and greater ease of adjustment, and reducing the outlay for auxiliary equipment.

Other features

In Western Electric 1, 5 and 50 KW AM transmitters, you also get two other famous Bell Laboratories developments—stabilized feedback and grid bias modulation. These, together with the Doherty Circuit, are your assurance of superlative performance at rock-bottom operating cost!

Get full details

If you're thinking about a new AM transmitter, remember this: *only* Western Electric has the Doherty *High Efficiency* Circuit—unmatched today in performance, dependability, and economy! For full details, call your local Graybar Broadcast Representative or write Graybar Electric Co., 420 Lexington Ave., New York 17. N. Y.

The 1 KW AM transmitter, with the Doherty Circuit, is extremely compact—requires floor space only 44″ wide by 42″ deep.

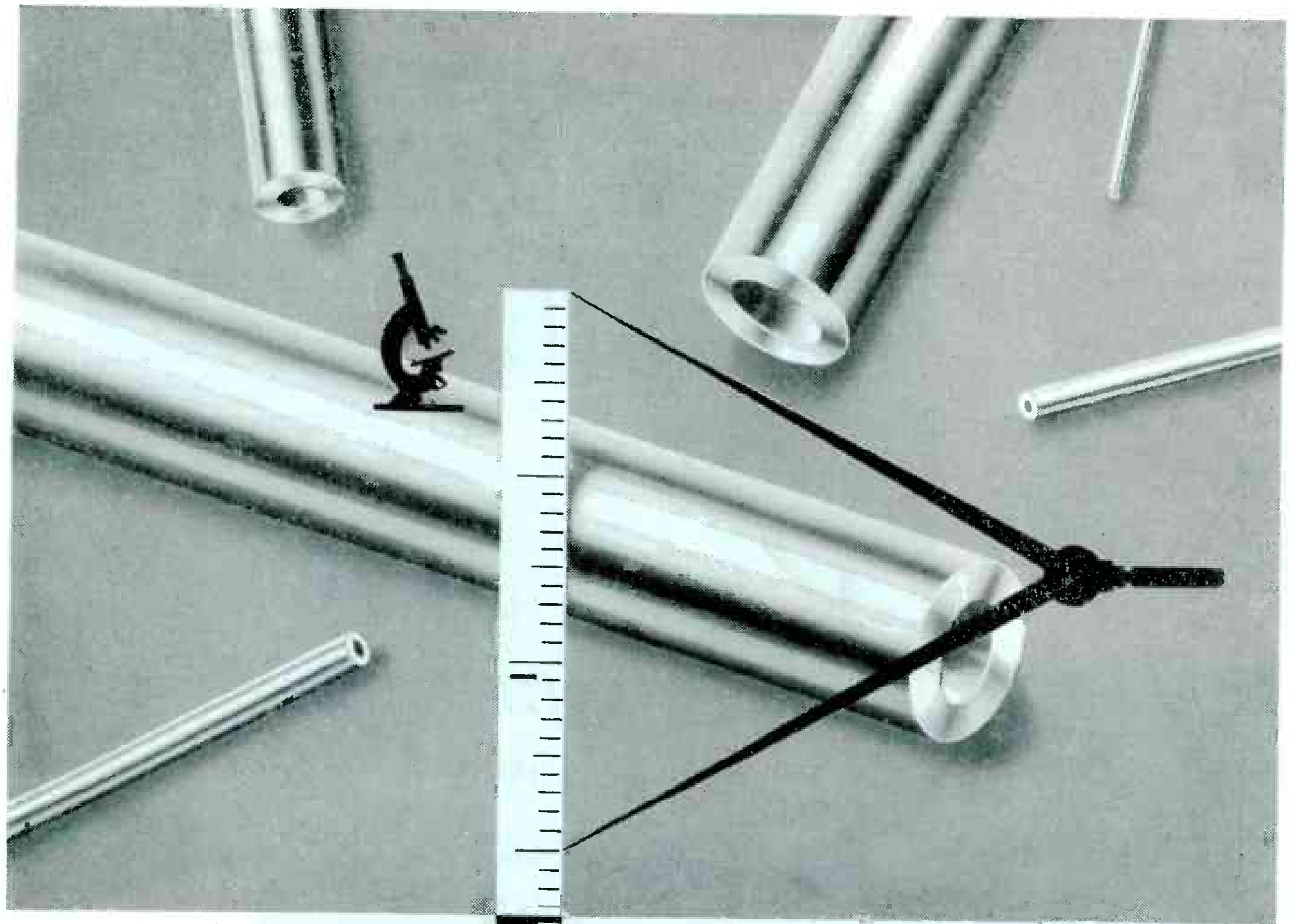
DISTRIBUTORS: IN THE U. S. A.—Graybar Electric Company. IN CANADA AND NEWFOUNDLAND —Northern Electric Company, Ltd.

—QUALITY COUNTS—

Western Electric

Manufacturing unit of the Bell System and the nation's largest producer of communications equipment.

Distributed by Graybar — Offices in 91 principal cities



brief specifications

PURITY: 99.9+% pure molybdenum

OTHER QUALITIES:
Callite molybdenum tubing is readily machineable; can be worked and shaped within reasonable tolerances; welds to iron, nickel and similar materials; will not react with hydrofluoric acid and hot aqueous solutions of sodium and potassium hydroxide. Molybdenum tubing will also withstand high tensile stresses at elevated temperatures when sustained in a protective atmosphere.

SPECIFIC GRAVITY: 10.2

MELTING POINT: 2,620° C.

TENSILE STRENGTH: From 180,000 – 250,000 psi, depending upon diameter

HARDNESS: 160-185 Brinell (10 mm. ball 3,000 Kg. load)

THERMAL EXPANSION: 25° to 500° C. (4.7 – 5.7) x 10^{-6} per °C.

THERMAL CONDUCTIVITY: 1.46 watts per cm/°C. at 20° C.

SIZES – Now being produced in standard production diameters up to .500". Other diameters, with smaller wall thickness, to meet your individual requirements on request. Available in lengths up to 9.0".

O.D. AND I.D. FOR VARIOUS SIZES

Outside Diameter	Inside Diameter	Outside Diameter	Inside Diameter
.500"	.290" to .295"	.140"	.077" to .079"
.427"	.257" to .262"	.110"	.062" to .064"
.375"	.220" to .225"	.090"	.051" to .053"
.312"	.182" to .187"	.075"	.041" to .043"
.250"	.142" to .147"	.060"	.033" to .035"
.187"	.104" to .107"	.050"	.027" to .029"
		.040"	.022" to .023"

seamless molybdenum tubing 99.9 + % pure

Available in Commercial Quantities
in all diameters up to 0.5" in lengths to your specifications

Seamless molybdenum tubing offers you many opportunities for improving the efficiency of your end-product or in the actual processing of materials. Callite engineers developed it to provide a superior molybdenum tubing – without seams and in sufficient quantities – for modern mass production techniques. You can order all your requirements on pin-point delivery schedules. Our engineers will be glad to consult with you on specific applications. Samples on request. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, New Jersey. Branch offices in Chicago, Illinois; Cleveland, Ohio.

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MOLY TUBING

NOW! 10 cps to 10 mc

...with the New -hp- 650A RESISTANCE-TUNED OSCILLATOR

HERE IT IS . . . another *-hp-* "first" . . . a new resistance-tuned oscillator that not only covers a frequency range of 10 cps to 10 mc, but brings to the r-f and video field all the speed, accuracy and ease of measurement traditional to famous *-hp-* audio oscillators. And, this important addition to the *-hp-* line incorporates all the family characteristics of other *-hp-* oscillators . . . no zero setting, minimum adjustment during operation, virtual independence of line and tube characteristics, accurate calibration, and streamlined circuits for long, trouble-free performance.

The result is a highly stable, wide-band precision instrument which provides output flat within 1 db from 10 cps to 10 mc, and a voltage range of .00003 to 3 volts. Output impedance is 600 ohms or 6 ohms with output voltage divider.

LIKE OTHER *-hp-* resistance-tuned oscillators, the new 650A gives you the advantage of decade frequency ranges, a 94" scale length, and a 6 to 1 micro-controlled vernier drive. A complete vacuum tube voltmeter, included in the 650A circuit, monitors output in volts or db at the 600 ohm level. A continuously variable output voltage is obtained by means of an output attenuator of 50 db, variable in 10 db steps and an amplitude control which adjusts the level to the monitor vacuum tube voltmeter.

Where it is desirable that the measurements be made with a low source impedance, an output voltage divider unit is supplied. This attachment consists of a cable, which may be extended to the point of measurement and provides an internal impedance of 6 ohms. It also reduces the output voltage 100 to 1.

THE COMPACT, efficient *-hp-* 650A is available now for making a wide number of measurements . . . testing television amplifiers, wide-band systems, filter transmission characteristics, tuned circuits, receiver alignments. And . . . it serves admirably as a power source for bridge measurements or as a signal generator modulator.

1495

For full information...write today

Hewlett-Packard Company • 1495A Page Mill Road • Palo Alto, Calif.

SPECIFICATIONS

FREQUENCY RANGE: 10 cps to 10 mc

FREQUENCY CALIBRATION: 0.9 to 10. Multiplying factors are:

MF	Freq. Range
X10 cps	9 to 100 cps
X100 cps	90 to 1000 cps
X1kc	900 to 10,000 cps
X10kc	9 to 100 kc
X100kc	90 to 1000 kc
X1mc	0.9 to 10 mc

STABILITY: ±2%, 10 cps to 100 kc; ±3%, 100 kc to 10 mc including warmup, line voltage, and tube changes.

OUTPUT: 10 milliwatts or 3 volts into 600 ohm resistive load. Open circuit voltage is at least 6 volts. 600 ohm reflected impedance. Output impedance of 6 ohms also available.

FREQUENCY RESPONSE: Flat within ±1 db, 10 cps to 10 mc.

DISTORTION: Less than 1% from 100 cps to 100 kc. Approx. 5% from 100 kc to 10 mc.

OUTPUT MONITOR: Vacuum tube voltmeter monitors output level in volts or db at 600 ohm level. Output response beyond monitor is accurate within ±5% all levels and frequencies.

OUTPUT ATTENUATOR: Output level attenuated 50 db in 10 db steps, providing continuously variable output voltage from +10 dbm to —50 dbm, 3 volts to 3 millivolts, or down to 30 microvolts with voltage divider.

HUM VOLTAGE: Less than 0.5% below maximum attenuated signal level.

POWER SUPPLY: 115 volts 50/60 cps. Consumption 135 watts. Plate supply electronically regulated.

MOUNTING: Cabinet or relay rack. Panel size 19" x 10½". Depth 13".

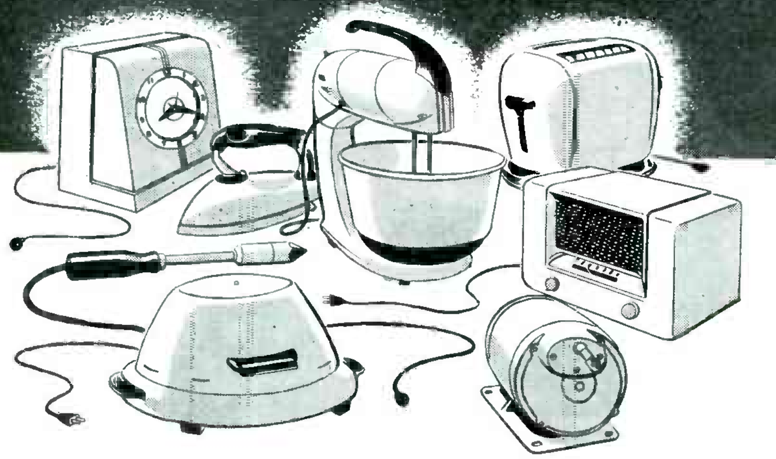
Attention FM Engineers!
Full information on the new -hp-
FM TEST EQUIPMENT
Available on Request.
Write Today!

hp laboratory instruments
FOR SPEED AND ACCURACY

"LIVE WIRE" PERFORMERS

are wired with

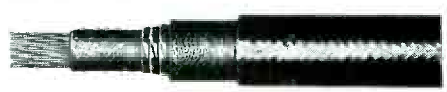
ROCKBESTOS FOR THESE SIX REASONS



A few of the 125 permanently insulated wires, cables and cords developed by Rockbestos.

ROCKBESTOS ALL-ASBESTOS APPLIANCE LEAD WIRE
Available in several types to fit the electrical and mechanical requirements of your product. Solid or stranded copper, nickel or monel conductors insulated with .030″ or .040″ of impregnated felted asbestos in black, white and colors.

ROCKBESTOS A.V.C. 600 VOLT SWITCHBOARD WIRE
This wire was designed to make complicated wiring jobs permanent. The impregnated felted asbestos wall beneath the flame-proofed cotton braid is heat, flame and moisture resistant and assures fine appearance of boards as it gives on bends to prevent braid-cracking. Sizes 18 to 4/0 AWG with solid or stranded conductors in black, gray and colors. Rockbestos A.V.C. Hinge and Bus Cables have the same characteristics.



ROCKBESTOS A.V.C. 600 VOLT MOTOR LEAD CABLE
Use this apparatus cable for coil connections, motor and transformer leads exposed to overloads or high ambient temperatures. It makes a permanent installation as it is resistant to heat, flame, oil, grease and moisture. Sizes No. 18 AWG to 1,000,000 CM insulated with two walls of impregnated asbestos and a high-dielectric varnished cambric insert, with a heavy asbestos braid covering.

The best sales force can't up your sales curve if your product's performance is "short circuited" by wire failures due to high operating or ambient temperatures. Rockbestos wires, cables and cords have permanent insulation of impregnated felted asbestos which gives you *six advantages:*

(1) It *won't* bake out, crack or flow when exposed to high ambient or operating temperatures.

(2) It *won't* rot, bloom or swell when exposed to corrosive fumes, oil or grease.

(3) It *won't* bake brittle under conductor overloads.

(4) It *won't* burn — provides definite wire-fire protection.

(5) It *won't* deteriorate under age or oxidation.

(6) It *won't* fail to deliver greater current carrying capacity.

These advantages can mean the difference between red ink and black in terms of good will, reduced servicing and replacement. You'll find them in 125 different standard Rockbestos constructions. For recommendations or samples for *your* product write:

ROCKBESTOS PRODUCTS CORPORATION
456 Nicoll St., New Haven 4, Conn.

NEW YORK BUFFALO CLEVELAND DETROIT
CHICAGO PITTSBURGH ST. LOUIS
LOS ANGELES OAKLAND, CAL.

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

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Precision standards are set in the laboratory.

Accurate performance of your product is limited by the precision of its component parts. It is only through selection of precision components that superior performance can be assured. Hi-Q Ceramic Capacitors, for example, can be held to a minimum tolerance of .25 MMF. Constant surveillance throughout every stage of manufacture . . . from raw material to finished product . . . is responsible for this uniformly high quality of all Hi-Q components. Specify Hi-Q components . . . your assurance of precision performance.

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Hi-Q Ceramic Capacitors of unquestionable stability assure you the ultimate in performance for all electronic appliances. Let us assist you with your Ceramic Capacitor problems.

CHOKE COILS

STAND-OFF CONDENSERS

WIRE WOUND RESISTORS

HI-Q COMPONENTS BETTER 4 WAYS

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

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

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

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

HI-Q Electrical Reactance Corp.
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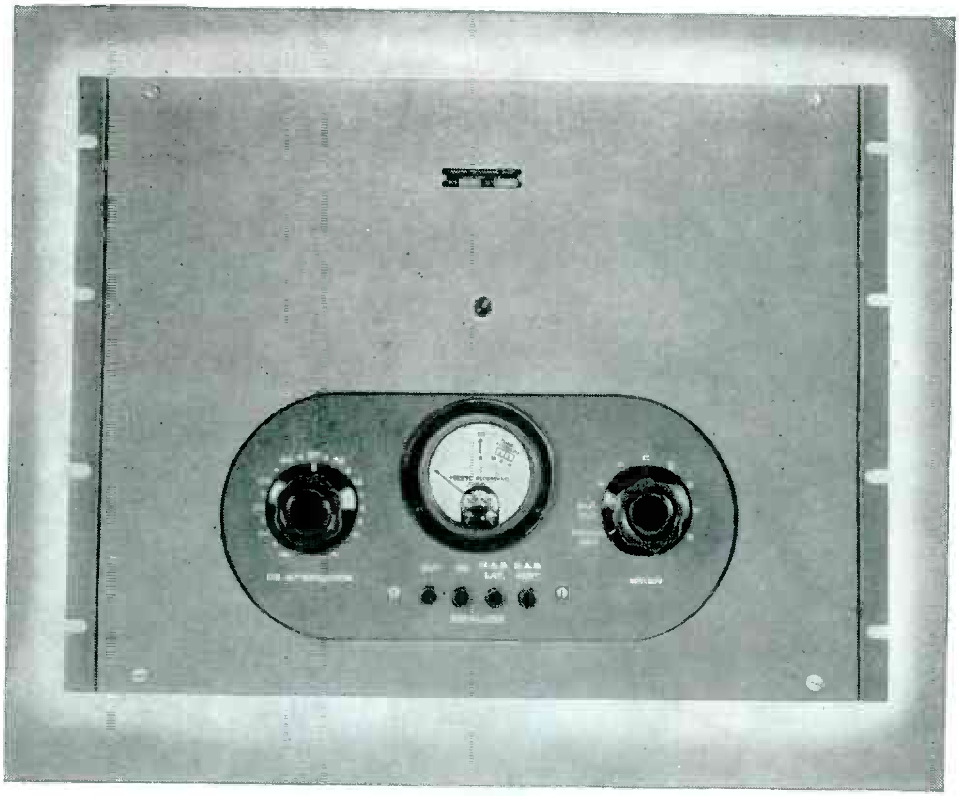
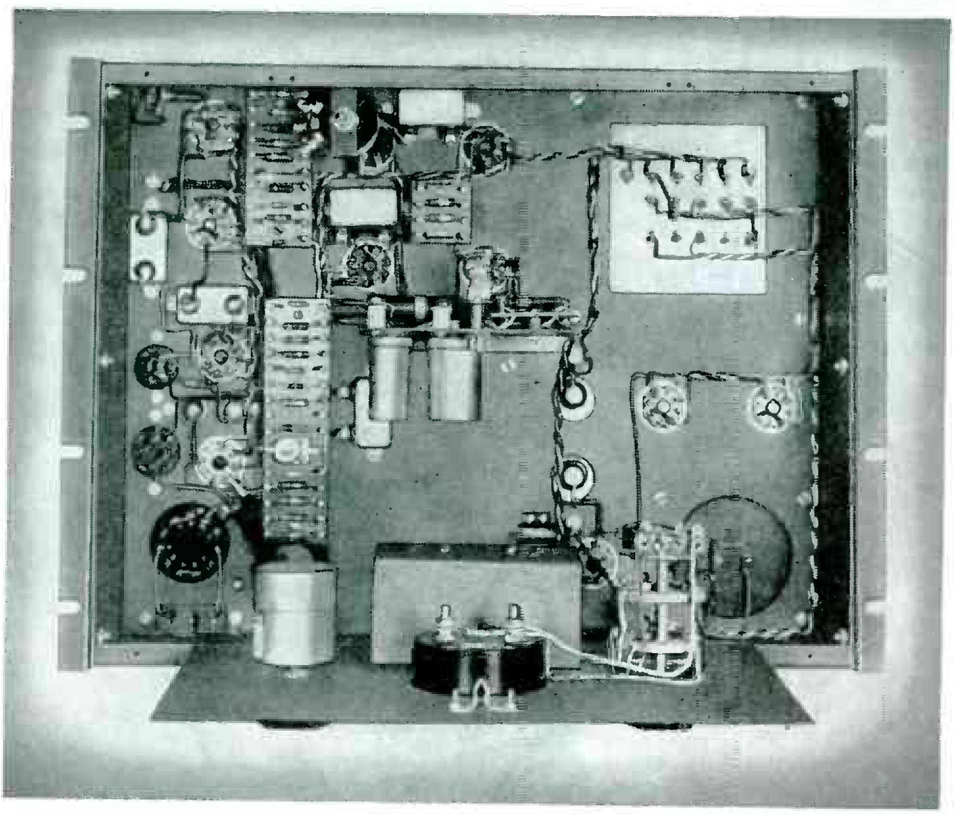
Plants: FRANKLINVILLE, N. Y. — JESSOP, PA.
Sales Offices: BOSTON, NEW YORK, PHILADELPHIA, DETROIT, CHICAGO, LOS ANGELES

Presto Presents Something New in Recording Amplifiers...

The new Presto 92-A is a 50-watt amplifier designed specifically for recording work. It answers the need for an amplifier of exceptional quality and performance, and includes a number of outstanding features thoroughly proved in operation:





1 Selector switch and meter provide both output level indicator (not for "riding gain") and plate current readings for all tubes.

2 Chassis is vertically mounted. Removal of the front panel gives access to all circuits without removing amplifier from rack.

3 The output stage has four 807's in push-pull parallel with an unusual amount of feedback. This produces ample peak power with low distortion and an extremely low internal output impedance for best performance from magnetic cutting heads.

Push buttons select any of these recording characteristics: flat, 20-17,000 cps, 78 rpm, standard NAB lateral, NAB vertical—all within an accuracy of ±1 db. Distortion is only 1½% at full output.

PRESTO

RECORDING CORPORATION

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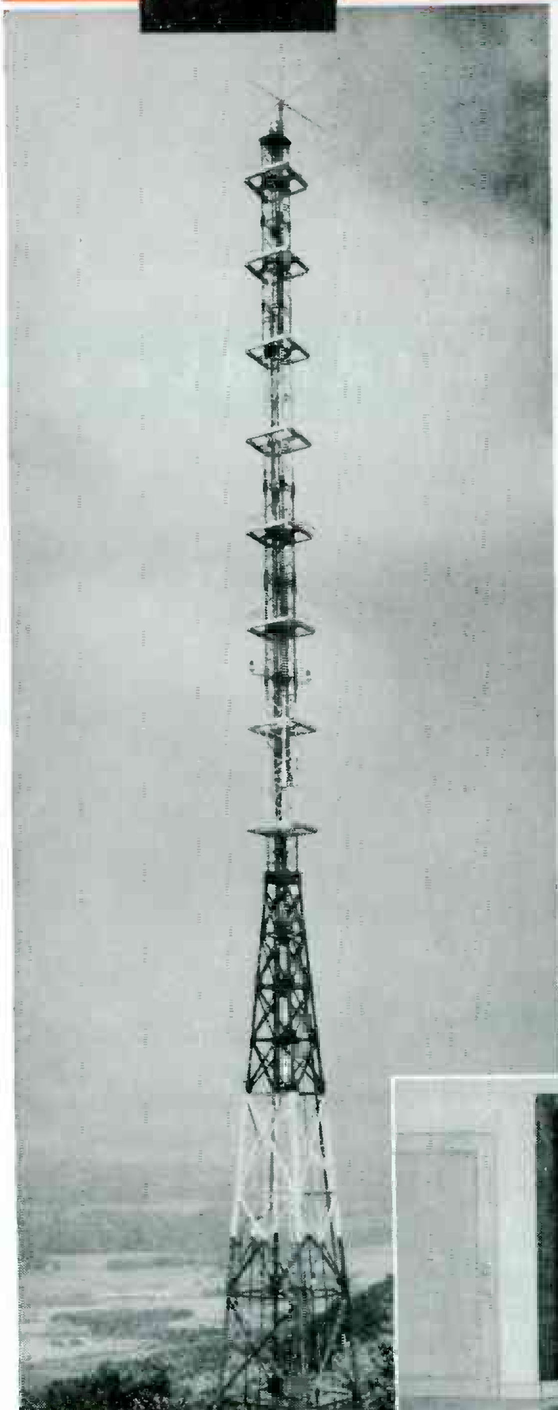
Walter P. Downs, Ltd., in Canada

FREE! Presto will send you free of charge a complete bibliography of all technical and engineering articles on disc recording published since 1921. Send us a post card today.

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT & DISCS

for FM COVERAGE and PERFORMANCE

you can't beat Federal's
COMPLETE "ONE-PACKAGE" STATION



A broadcast station that's FM by Federal all the way—from microphone to antenna—offers *three exclusive features* that assure maximum coverage at minimum operating cost, and maximum performance with minimum maintenance expense.

1. FEDERAL'S SQUARE-LOOP ANTENNA!

The coverage of an FM station depends primarily on the effective strength of the radiated signal. And Federal's 8-Element, Square-Loop Antenna gives an effective radiated power *more than 8 times* the transmitter rating. Actual installations have repeatedly *proved* its ability to give outstanding coverage—and to withstand high winds and heavy icing loads.

2. FEDERAL'S HIGH-FIDELITY TRANSMITTER!

All Federal FM transmitters feature the exclusive "Frequematic*" modulator—for outstanding fidelity and performance. Maintains center-frequency stability within 0.001%—reduces signal-to-noise ratio to 5600-to-1—uses simple all-electronic circuits with standard receiver tubes—easy to align, simple to maintain.

3. FEDERAL ENGINEERING ALL THE WAY!

Complete FM by Federal means FM at its best, with all components precision engineered to work together. Transmitter console, studio console, transcription units, power supplies—everything from microphone to antenna—designed and coordinated for maximum over-all performance and economy.

When planning your new FM station, remember these exclusive advantages. And if you want to get on the air *fast*, Federal can now make your complete installation in record time! For further information, write to Federal, Dept. B613.

*Trade Mark

With this Federal 8-Element Square-Loop Antenna, now on the air at Station WMRC-FM, Greenville, South Carolina, listeners more than 200 miles away—including cities in 6 different states—report excellent reception. Lower photo shows WMRC's transmitter room, with Federal 10-Kw transmitter, console, monitor speaker and power supply.

FTR An IT&T Associate

Federal Telephone and Radio Corporation

100 KINGSLAND ROAD, CLIFTON, NEW JERSEY

KEEPING FEDERAL YEARS AHEAD... is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

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ELECTRICAL INSULATIONS

*MIRAGLAS IS THE NAME FOR

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

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

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

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Try it! —and you'll come back for more!

It's just this size!

THE NEW WESTERN ELECTRIC 755A 8-INCH LOUDSPEAKER

Available immediately —in quantity!

Here's more quality than you ever thought possible in an 8-inch speaker!

This new Western Electric 755-A gives you wide frequency response—exceptionally brilliant tonal quality—ample output—all at surprisingly modest cost.

The relatively small space required to obtain such high quality with this 8-inch speaker makes it ideal for broadcast station use, wired music, program distribution and sound systems, home radios and record players—in fact *everywhere* for top quality reproduction!

Brilliant performance *is* possible with an 8-inch speaker. Prove it to yourself by putting the 755-A through its paces. We'll bet you'll be so pleased you'll come back for more!

Call Graybar today!

Get your 755-A's quickly—call your nearest Graybar representative right now—or write to Graybar Electric Co., 420 Lexington Ave., New York 17, N.Y.

Specifications of the 755-A

Power Handling Capacity
8 watts continuous

Frequency Response
70 to 13,000 cycles

Input Impedance
4 ohms

Efficiency
Sound level at 30 feet on axis is 81.5db above 10^{-16} watts per square centimeter at 8 watts input

Coverage Angle
70 degrees

Weight
4¾ pounds

Dimensions
Diameter: 8⅜"
Depth: 3⅛"
Baffle Hole Diameter 7"

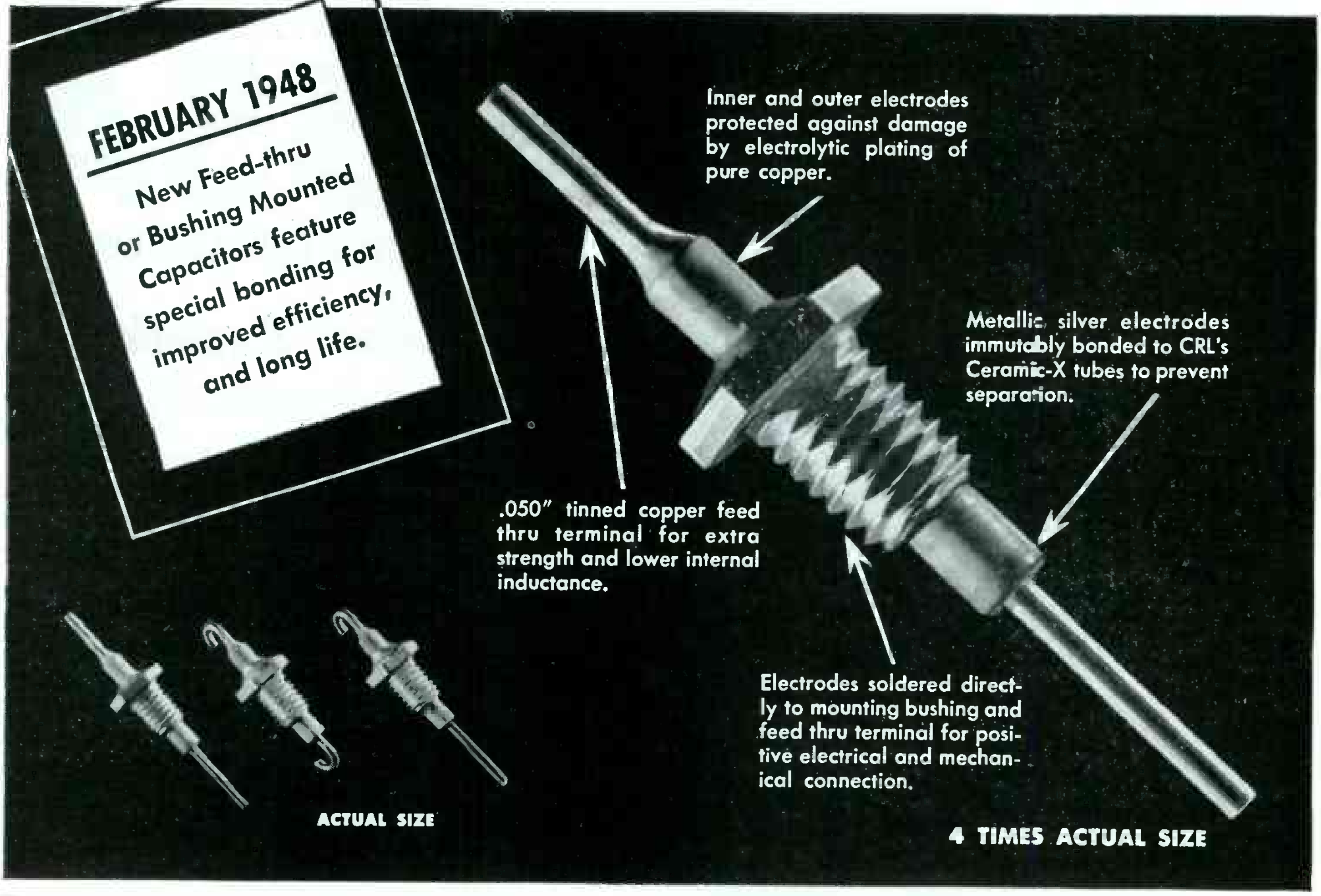
Enclosure Required
2 cubic feet

Distributed by Graybar — Offices in 93 principal cities

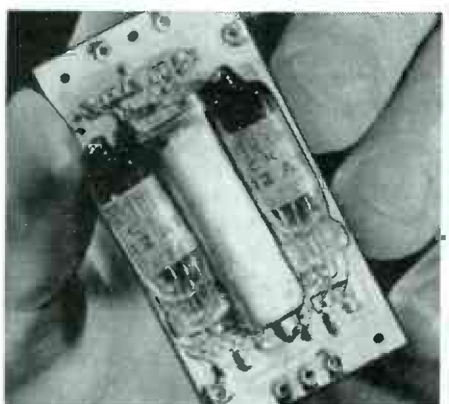
DISTRIBUTORS: IN THE U. S. A.—Graybar Electric Company. IN CANADA AND NEWFOUNDLAND—Northern Electric Company, Ltd.

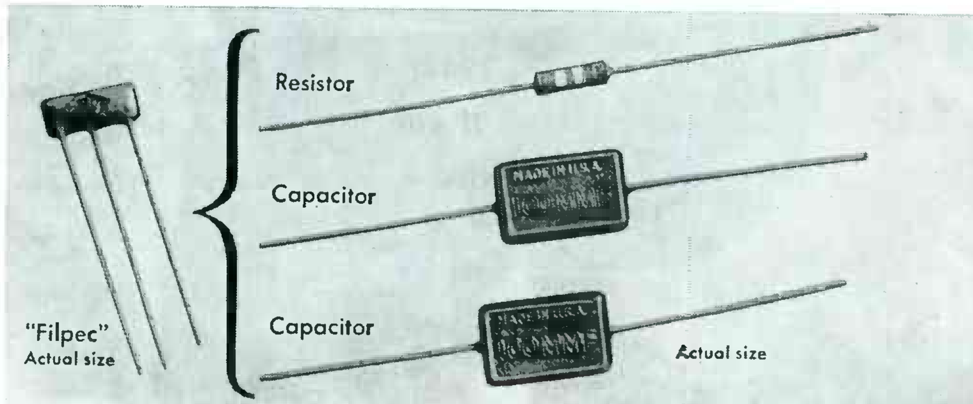
Western Electric
—QUALITY COUNTS—

Centralab reports to



1 Made with high dielectric Ceramic-X, CRL's new *FT Hi-Kaps* now eliminate structural and electrical damage during installation. Two special bonds are reason: 1) between inner feed-thru terminal and inside diameter of tube, and 2) between mounting bushing and outside diameter of tube. Capacity from 55 to 2,300 mmf. 500 WVDC. Flash test, 1000 VDC. For use in high frequency circuits where, in addition to feed-thru, a capacity ground to either chassis or shield is desired. Write for Bulletin 975.

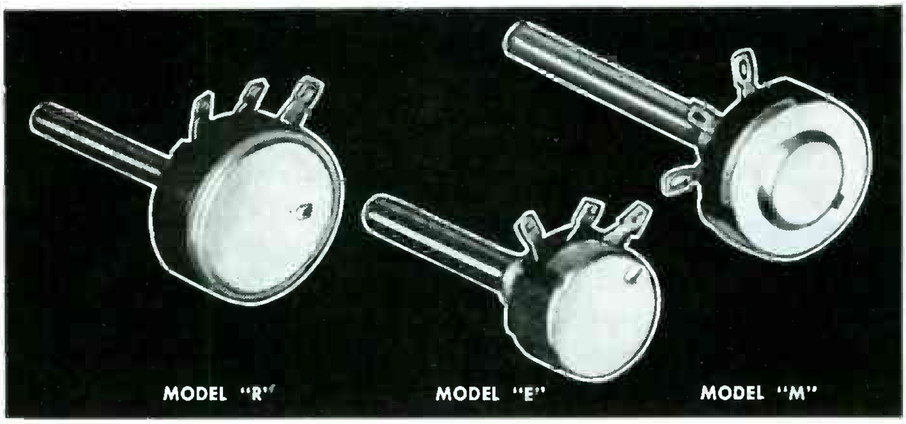


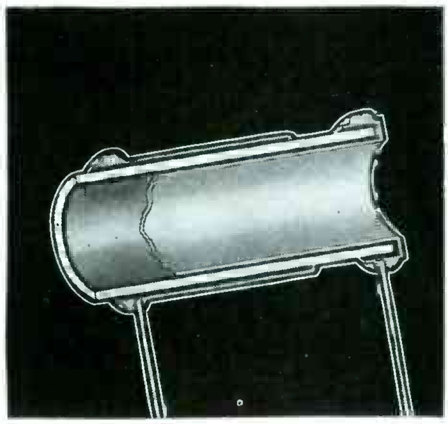


2 *Ampec* is CRL's newest application of its revolutionary "printed electronic circuit" (PEC). Complete 3-stage audio amplifier. Order Bulletin 973.

3 Using the "printed electronic circuit", CRL's *Filpec* combines up to three major components into one tiny filter unit, lighter and smaller than one ordinary capacitor! Capacitor values from 50 to 200 mmf. Resistor values from 5 ohms to 5 megohms. Write for Bulletin 976.

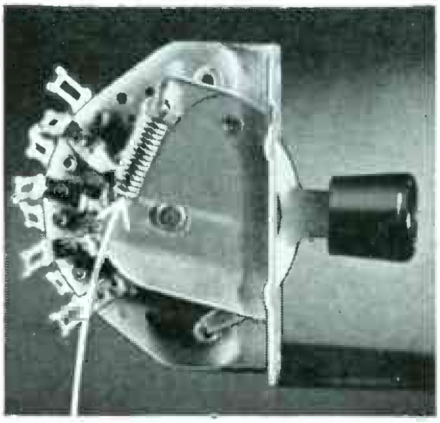
Electronic Industry

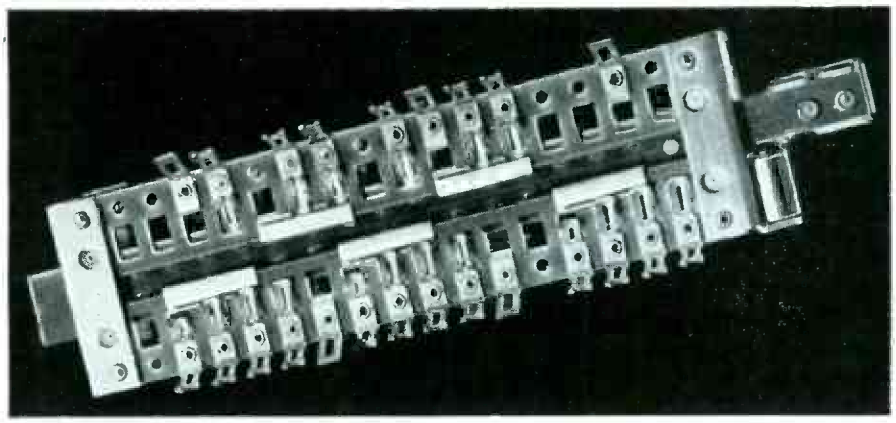




4 Let Centralab's complete Radiohm line take care of your special needs. Wide range of variations: *Model "R"* — wire wound, 3 watts; or composition type, 1 watt. *Model "E"* — composition type, $\frac{1}{4}$ watt. Direct contact, 6 resistance tapers. *Model "M"*—composition type, $\frac{1}{2}$ watt. For complete information, write for Bulletin 697.

5 For quality and dependability, more and more manufacturers are switching to Centralab's line of ceramic capacitors. Order Bulletin 933.





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

7 Centralab's development of a revolutionary, new *Slide Switch* promises improved AM and FM performance! Flat, horizontal design saves valuable space, allows short leads, convenient location to coils, reduced lead inductances for increased efficiency in low and high frequencies. Rugged, efficient. Write for Bulletin 953.

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

Centralab

CRL

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

Here Permanent Magnets are Designed

...FOR RESULTS!

The Indiana Steel Products Company offers you the advantages of the largest facilities in the world for the manufacture of permanent magnets and complete permanent magnet sub-assemblies.

Results that pay off in performance are the results you get in permanent magnets made by *The Indiana Steel Products Company.* Here permanent magnets are functionally designed and manufactured to meet exacting specifications for *more efficient and economical* performance of the device or instrument they serve.

This Is No Secret Formula...

The chart shows the typical demagnetization and energy product curves on which our engineers base their calculations. It shows the characteristics of various kinds of permanent magnet materials which can be expected in our production, and from which the optimum designs can be determined. Such fundamental information permits us to engineer the inside of your magnet so that each one will give you a maximum result.

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Eliminate one of your most costly sub-assembly operations by allowing us to supply you with complete magnetic packages ready to install in your equipment. We accept the responsibility for assembly casualties and test procedure. The handling and shipping of brittle magnetic materials is vastly improved and losses reduced. Consult us for additional information and cost analysis.

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"

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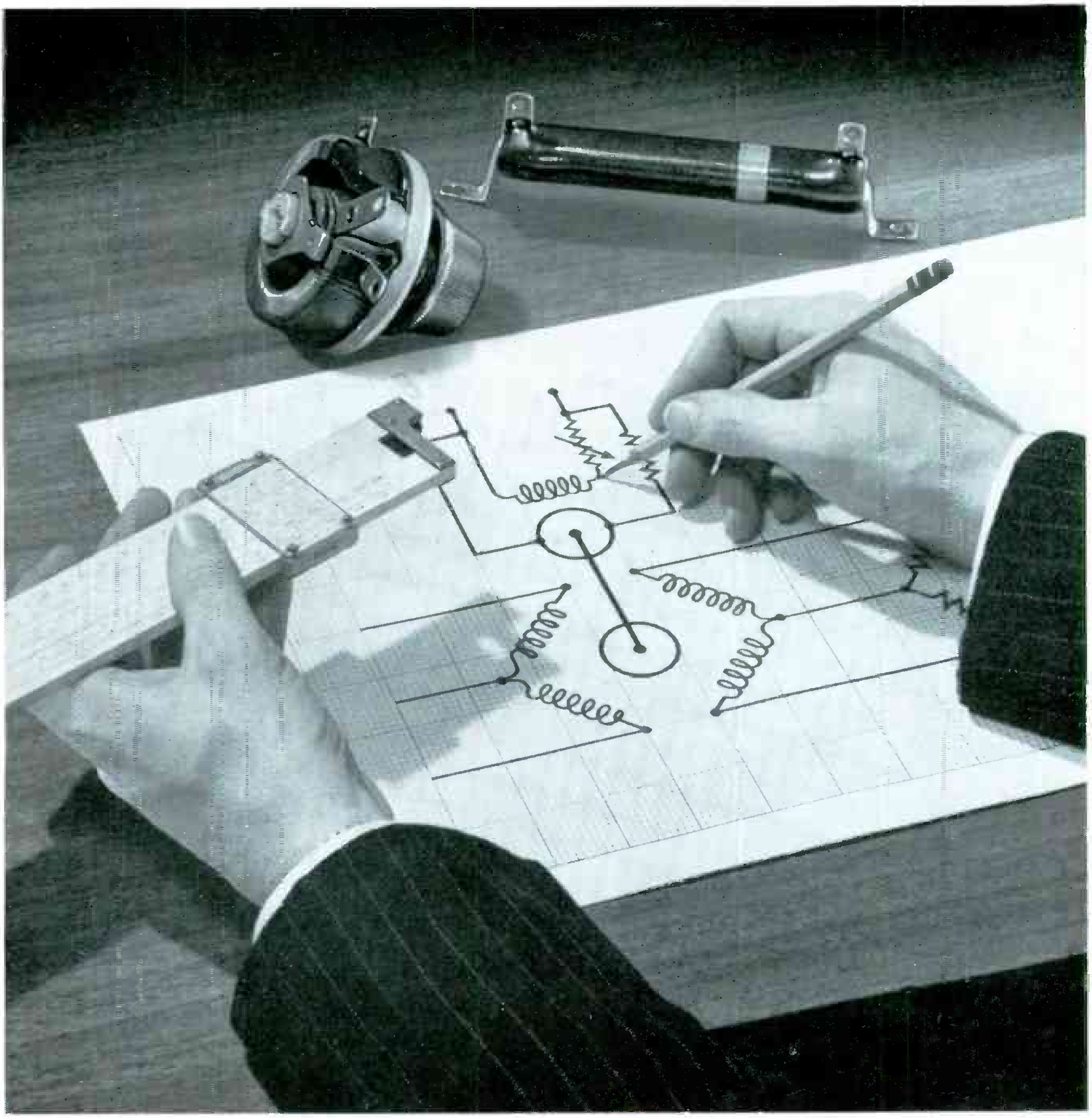
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { Valparaiso, Indiana / Chauncey, New York



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THE manner in which a mechanical device performs is often determined by the excellence of the Small Gears you employ. Unless those Gears are . . 1. correctly designed, 2. made from the right materials, 3. uniformly cut to close tolerances, 4. and if required . . finished and polished to flawless smoothness . . excessive noise and vibration may shorten the life and ruin the performance of the product. Don't take chances. Only the finest Gears are good enough! You'll do well to entrust YOUR needs to G.S. . . *Specialists* in *production runs* of better Fractional Horsepower Gears exclusively for more than 30 years. Let our skilled Small Gear craftsmen aid you in producing a product that will give utmost satisfaction!

It's good business to "ASK G.S." when a small gear problem is involved. Or write today for the free G.S. Bulletin describing almost 100 G.S. Small Gears and applications.

GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

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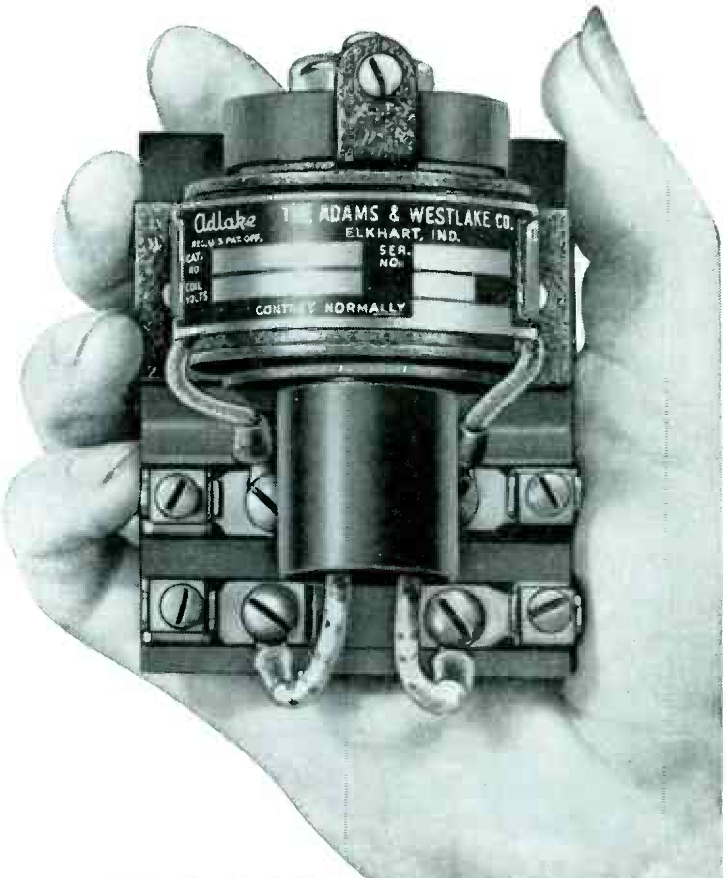
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

MIGHTY Midget!

Despite small size, handles **30** amps.!

It's the **new** ADLAKE No. 1110 **RELAY**



Thirty amps. is a big load, but the new Adlake No. 1110 Relay is rugged enough to handle it. It is small enough to fit in one hand, yet it makes and breaks 30 amps. easily, and with low operating current.

Like all Adlake Relays, No. 1110 is hermetically sealed against dust, dirt, moisture and oxidation; mercury-to-mercury contact prevents burning, pitting and sticking; it's silent and chatterless, absolutely safe and requires no maintenance. And it's cushioned against impact and vibration.

Both contact and coil leads are fastened to the terminal posts. Block is equipped with compression type terminals to simplify installation.

Write today for free, illustrated Adlake Relay folder, giving full details on No. 1110 and other new Adlake Relays. Address: The Adams & Westlake Company, 1107 N. Michigan, Elkhart, Indiana.

USES:

- power circuits
- motor controls
- heater controls
- traffic controls— and a host of others

Adlake TRADE MARK

THE Adams & Westlake COMPANY

Established 1857 • ELKHART, INDIANA • New York • Chicago

Manufacturers of Adlake Hermetically Sealed Mercury Relays for Timing, Load and Control Circuits

Do you know all these facts about NYLON?

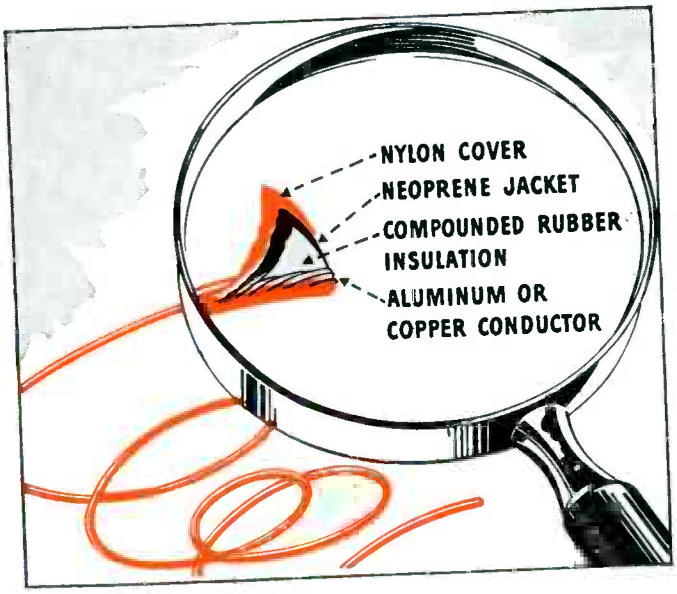
Learn the valuable details about this versatile Du Pont plastic for better electrical products of all types

WIRE AND CABLE and hundreds of other electrical products today employ the properties of Du Pont nylon. This Du Pont plastic can be molded or extruded, and colored to fit specifications. And because of its outstanding combination of properties, Du Pont nylon can help fill in many an electrical engineer's blueprint blank spots.

For your own good—don't overlook the remarkable properties of nylon. We'll be glad to send you specific factual data on nylon. And Du Pont technical men will gladly work with you in applying nylon to solve specific problems.

Write for free booklet, "Du Pont Plastics." Filled with helpful facts on nylon and other interesting and versatile plastics by Du Pont. Just write E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Room 142, Arlington, N. J.

Why Du Pont NYLON covers U. S. Rubber's *Neolay* wire



NEW SMALL-DIAMETER, LIGHT-WEIGHT BUILDING WIRE GETS PROTECTION AND BETTER WORKABILITY WITH NYLON

Called the smallest-diameter, lightest-weight building wire on the market, U. S. Rubber Company's new "Neolay" is a better building wire and a better-looking wire thanks to Du Pont nylon.

Supplied with copper or aluminum conductor, this new wire is insulated with compounded rubber, jacketed with neoprene and finished with a smooth, tough, flexible nylon cover. Its small diameter and light weight give it special advantages, of course, for raceway and other wiring. The nylon surface is seamless, brilliantly colored . . . and extra-smooth for easier pulling. Nylon also provides extra strength and resistance to abrasion.

CHECK THESE 7 BASIC FEATURES OF NYLON FOR ELECTRICAL USES

1. Good flexibility.
2. High tensile strength.
3. Resists abrasion.
4. Extremely tough.
5. Resists permanent set.
6. Resists chemical attack.
7. Can be molded or extruded . . . colored or natural.

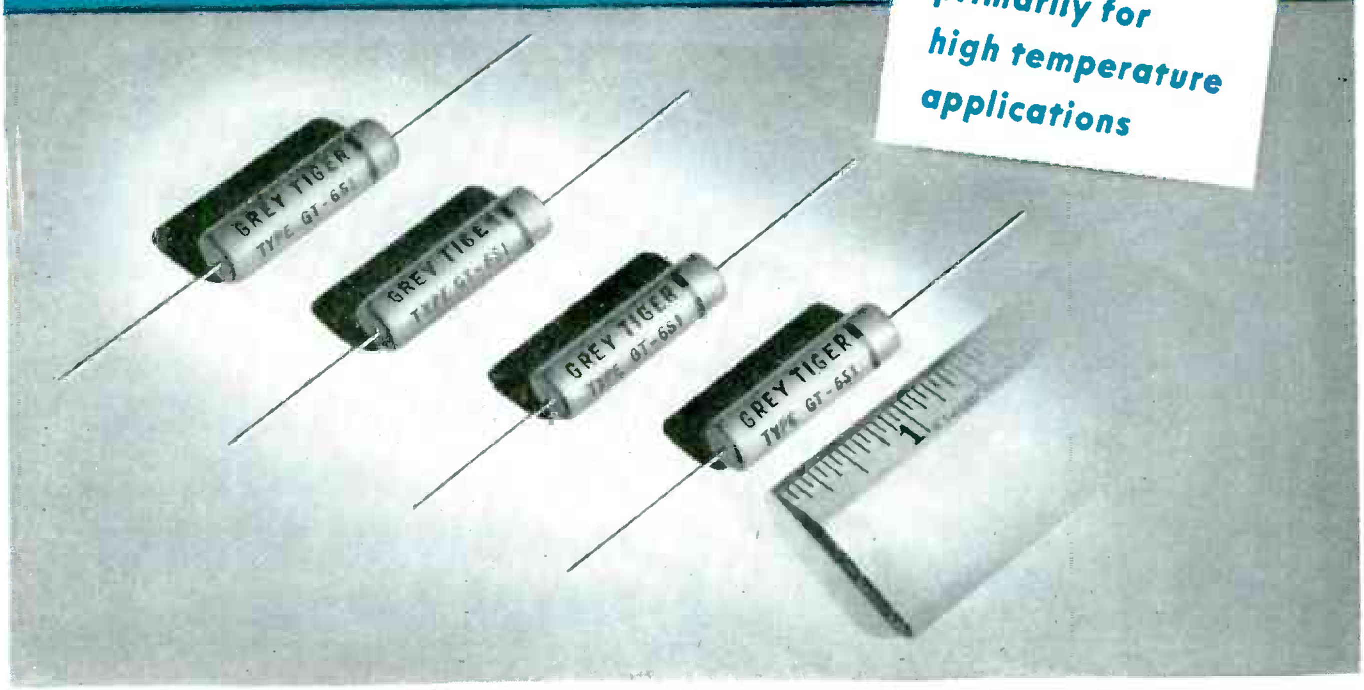
DU PONT
REG. U. S. PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Now another C-D first!

NEW HIGH TEMPERATURE PAPER TUBULAR CAPACITOR

TYPE GT "GREY TIGER"

Designed primarily for high temperature applications



C-D's new "Vikane" impregnated tubular capacitor—Type GT "Grey Tiger"—has won wide industry acclaim. "Remarkable durability"—the unanimous decision after many rigid laboratory tests. Write for samples today. Cornell-Dubilier Electric Corporation, Dept. H1, South Plainfield, New Jersey. Other plants in New Bedford, Worcester and Brookline, Massachusetts; and Providence, Rhode Island.

- new "Vikane" impregnation assures extra long life at high operating temperatures,
- new moisture seal and tube impregnation designed to withstand temperatures to 100°C.,
- high insulation resistance: at 25°C. above 10,000 megohms per unit or 2,000 megohms per mfd.,
- low power factor; averages .35% at 1,000 cycles,
- eliminates need for stocking high and low temperature units,
- excellent capacity stability over wide temperature range,
- excellent electrical stability over life of unit,
- available in all commercial capacity and voltage ratings for maximum flexibility,
- one line to meet all your production requirements—whether for high or low temperature and humidity applications.

"GREY TIGER"

Capacity and DC Voltage Ranges

Capacity Mfd.	100 Volts	200 Volts	400 Volts	600 Volts	1,000 Volts	1,600 Volts
.001				GT-6D1	GT-10D1	GT-16D1
.002				GT-6D2	GT-10D2	GT-16D2
.003				GT-6D3	GT-10D3	GT-16D3
.005			GT-4D5	GT-6D5	GT-10D5	GT-16D5
.01			GT-4S1	GT-6S1	GT-10S1	GT-16S1
.02			GT-4S2	GT-6S2	GT-10S2	GT-16S2
.03		GT-2S3	GT-4S3	GT-6S3	GT-10S3	GT-16S3
.05	GT-1S5	GT-2S5	GT-4S5	GT-6S5	GT-10S5	GT-16S5
.10	GT-1P1	GT-2P1	GT-4P1	GT-6P1	GT-10P1	
.15	GT-1P15	GT-2P15	GT-4P15	GT-6P15	GT-10P15	
.25	GT-1P25	GT-2P25	GT-4P25	GT-6P25		
.50	GT-1P5	GT-2P5	GT-4P5	GT-6P5		
1.0	GT-1W1	GT-2W1	GT-4W1			

1910 C-D 1948

MICA • PAPER DYKANOL AND ELECTROLYTIC CAPACITORS

CORNELL-DUBILIER
WORLD'S LARGEST MANUFACTURER OF
CAPACITORS

CORNELL-DUBILIER ELECTRIC CORPORATION, Department K-2
SOUTH PLAINFIELD, NEW JERSEY

GENTLEMEN: Please send Bulletin Number NB116 describing type GT tubulars.......... ☐
Catalog Number 200 .... ☐

Name.......... Title..........

Firm..........

Address..........

. . . the new Model "S"

Here is welcome news to manufacturers of radio-phonographs—Seeburg announces the addition of a new, single-post record changer—the Model "S".

This new Seeburg Changer has been designed and engineered to bring important competitive advantages to your table model and popularly priced consoles. For while the Model "S" is moderately priced, it is Seeburg quality throughout, possessing many of the features found only in more expensive changers.

Plan now to give desired appeal to your instruments with new Seeburg Model "S" Record Changers.

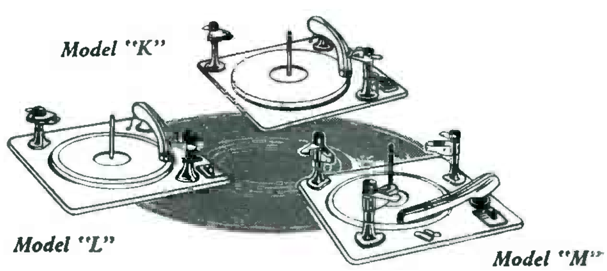
MODEL "S" FEATURES

- Sturdy, single-post changer
- Modern styling — smart, shield-shaped base
- Lightweight tone arm
- Automatic shut-off after last record is played
- Recessed turntable
- Strong, quiet motor assures constant turntable speed
- Plays twelve 10-inch or ten 12-inch records. May also be set for manual play
- Shock-mounted center spindle for minimum center hole wear of records — record load stacked in horizontal position

Seeburg

RECORD CHANGERS ★ MUSIC SYSTEMS

J. P. SEEBURG CORPORATION
1500 N. Dayton St., Chicago 22



INSTRUMENTS FOR
ELECTRONIC MAINTENANCE

WESTON *Electronic Analyzer*—Model 769. Incorporating: 1. A conventional Volt-Ohm-Milliammeter with self-contained power source. 2. A high-impedance electronic Volt-Ohmmeter using 115 volt, 60 cycle power. 3. A stable, probe-type, Vacuum Tube Voltmeter, for use to 300 megacycles.

WESTON *Multi-Purpose* *TUBECHECKER* — Model 798. This universal tubechecker offers within one instrument provision for testing: 1. Receiving tubes. 2. Voltage regulator tubes. 3. Light duty thyratron tubes such as 2A4—6D4—884—885—2051. Scale is calibrated "Good-Bad" as well as in mutual conductance readings.

Direct Reading Insulation Tester —Model 799. Compact, one-hand-operated insulation tester with .1 to 10,000 megohm range, using a test potential less than 50 volts d-c. Indicates: 1. Insulation properties. 2. Leakage resistance. 3. Conductivity of insulating materials. 4. Leakage due to moisture absorption.

These portable Westons are specifically designed for expediting electronic maintenance . . . for doing the job better—faster. All are engineered and built in the strictest traditions of Weston accuracy and dependability. For further details see your local WESTON representative, or write . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON

Instruments

Diameter of Thermocouple compared with ordinary Pin. Temperatures only register at point of Thermocouple Junction.

TO RECORD the temperatures at specific points in the anatomy of a "jet" is a tough assignment, but this small-diameter thermocouple, manufactured by Precision Tube Company of Philadelphia, does it.

Thin as a thread, it can be employed effectively in lengths up to 20 feet—laid along surfaces, snaked around obstructions, pushed down channels, fed through tiny apertures, sealed in walls and left protruding into space. Temperatures are only registered at the end where the thermocouple junction is located. Thus when inserted into pressure and exhaust chambers of jet engines, it can be maneuvered in any direction to obtain temperatures of gases with pin-point accuracy at different points.

Top performance has been achieved by use of Advance* Wire—because, in its finer forms, it has a negligible temperature coefficient of resistance, only ±.00002/°C; develops maximum and uniform thermal e.m.f. against copper; is extremely ductile; is resistant to heat and corrosion. An insulated winding of Advance is inserted into a seamless copper tube, and themocouple junction is made by cutting the assembly to length and brazing or welding the wire and the tube at one end.

Rapid response to temperature change, and small heat storage are characteristic of this thermocouple — permitting accurate readings to be obtained almost instantly. Moreover, its small proportions render it ideal for use with midget-size mechanisms.

Whether your product be small or large, if its successful operation rests upon application of special purpose alloys, send your specifications to us. We will supply the alloy with electrical and physical properties best suited to your requirements.

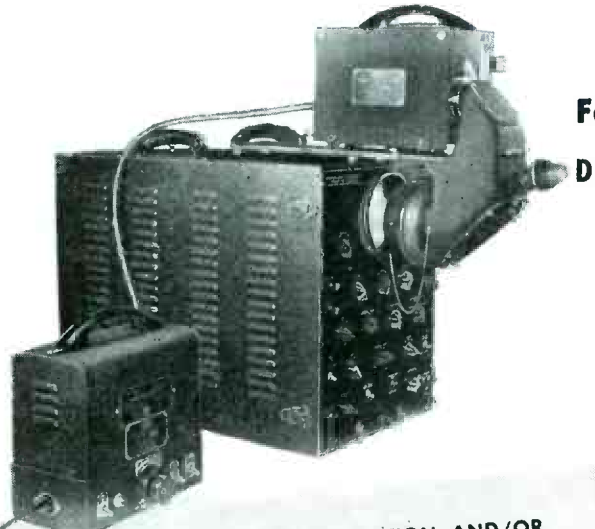
SPECIAL PURPOSE ALLOYS SINCE 1899 · D H · TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris
COMPANY
HARRISON, N. J.

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

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

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



For any kind of oscillographic recording . . .

DU MONT TYPE 271-A and/or DU MONT TYPE 314

Oscillograph-Record CAMERAS

to convert your oscillograph into a recording instrument

TYPE 314 CONTINUOUS-MOTION AND/OR SINGLE-FRAME CAMERA

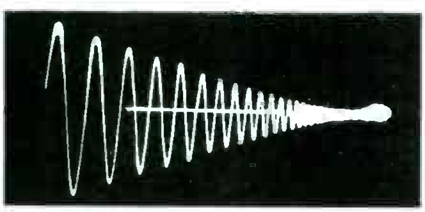
In addition to single-frame exposures, the Du Mont Type 314 Oscillograph-Record Camera provides continuous-motion photography. Recommended for recording continuous, changing processes, and where variations to be studied require an extended period of time. Film speed electronically controlled within range of 1 inch per minute to 5 feet per second. Applicable to widest variety of uses such as study of Welding, Biology, Switches, Electric Shavers, Synchronous Motors, Fluorescent Lamps, Guided Missiles, Oscillator Drift, Voltage Stabilizers, Nuclear Physics, Hydraulics, Mechanics, Dynamic Unbalance, Cylinder Pressure, Acoustics, etc.

Type 314 Oscillograph-Record Camera, Cat. No. 1217-E (f/2.8 lens) $980; Cat. No. 1366-E (f/1.5 lens) $1,155; delivered in U.S.A.

TYPE 271-A SINGLE-FRAME CAMERA

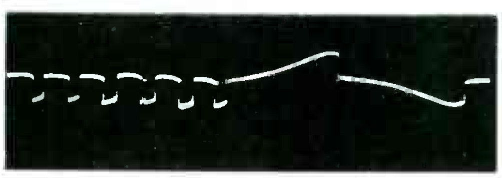
For single-frame exposures of high-speed transients, or for multiple exposures to record a family of curves, the Du Mont Type 271-A Oscillograph-Record Camera is your ideal selection. And the cost is well within reach of the modest instrument budget. May also be used to good advantage with Du Mont Type 264-A Voltage Calibrator for amplitude and wave-form measurements. Equipped with f/3.5 lens. Uses standard 35 mm. film. And remember, this camera is readily fitted to any 5-inch oscillograph.

Type 271-A Oscillograph-Record Camera, Cat. No. 1216-E, $162.50 delivered in U.S.A.

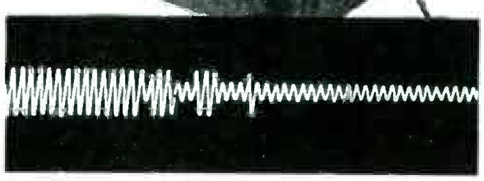


Typical high-speed recording: 2 mc transient (with Du Mont Types 281 and 286 Cathode-Ray Oscillographs using Type 271-A).

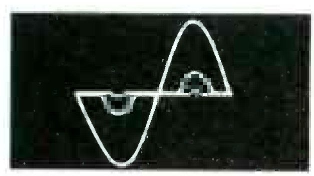
DETAILED SPECIFICATIONS FOR EACH CAMERA, SUPPLIED ON REQUEST.



Output voltage of Type OB2 Voltage-Regulator Tube, with sudden applications of resistive load, using Type 314 Continuous-Motion/Single-Frame Camera.



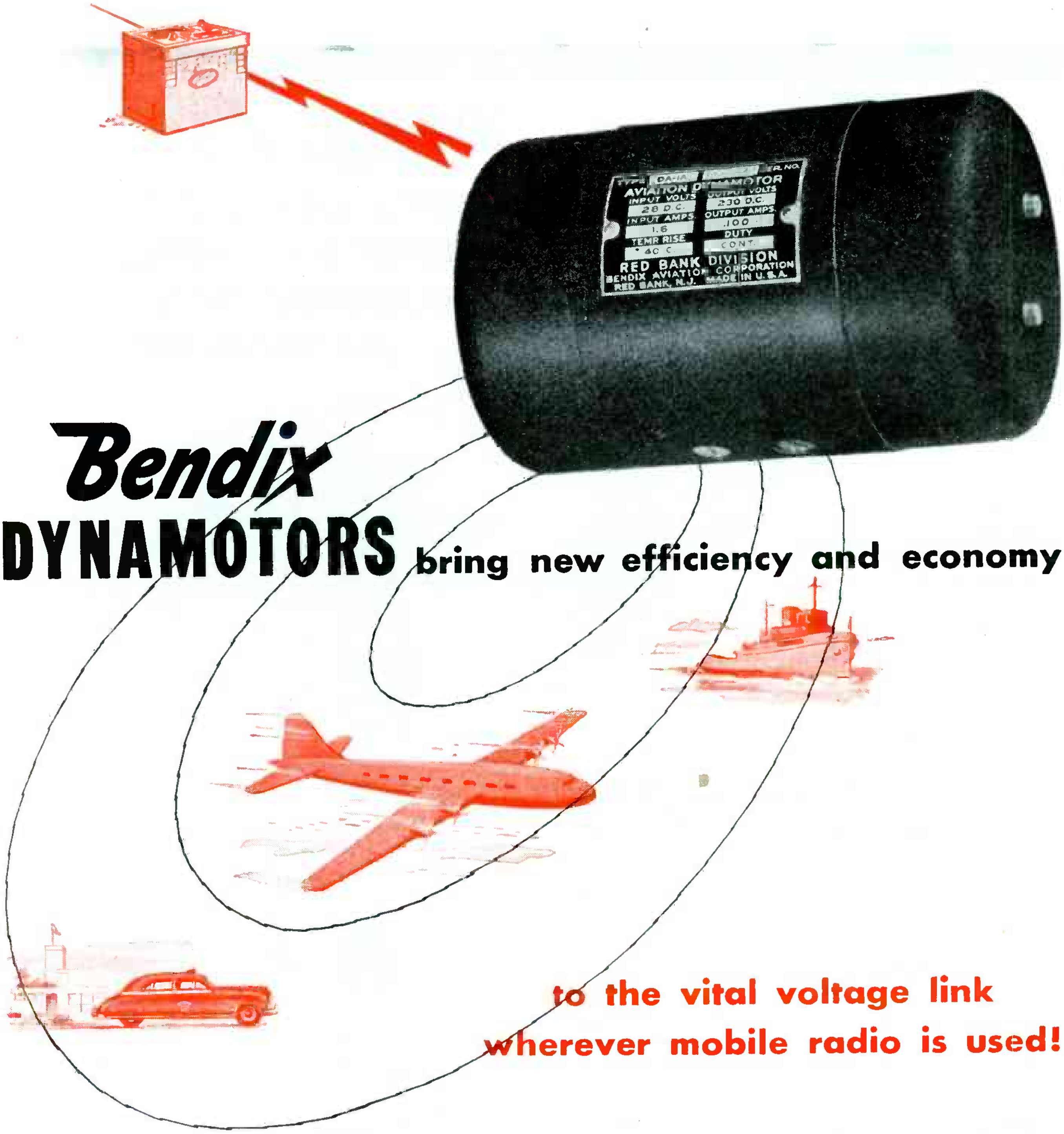
Plot made on Type 314 of starting current of small synchronous motor. (Note variation in current as the rotor "hunts" for its synchronous speed).



Triple exposure made with Type 271-A while varying constants of peak-clipping circuit.

DUMONT *Precision Electronics & Television*

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



Bendix DYNAMOTORS bring new efficiency and economy

to the vital voltage link wherever mobile radio is used!

89 DIFFERENT MODELS

Covering all frame sizes and voltages

Bendix Dynamotors cut down on service requirements—are designed for easy servicing with standard tools, and feature complete interchangeability of parts. Write for details—there's a Bendix Dynamotor tailor-made for your installation!

Wherever a mobile radio operates from a storage battery, *Bendix** Dynamotors can add materially to *efficiency* and *economy*. These precision-built units have a remarkably long life—operate day after day with virtually no service, providing the vital voltage that is the key to efficient performance. If you are designing a new mobile radio set or replacing dynamotors, specify Bendix Aviation Quality Dynamotors—they're priced right and built by the foremost producer of mobile power equipment. Available for quick delivery in all standard frame sizes and voltages.

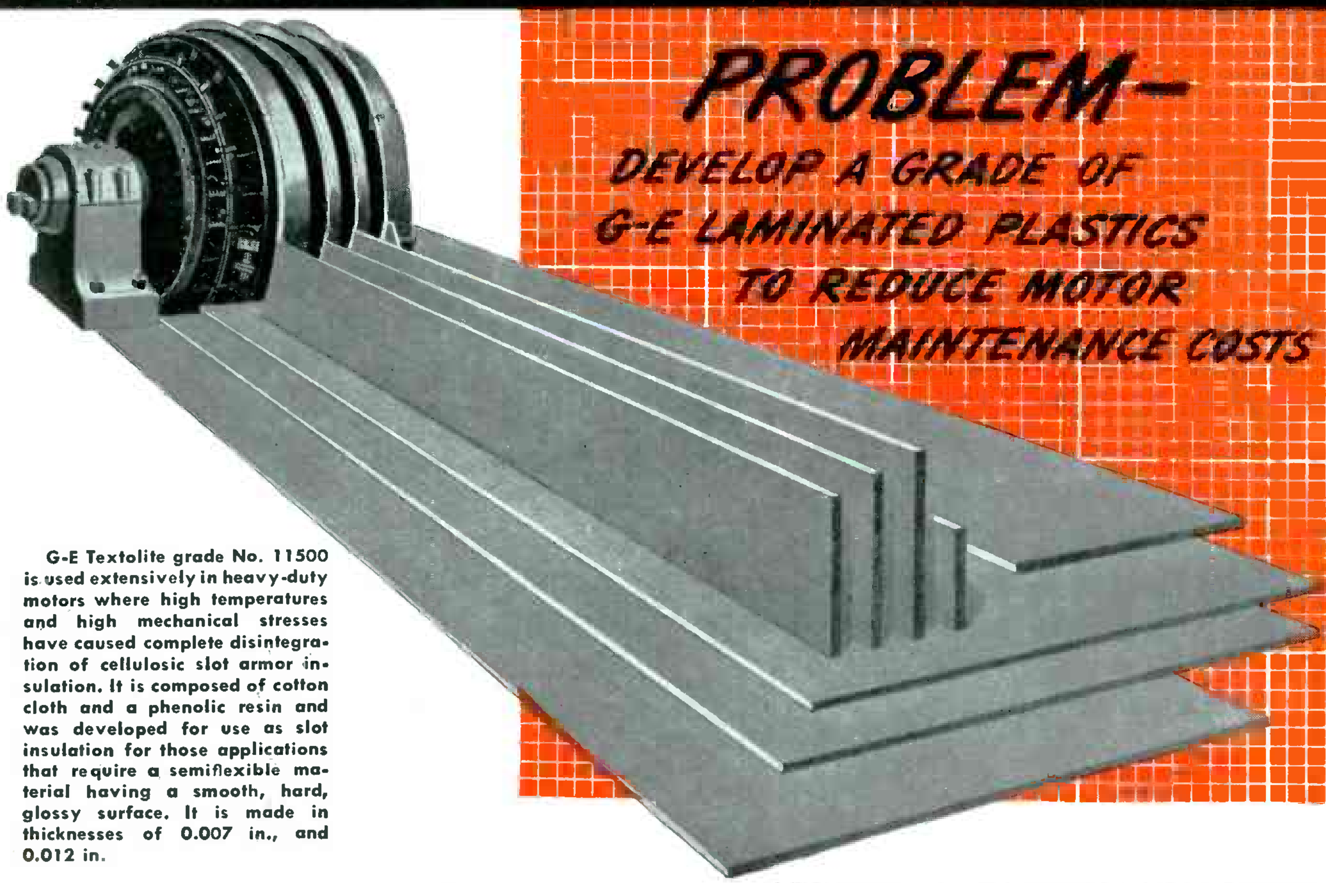
*REG. U.S. PAT. OFF.

Dynamotors · Inverters · Convertors · D.C. Motors · Carbon Pile Voltage Regulators

RED BANK DIVISION of Bendix AVIATION CORPORATION

RED BANK, N. J.

MORE THAN 50 GRADES OF G-E TEXTOLITE LAMINATED PLASTICS ARE AVAILABLE



G-E Textolite grade No. 11500 is used extensively in heavy-duty motors where high temperatures and high mechanical stresses have caused complete disintegration of cellulosic slot armor insulation. It is composed of cotton cloth and a phenolic resin and was developed for use as slot insulation for those applications that require a semiflexible material having a smooth, hard, glossy surface. It is made in thicknesses of 0.007 in., and 0.012 in.

TAKE YOUR PICK

G-E Textolite grade No. 11500 was developed to reduce insulation maintenance costs on heavy-duty motors. However, it isn't the only grade of Textolite manufactured. There are more than fifty grades available, and EACH has an INDIVIDUAL COMBINATION of properties.

Some grades excell in heat resistance, some in dielectric strength, others in loss factor. And you need this large assortment to select from if you want to produce your products in the most economical and satisfactory way.

Then, too, these many grades of Textolite are supplied in five different forms. Again you get a choice which can pay you dividends in many ways. Plastics Division, Chemical Department, General Electric Co., Pittsfield, Mass.

GET THE COMPLETE STORY!

Send for the new bulletin G-E TEXTOLITE LAMINATED PLASTICS which lists grades, properties, fabricating instructions and detailed information about the five forms of Textolite. Fill in and mail the coupon below for your free copy.

PLASTICS DIVISION, CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY (BA-2)
ONE PLASTICS AVE., PITTSFIELD, MASS.

Please send me the new G-E Textolite laminated plastics bulletin.

Name..

Firm..

Address..

City.............................. State..............................

GENERAL ELECTRIC

CD48-M1

TEXTOLITE LAMINATED IS SUPPLIED IN FIVE FORMS

SHEETS, TUBES, AND RODS—These standard shapes are available in thousands of sizes. Up-to-date manufacturing methods facilitate quick deliveries.

FABRICATED PARTS—G.E. has modern fabricating equipment to machine Textolite laminated plastics parts to your own specifications.

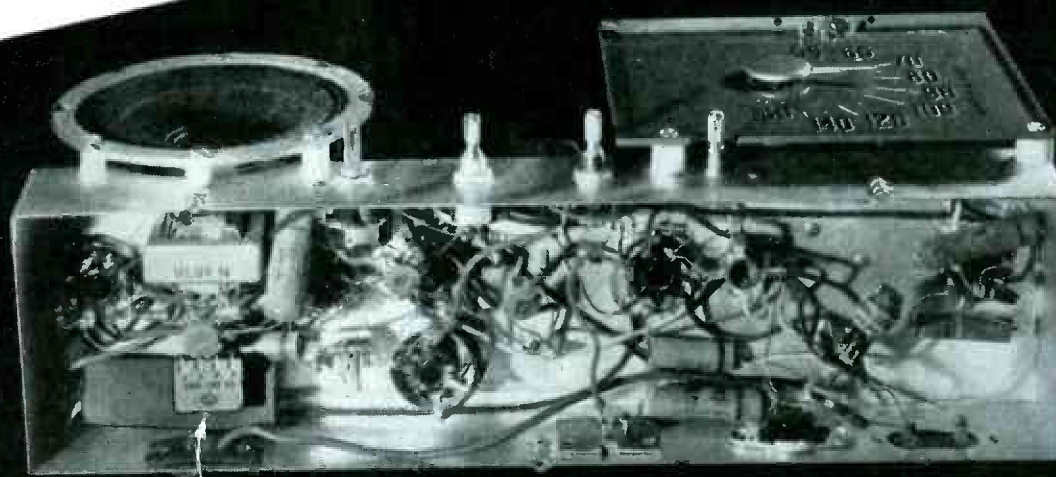
MOLDED-LAMINATED PARTS—Textolite is custom molded directly to shape. Molded laminated products are among the strongest plastics parts produced.

LOW-PRESSURE MOLDED PARTS—Extremely large and irregular Textolite shapes are custom molded by the low-pressure laminating process.

POST-FORMED LAMINATES—Sheets of Textolite laminated plastics are custom formed into simple shapes by this very inexpensive method.

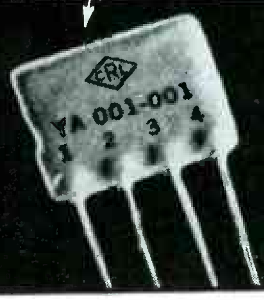
PROGRESS REPORT ON P.E.C.*

How up-to-the-minute engineering at Sonora Radio uses Centralab Couplate to improve manufacturing efficiency, and reduce servicing.



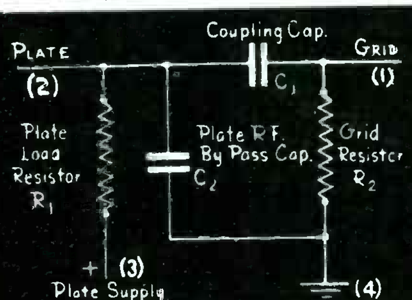
Sonora engineers take advantage of Couplate's long life, high efficiency, mechanical strength and resistance to humidity. Result: more dependable performance, simplified production for Sonora Radios.

Chassis courtesy of Sonora Radio and Television Corporation



ACTUAL SIZE

Integral Ceramic Construction: Each *Couplate* is an integral assembly of *Hi-Kap* capacitors and resistors closely bonded to a steatite ceramic plate and mutually connected by means of metallic silver paths "printed" on the base plate. Note schematic diagram below.



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

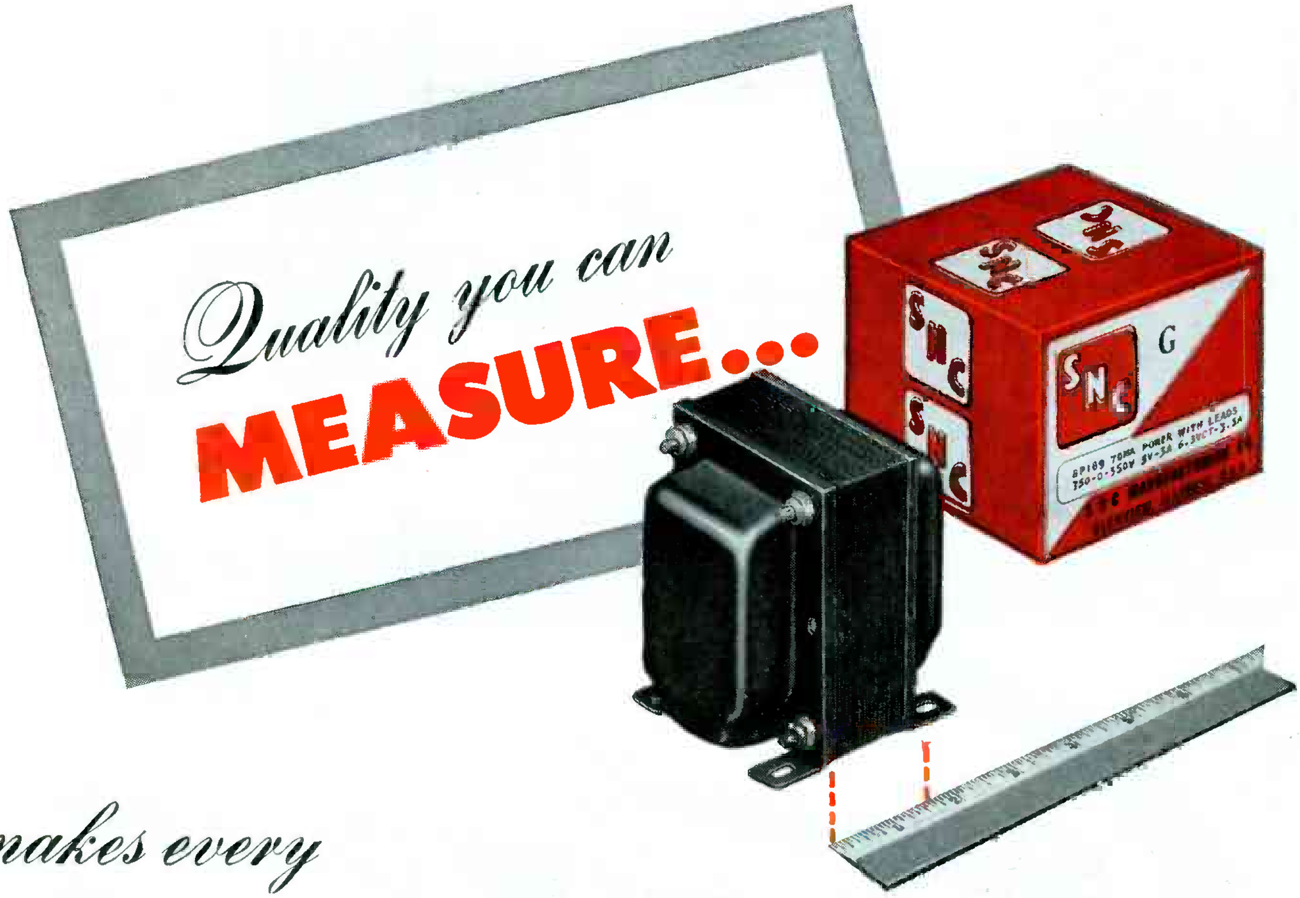
YES, and Sonora is just one of the many famous radio manufacturers who are designing Centralab's revolutionary *printed interstage coupling plate* into their 1948 sets.

The reason? One look at *Couplate's* design and manufacturing advantages gives you the answer. 1) *Couplate* requires only four soldered connections instead of eight, simplifies wiring and production. 2) *Couplate* saves space and mass weight, makes possible more compact and dependable finished equipment at lower cost. 3) *Couplate* improves set performance by lengthening life, gives you a complete "printed" interstage coupling circuit engineered and manufactured by Centralab.

First commercial application of the "printed electronic circuit", Centralab's *Couplate* is a complete interstage coupling circuit which combines into one compact unit the plate load resistor, the grid resistor, the plate by-pass capacitor and the coupling capacitor. For all the facts on how *Couplate* can simplify your production problems and cut your costs, see Centralab's local representative, or write for Bulletin 943.

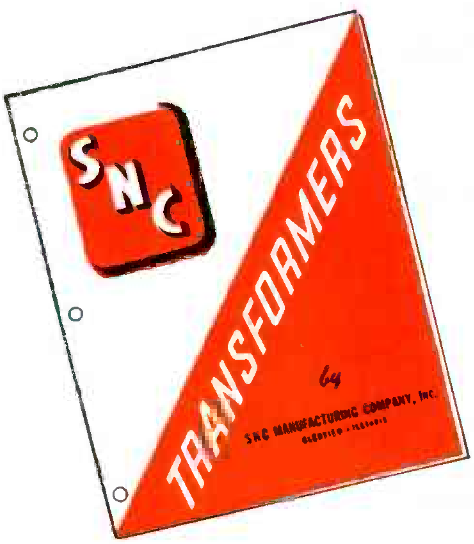
LOOK TO **Centralab** IN 1948!

Division of GLOBE-UNION INC., Milwaukee



makes every

SNC TRANSFORMER *give outstanding performance*



Join the increasingly large number of manufacturers, retailers, hams and other component part buyers who rely on SNC for quality, trouble-free equipment. Write for catalog today.

Place a rule against the stack of an SNC No. **8P189** transformer and the *extra* width clearly indicates the added quality built into every item in the complete SNC line.

Skillful engineering, latest production techniques and highest quality materials . . . backed by careful workmanship, exacting step-by-step inspection and rigorous final testing . . . are just a few of the reasons why SNC transformers keep rejects at a minimum and give outstanding performance.

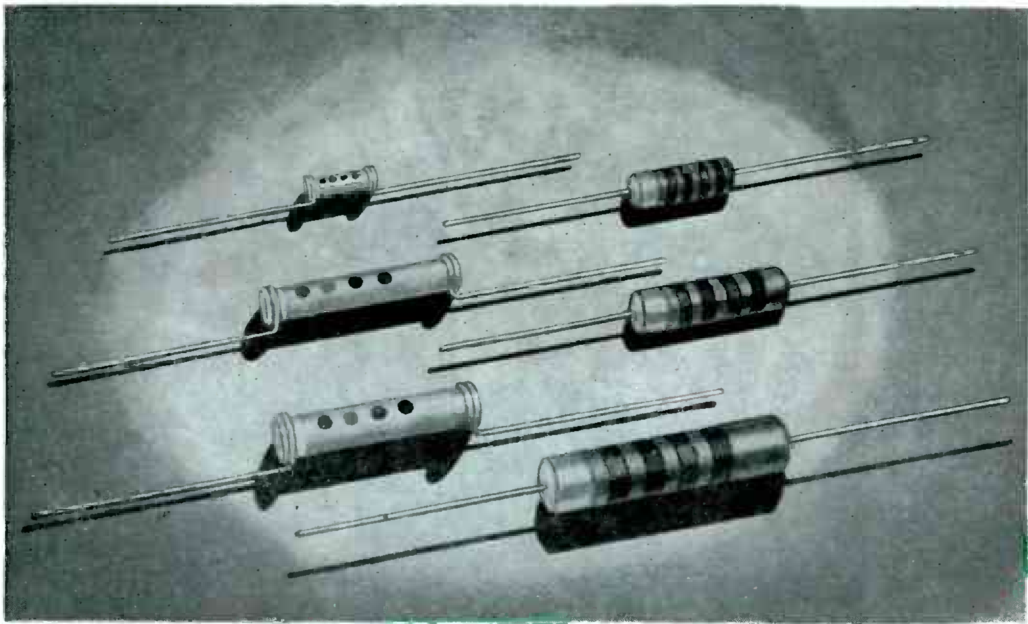
Remember! SNC gives MORE applications with SMALLER inventories for GREATER profits!

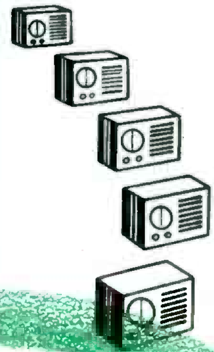
SNC MANUFACTURING CO., INC.

Quality Transformers

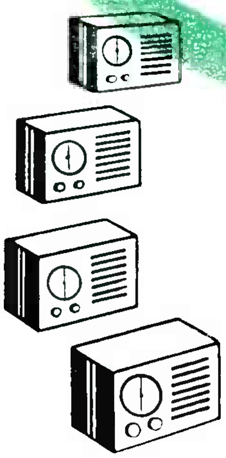
WEST LAKE AVE. NEAR LEHIGH • GLENVIEW, ILLINOIS

Export Department: 308 W. Washington St., Chicago 6, Illinois, U. S. A.





Speed up assembly in your plant— use ERIE "GP" Ceramicons



ERIE "GP" Ceramicons are small and compact, even in high capacities. Tubular in shape, they require less space than rectangular condensers. They can be wired into position more easily and quickly where space conditions are close, and thus are basically easier to handle in any type of installation.

The wide range of adaptability of ERIE "GP" Ceramicons simplifies the inventory problem, reduces "out-of-stock" bottlenecks, and saves confusion generally.

The enormous popularity of "GP" Ceramicons is the result of a combination of their superb performance and economical cost. Their inherently simple construction results in higher resonant frequencies that are so important in by-passing applications for FM and Television.

ERIE "GP" Ceramicons are made in insulated styles in popular capacity values up to 5,000 MMF, and in non-insulated styles up to 10,000 MMF. If you haven't switched to "GP" Ceramicons for by-pass and coupling applications, write for full details.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND · TORONTO, CANADA

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

A size, type, style "*Triplett-made*" for every need

"Half a Century of Instrument Know-How Is Built into These Fine Electrical Meters" . . . in sizes from 2″ to 7″ in a wide variety of case shapes and mounting arrangements.

No matter how specialized your requirements may seem, the chances are that Triplett has already engineered and tooled up for a design so nearly akin that a few inexpensive changes or additions will suffice.

Triplett . . . . A Self Contained Electrical Instrument Factory . . . From screw machine parts to plastic moldings, from moving elements to dial faces, all are fabricated in Triplett's modern air-conditioned factory. Equipped with special humidity and dust controls in assembly rooms. This self-contained factory means one overall profit markup with better quality control and consequent savings to you.

Complete meter satisfaction is yours in performance, appearance, and dependability. Let Triplett add lustre and give precision performance to your instrument panel.

"Complete Engineering Service" . . . Triplett maintains a field engineering staff available on short notice. These engineers are ready to help you with your problems and to bring you the latest practices in instrumentation from the Triplett laboratories. Complete facilities for shock, vibration and humidity testing as required under JAN specs.

Sizes 2″ to 7″
Round or Square

A.C., D.C.,
R.F., Rectifier or Dynamometer

Triplett can supply on short notice electrical meters in 2″, 3″, 4″, 5″, 6″ and 7″ sizes in round, rectangular, square and fan shapes; wide flange, narrow flange, flush projection and portable. Molded and metal cases. Rear illumination, special dials and other features available on most models.

Be sure your files are up-to-date with current Triplett catalog and descriptive literature. Address, Dept. E28 *and specify any particular types in which interested.*

TRIPLETT ELECTRICAL INSTRUMENT CO. • BLUFFTON, OHIO

Representatives in Principal U. S. and Canadian Cities

TRIPLETT

Minimize Control Size!

REDUCE COST!

WITH THESE NEW ALLIED RELAYS

The Allied PO and POY relays, replacing the DO and DOY relays, save space, save cost. These advantages will have special appeal for engineers in electronic, aircraft and other industries requiring medium power, all-purpose relays.

POY RELAY

A semi-sensitive, dual coil relay for operation in vacuum tube or other limited power circuits. Same contact rating and arrangement as PO.

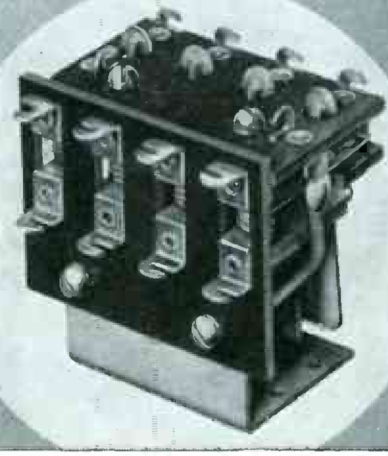
DIMENSIONS:
Same as PO.

COIL RATING:
Up to 110 volts D.C. at 600 milliwatts. Not supplied for A.C.

MOUNTINGS:
Standard, #6-32 tapped holes. Not supplied with stop nuts.

The PO & POY relays are adaptations of the well-known general purpose Allied BO relay, and like all other Allied relays may be obtained hermetically sealed.

Every part in these precision-built relays is designed to deliver thoroughly dependable service with extra long life. For complete information and operating characteristics of the new PO and POY and other precision-built Allied Relays, write us for latest Allied catalog.



PO RELAY

This relay, shown above in the 4-pole model and shown below in the 3-pole model, is supplied in 2-, 3- and 4-pole normally-closed, normally-open or double-throw contacts. Its standard silver contacts have carrying capacity of 15 amperes at 24 volts D.C. or 110-volts A.C. non-inductive.

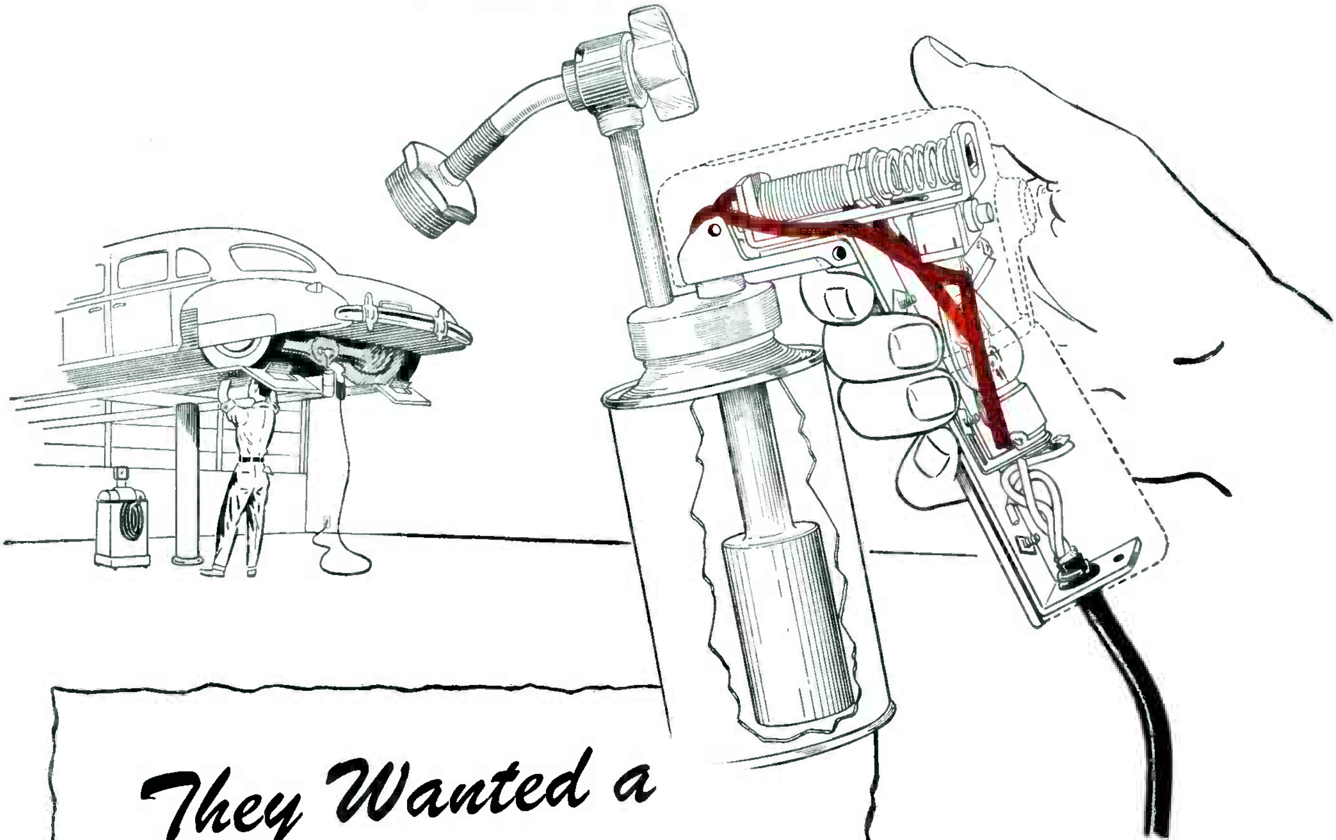
COIL RATING: A.C. 10.5 volt-amperes nominal or 17.5 volt-amperes maximum at 25 to 60 cycles and up to 220 volts.

D.C. Up to 120 volts at 1 watt minimum or 8 watts maximum.

MOUNTING. Standard #6-32 tapped holes. Also supplied with #6-32 stop nuts.

ALLIED CONTROL COMPANY, INC.

2 EAST END AVENUE, NEW YORK 21, NEW YORK



They Wanted a Rugged Insulation

"From a dead cold start, our Dee Tee Cleaner reaches a temperature peak of 500°F. in a matter of seconds—and that's only half of our insulation problem. The insulation we need must bend without splitting or cracking and resist vibration and wear."

So said Circo Products Co. when they came to Bentley, Harris with the design for a differential and transmission cleaner. Here is their most recent report to us:

"Never before have we found an insulation that meets all of our requirements as well as BH Extra Flexible Double Braided Fiberglas Sleeving. It withstands heat and rough handling without deterioration. Its remarkable flexibility speeds assembly."

BH Fiberglas Sleeving can be subjected to grease and moisture without any deteriorating effect. Unaffected by harmful gases. Cuts clean, will not fray. Heat resistant to 1200°F. Try BH Fiberglas Sleeving in your own plant—in your own product.

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

BH Fiberglas* SLEEVINGS

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

USE COUPON NOW

Bentley, Harris Mfg. Co., Dept. E-19, Conshohocken, Pa.

I am interested in BH Non-Fraying Fiberglas Sleeving for ______________ (product)

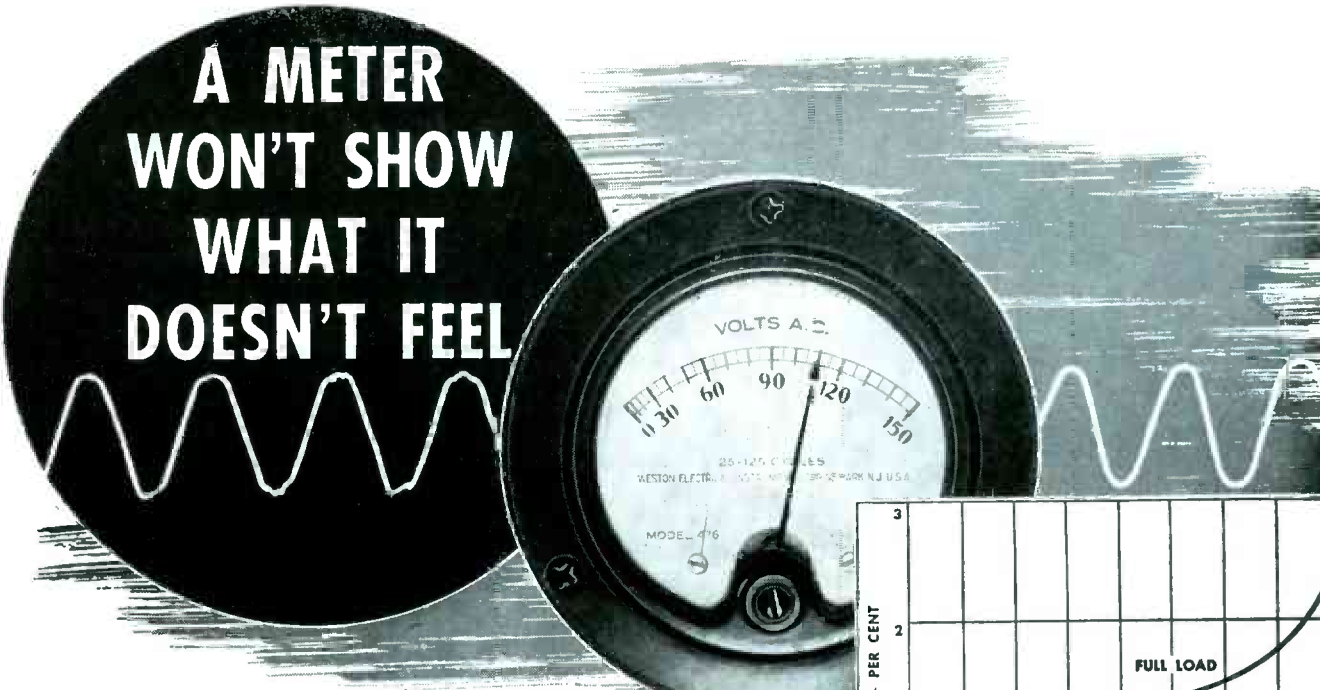
operating at temperatures of ____°F. at ____ volts. Send samples so I can see for myself how BH Non-Fraying Fiberglas Sleeving stays flexible as string, will not crack or split when bent.

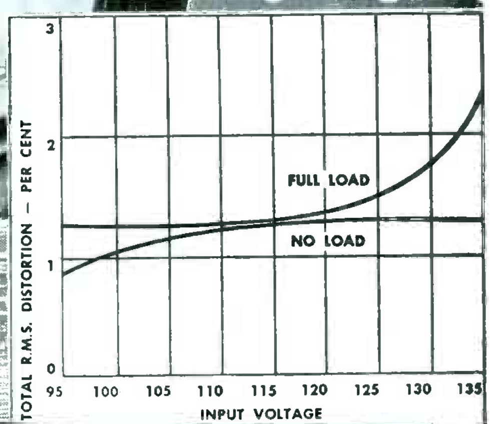
NAME ______________ COMPANY ______________

ADDRESS ______________

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

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





A STABILINE Automatic Voltage Regulator Type IE limits waveform distortion to 3% therefore . . .

a meter is not affected by the negligible waveform distortion (3% maximum) of a STABILINE Automatic Voltage Regulator Type IE (Instantaneous Electronic).

Investigations by Weston Electrical Instrument Corp., as to errors due to harmonics in iron-vane a-c ammeters or voltmeters, show that waveform distortion up to 3% in 60 cycle circuits produce negligible errors not recognized in instrument readings. The results are noted in the October 1947 issue of Weston Engineering notes. Since a STABILINE Voltage Regulator Type IE has a maximum waveform distortion less than 3%, it is the ideal equipment to employ for maintaining a constant voltage to electrical apparatus.

However, negligible waveform distortion is just one of the many outstanding features of a STABILINE Automatic Voltage Regulator Type IE. The STABILINE Type IE has no moving parts and is completely electronic in operation. It delivers a constant output voltage regardless of variations in input voltage or load current. The maximum change in output voltage due to any of these variations will not exceed ±0.25 of 1%. For input changes only, the change in output voltage will not exceed ±0.1 of 1%. Speed of correction is in the order of 3 to 6 cycles.

Numerous models are available in attractive black wrinkle-finish cabinets or for relay rack mounting.

Complete engineering data is contained in Bulletin 547.

Write The Superior Electric Co., 402 Meadow Street, Bristol, Connecticut

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

POWERSTAT VARIABLE TRANSFORMERS • VOLTBOX A-C POWER SUPPLY • STABILINE VOLTAGE REGULATORS

For Speedier Assembly, Smarter Appearance...

Postage Meter and Mailing Equipment Makers Put the Stamp of Approval on AMERICAN PHILLIPS SCREWS

IN PRODUCTION: It's *first class* assembly for mailing and metering equipment manufacturers when power driven, American Phillips Screws provide fumble-proof starts, *automatically straight* driving and unspoiled work. These screws deliver—with "air mail speed" and "registered letter safety"! What's more, they *can't* snag envelopes but *do assure* permanent tightness of fastening. Best of all, TIME SAVINGS RUN AS HIGH AS 50%!

IN SALES PROMOTION: The jobber, the dealer and John Q. Public *all* like the streamlined, modern look that dresses up products as varied as autos and radios, stoves and sofas, boats and bicycles — and American Phillips Screws help provide it! Write *special delivery* today for fastening facts that can cut *your* costs.

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

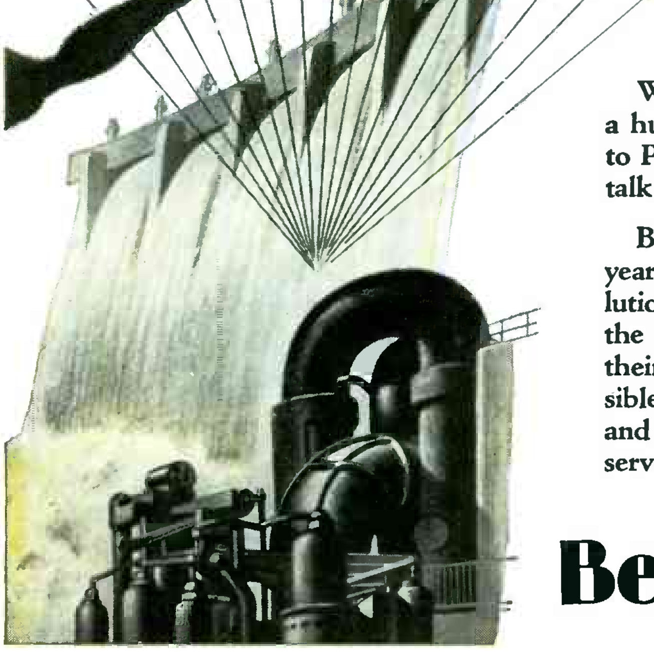
AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND
Chicago 11: 589 E. Illinois St. *Detroit 2:* 502 Stephenson Building

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

Where there is Horsepower...

There is Wire



What has happened to transportation? A little over a hundred years ago Napoleon "sped" from Moscow to Paris at approximately 3 miles per hour. Today we talk of speeds of a thousand miles per hour.

Belden Manufacturing Company in its life of 40 years has witnessed and served a "transportation revolution." In that brief time, the automobile, the airplane, the diesel-electrics, and now the rockets, have taken their place in our living. All of these were made possible when wild horsepower ran into a trap of wire—and when other specialized products of the wiremakers served the inventors of our modern power.

Belden WIREMAKER FOR INDUSTRY

For Blue Ribbon Quality in Sheet Metal Housings

Send Your Blueprints to Karp

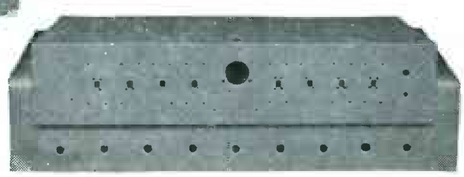


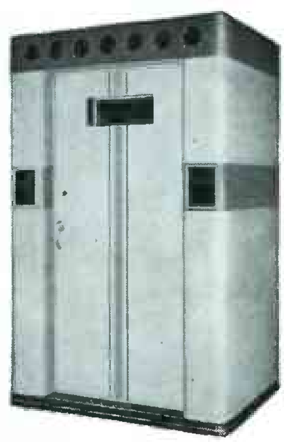

When manufacturers of electronic, radio and electrical apparatus, situated as far as 2000 miles and more from our plant, insist on Karp sheet metal craftsmanship, there must be good and profitable reasons.

One important reason is that Karp-constructed cabinets, enclosures, housings and chassis are custom-built to individual requirements; so precisely and uniformly made that time and money are saved on your assembly line. Another reason is that Karp builds good looks and streamlined styling into the product, giving you added sales and profit advantages.

Remember the Karp blueprint man symbolizes blue ribbon quality in cabinets, housings, enclosures and chassis. Tell us your needs. Get our quotations.

- *Any metal*
- *Any gauge*
- *Any size*
- *Any quantity*
- *Any finish*

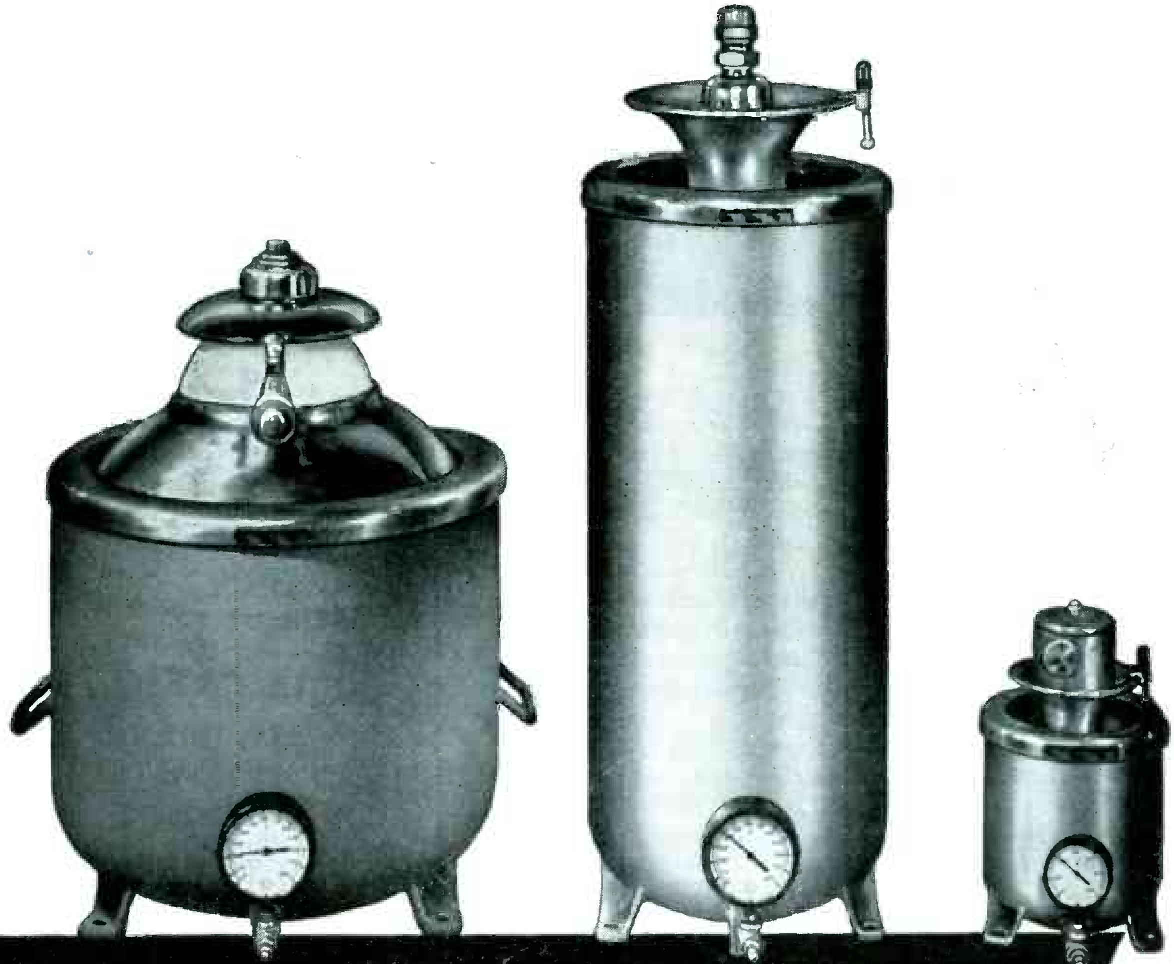




KARP METAL PRODUCTS CO., INC.

124 - 30th STREET, BROOKLYN 32, NEW YORK

Custom Craftsmen in Sheet Metal



NO INCREASE IN PRICE

LAPP GAS-FILLED CONDENSERS AT PREWAR PRICES . . .

There's good news for designers and builders of high voltage electronic circuits who find themselves caught in an inflationary spiral of costs. No advance in prices has been announced—none is contemplated—for Lapp Gas-filled Condensers. Known as the most satisfactory source of high current and high voltage capacitance, these units offer non-deteriorating, dependable performance; impossibility of puncture; lowest loss with consequent economy of power; constant capacitance under temperature variation; and compact, space-saving design. Variable, adjustable, and fixed units are available with current ratings up to 500 amperes R.M.S., power ratings up to 60 Kv peak. Units now in service range up to 60,000 mmf. (fixed units), 16,000 mmf. (variable and adjustable units).

Lapp

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

REVERE FREE-CUTTING COPPER ROD

... INCREASES ELECTRONIC PRODUCTION

SINCE its recent introduction, Revere Free-Cutting Copper has decisively proved its great value for the precision manufacture of copper parts. Uses include certain tube elements requiring both great dimensional precision, and exceptional finish. It is also being used for switch gear, high-capacity plug connectors and in similar applications requiring copper to be machined with great accuracy and smoothness. This copper may also be cold-upset to a considerable deformation, and may be hot forged.

Revere Free-Cutting Copper is oxygen-free, high conductivity, and contains a small amount of tellurium, which, plus special processing in the Revere mills, greatly increases machining speeds, makes possible closer tolerances and much smoother finish. Thus production is increased, costs are cut, rejects lessened. The material's one important limitation is that it does not make a vacuum-tight seal with glass. In all other electronic applications this special-quality material offers great advantages. Write Revere for details.

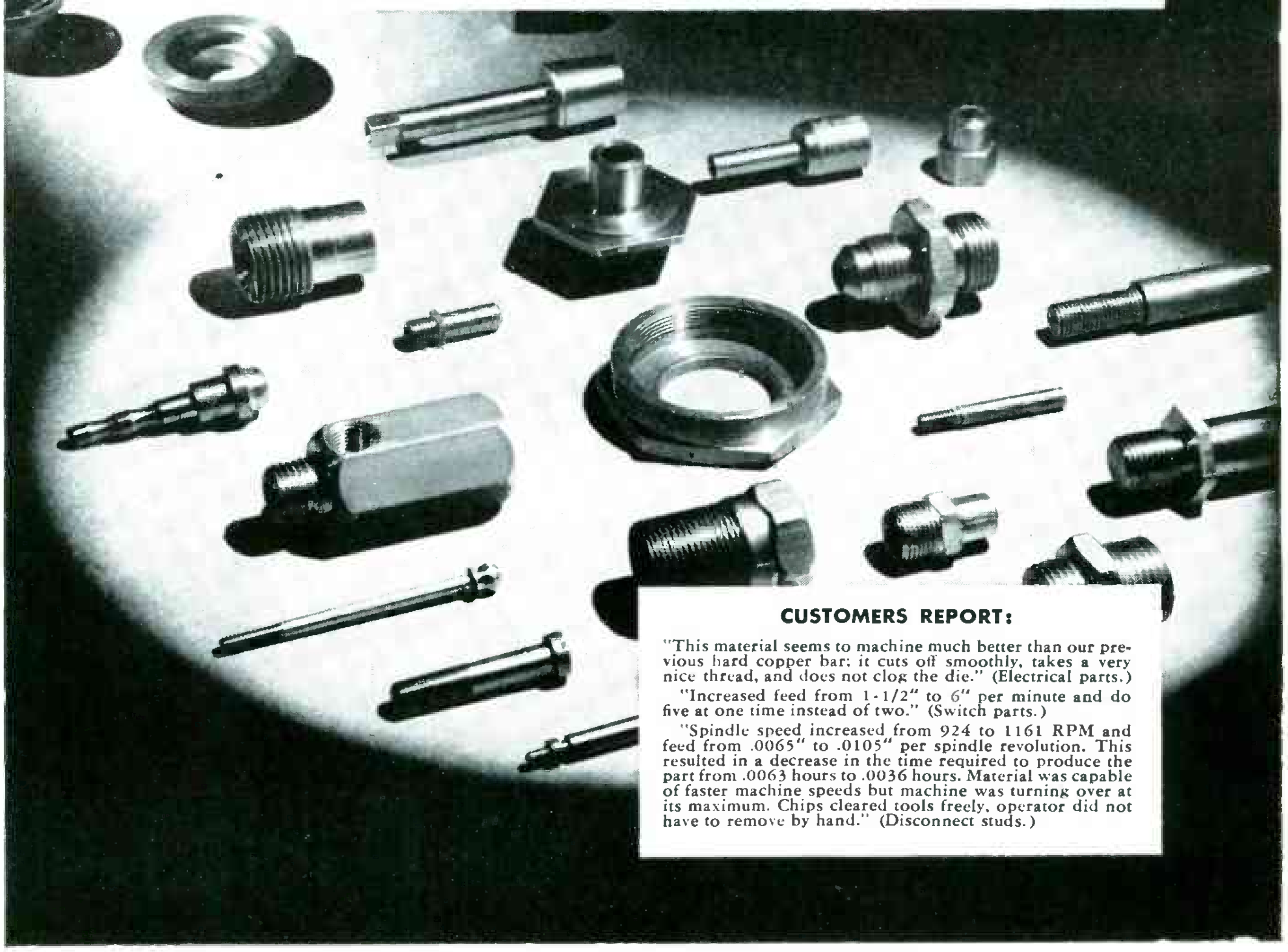
REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

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



CUSTOMERS REPORT:

"This material seems to machine much better than our previous hard copper bar; it cuts off smoothly, takes a very nice thread, and does not clog the die." (Electrical parts.)

"Increased feed from 1-1/2" to 6" per minute and do five at one time instead of two." (Switch parts.)

"Spindle speed increased from 924 to 1161 RPM and feed from .0065" to .0105" per spindle revolution. This resulted in a decrease in the time required to produce the part from .0063 hours to .0036 hours. Material was capable of faster machine speeds but machine was turning over at its maximum. Chips cleared tools freely, operator did not have to remove by hand." (Disconnect studs.)

New, Sensational FM Radiophone COMMUNICATIONS SYSTEMS

by PHILCO

—the Leader

with

"MICRO-SELECTIVITY"

ONLY PHILCO HAS IT!

The amazing PHILCO FM "Channel Saver" Circuit operates within a band width of only 20 Kilocycles. Its "micro-selectivity"—better than 85 db. down at 40 Kc from center frequency—permits adjacent channel operation on the basis of present frequency allocations. This allows higher standards of efficiency in only half the channel width without loss in voice quality, protects you against equipment obsolescence. Only PHILCO Has It . . . Plus . . . many new developments in equipment design. Mail the coupon, today, for full details.

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

PHILCO

INDUSTRIAL DIVISION

PHILADELPHIA • PENNSYLVANIA

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

Gentlemen:

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

NAME__________

ADDRESS__________

CITY__________

CORNISH

WIRES *at work*

(courtesy ECKSTEIN RADIO & TELEVISION CO.)

WHY ARE CORNISH WIRE PRODUCTS SPECIFIED BY THIS LARGE RADIO MANUFACTURER?

Because their

ENGINEERING DEPARTMENT

values their faithful performance and ability to meet the most exacting demands of insulation resistance and voltage breakdown. . . .

Because their

PRODUCTION DEPARTMENT

discovered after thorough testing that they possess the essential qualities which permit easy pushback or mechanical stripping. . . .

Because their

PURCHASING DEPARTMENT

knows these quality products, backed by dependable service, are always priced as low as such good wires can be made and sold. . . .

made by engineers for engineers

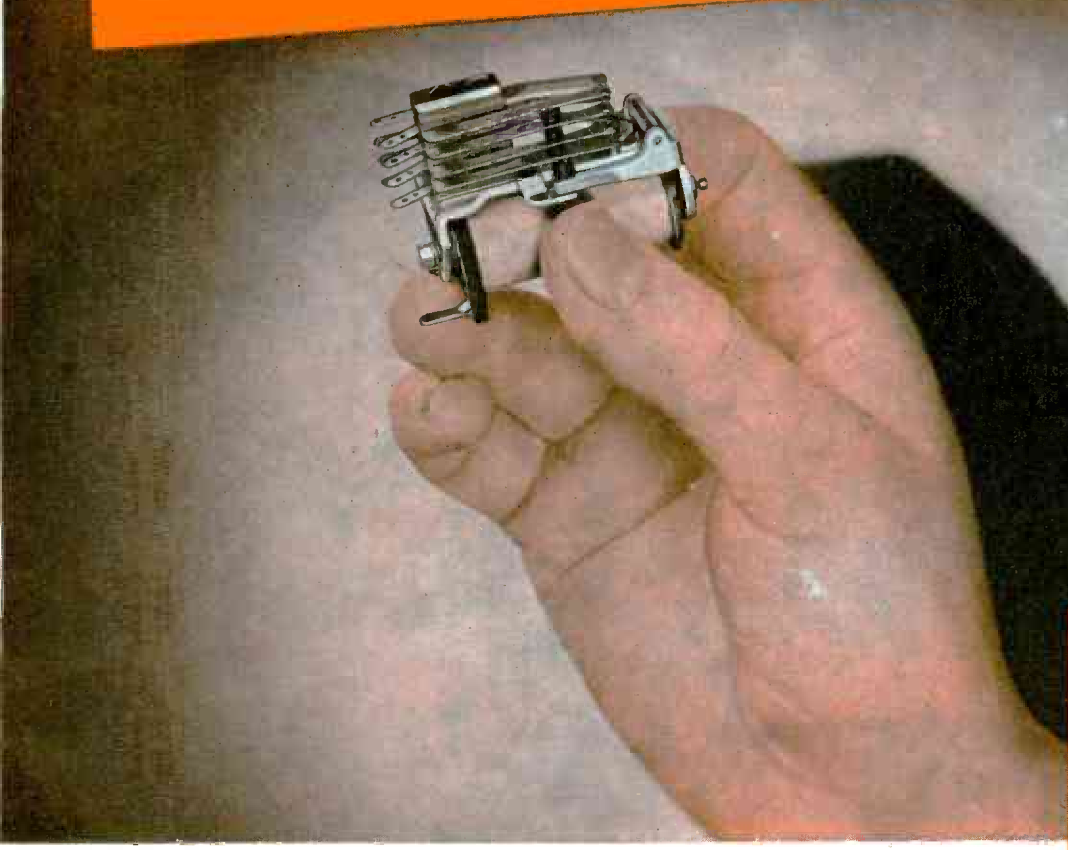
CORNISH WIRE COMPANY, Inc.

605 North Michigan Avenue, Chicago 11

15 Park Row, New York 7, N.Y.

1237 Public Ledger Bldg., Philadelphia 6

CLARE New Type "J" Relay Provides Sure, Positive Action with Exclusive Twin-Contact Design



● Here, at last, is a twin-contact design in which the chance of contact failure is actually reduced to the practical limit.

Exclusive design of the CLARE Type "J" d.c. Relay allows the twin contacts to operate independently of each other so that one contact is sure to close even when the other may be blocked by presence of dirt or grit.

This sensational new relay combines the best features of the conventional telephone-type relay with the small size and light weight developed during the war for military aircraft use.

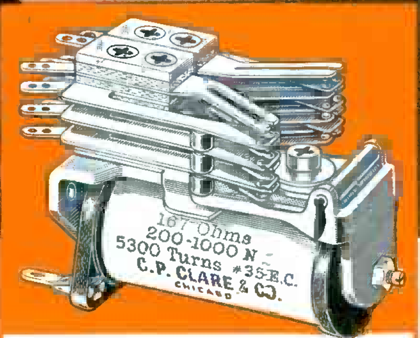
Weighing little more than two ounces, slightly over two inches in length, it has the sturdy construction, large contact spring capacity, extreme sensitivity, and adaptability to a wide range of specifications for which CLARE Relays are noted.

Modern designers, working to develop close-coupled, compact equipment to meet today's streamlined standards, welcome this highly efficient combination of capacity and small size.

CLARE Relays are especially designed for jobs where ordinary relays won't do. If you have such a relay problem, Clare Sales Engineers are located in principal cities to help you work out a Clare "Custom-Built" Relay that will just fit your needs. Write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable Address: CLARELAY. *In Canada: Canadian Line Materials, Ltd., Toronto 13, Ontario.*

CLARE RELAYS

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



All These Features . . . and More . . . Provided By CLARE Type "J" Relay

Independent Spring Contacts. Dome shaped contacts on movable springs; flat discs on fixed springs.

High Current-Carrying Capacity. Twin contact points of palladium. Rated current-carrying capacity: 4 amperes, 150 watts.

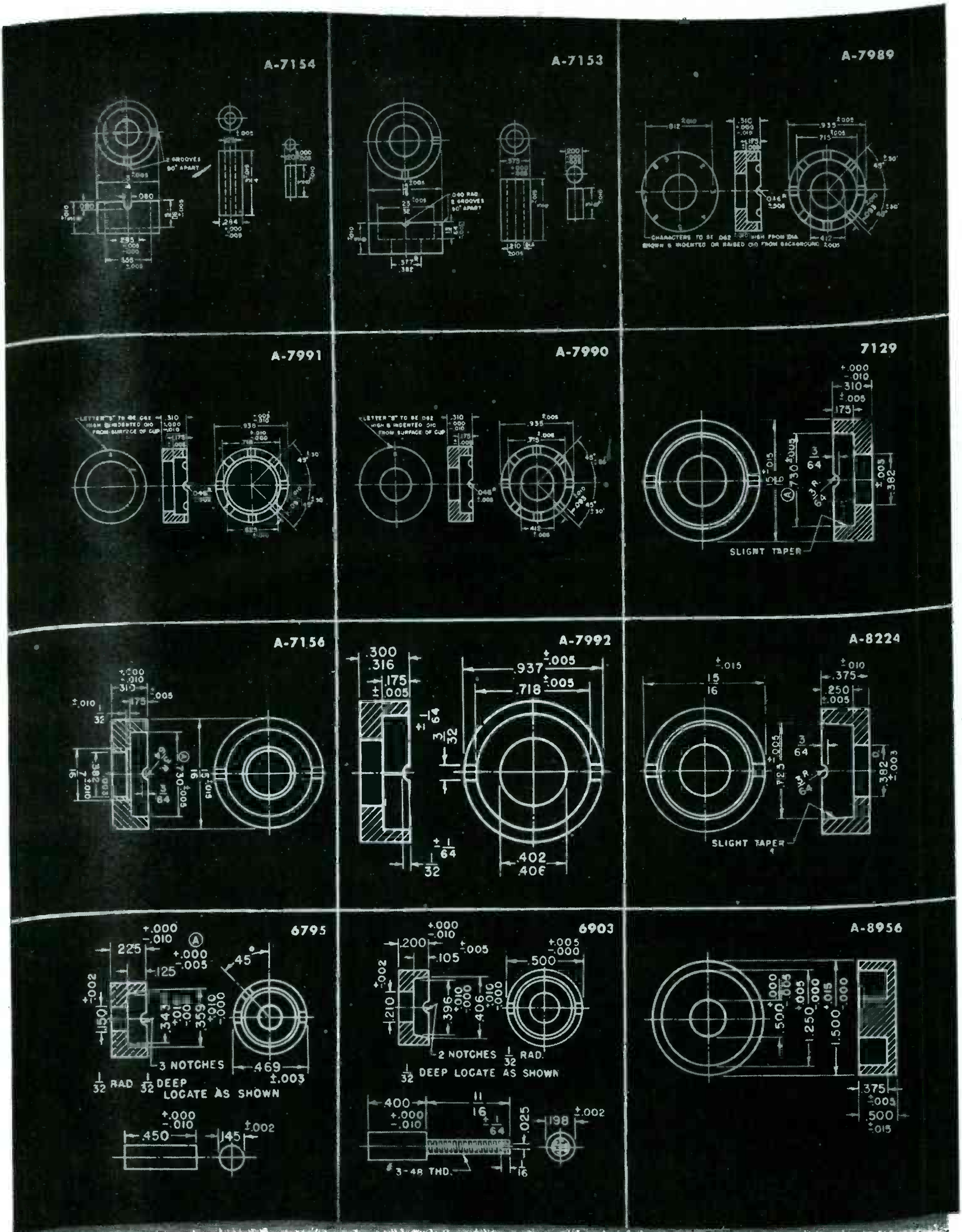
New Design Large Armature Bearing Area. Hinge type armature has new design bearing providing largest possible bearing surface. Pivot pin turns in cylinder of different metal which is full width of heelpiece.

Sensitive, Efficient Magnetic Structure. Heelpiece and other magnetic iron parts are exceptionally heavy for size of relay . . . provide highly sensitive and efficient magnetic path.

High Operating Speed. Designed for extremely fast operation . . . a minimum of one to two milliseconds.

Permits Handling Large Spring Loads. Power and sensitivity permit handling of large spring loads. Both single and double-arm relays available. Maximum of 10 springs on single-arm relay . . . 20 springs (10 in each pileup) on double-arm relay.

RESISTORS • CONTROLS



SWITCHES • IRON CORES

PROFESSIONAL PERFORMANCE—that keeps the original sound alive!

Ride 'em without Rumble!

—on a turntable free of vibration

The pounding of hooves may be sweet music to the ears of a race jockey. But to a disc jockey—whose program's success depends upon the undistorted high fidelity of his transcriptions—any extraneous mechanical noise leaves his listeners at the starting post. They just won't ride with him!

Fairchild engineers have succeeded in eliminating the last bit of extraneous mechanical noise — in the newly redesigned Unit 524 Transcription Turntable. Turntable noise, rumble and vibration are non-existent because of the unique method of mounting the drive — at the bottom of the cabinet . . . the use of a specially designed rubber coupling to connect the drive and synchronous motor which are spring-mounted and precision-aligned in a single heavy casting . . . the use of sound-stopping mechanical filters on the hollow drive shaft to reduce the transmission of vibration from the drive mechanism to the turntable . . . and the use of a heavy, webbed cast aluminum turntable mount at the top of the cabinet.

In addition to freedom from rumble, Fairchild offers you a wider frequency range and lower distortion content with its Unit 542 Lateral Dynamic Pickup, with a stylus mounting that allows the tip to follow the minute indentations engraved in the groove from 30 to 10,000 cycles and beyond, with a minimum of distortion. Want more details about sound equipment that really keeps the original sound alive? Address: 88-06 Van Wyck Boulevard, Jamaica 1, New York.

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

AM FM SOUND EQUIPMENT

Fairchild CAMERA AND INSTRUMENT CORPORATION

4 BEAM POWER ACES
for Communications Work

YOU just can't beat beam power tubes for efficiency. Their low drive requirements mean less space taken up by the driving stages, and a substantial saving in power. Builders and operators of mobile-radio and other communications equipment know this; they choose beam power tubes for a clear, reliable signal with minimum drain on the battery or other source of transmitter supply.

General Electric offers a complete line of beam power (and other) tubes designed to meet the full range of power outputs and frequencies in communications work. If you are a designer or builder of apparatus, G-E tube engineers stand ready to work closely with you in selecting the right tubes for circuits on your drawing-boards.

If you are an operator of police, taxicab, or ambulance radio equipment—of a ship-to-shore, airport, or other communications system — same-day, often *same-hour* replacement service on tubes is available from your nearby G-E tube distributor or dealer.

Specify G-E tubes in new equipment being designed and built; ask for G-E tubes when replacing present types. It's your A-to-Z guarantee of quality, efficiency, long-term dependable tube performance. *Electronics Department, General Electric Company, Schenectady 5, New York.*

Ratings (ICAS) for typical operation, Class C plate-modulated

Type	Plate voltage	Plate current	Driving power (approx)	Power output (approx)	Freq. at max ratings
GL-2E26	500 v	54 ma	0.15 w	18 w	125 mc
GL-807	600 v	100 ma	0.4 w	42.5 w	60 mc
GL-829-B	600 v	150 ma	0.9 w	70 w	200 mc
GL-813	2,000 v	200 ma	4.3 w	300 w	30 mc

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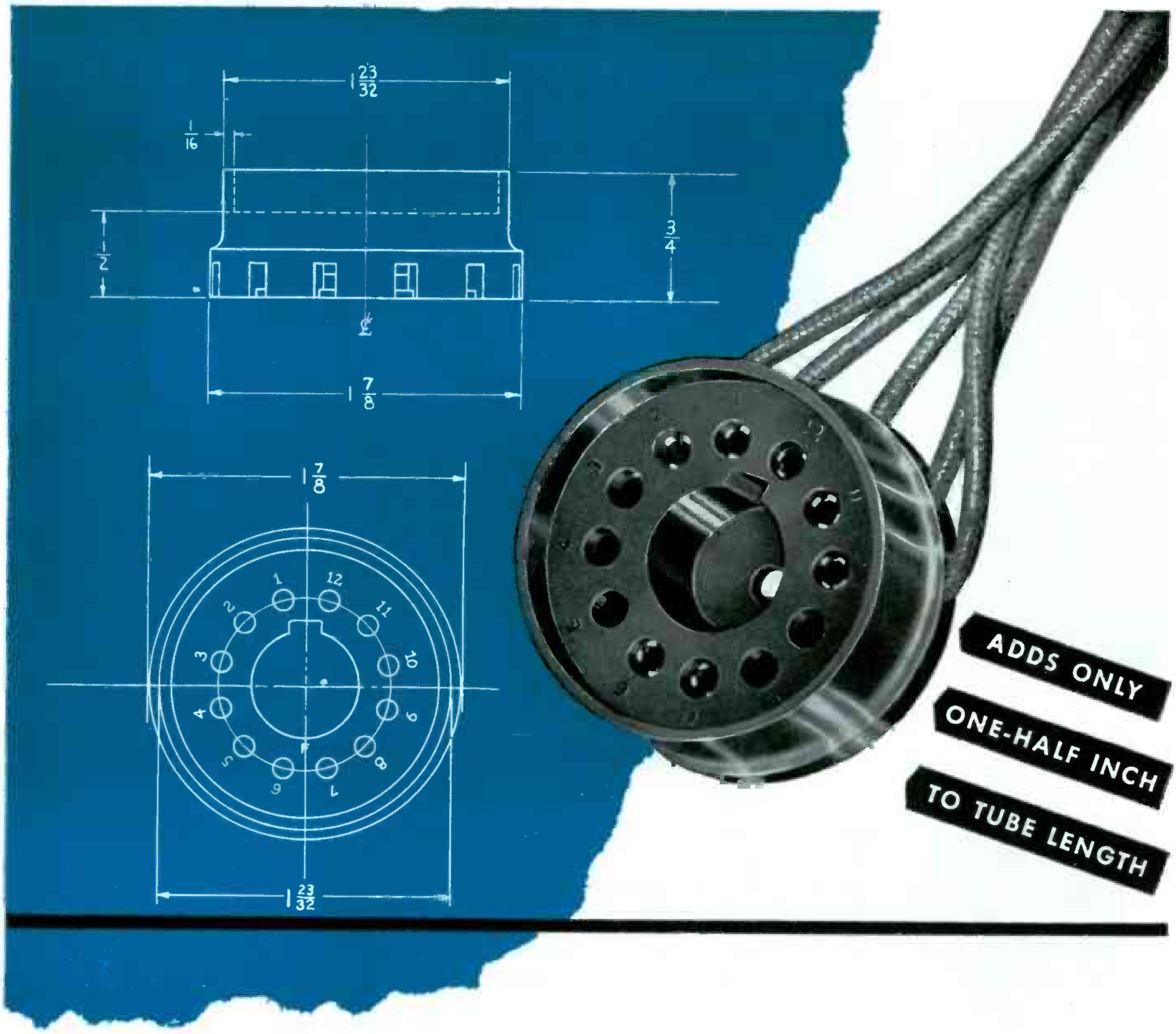

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ADDS ONLY ONE-HALF INCH TO TUBE LENGTH
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MODERN requirements for general purpose sound equipment have outmoded older designs. Replacing Models UH-20 and UH-24, these new JENSEN Hypex Projectors answer the demand for something new, better, more reliable, and at lower cost. Power handling capacity 25 watts maximum speech and music signal input. Voice coil impedance 16 ohms.

MODEL VH-20 (ST-684). For speech and music reproduction where principal requirement is for speech. Frequency range 140 to 6000 cps. Developed acoustic path length 52 inches. Coverage angle 80°. Mouth diameter 20¾ inches; length 20¼ inches. List price $63.00.

MODEL VH-24 (ST-685). For speech and music reproduction. Superior to Model VH-20 for music because of larger size. Frequency range 110 to 6000 cps. Developed acoustic path length 58 inches. Coverage angle 75°. Mouth diameter 24¾ inches; length 22⅜ inches. List price $74.50.

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9. JENSEN patented Hypex formula for improved acoustical performance.
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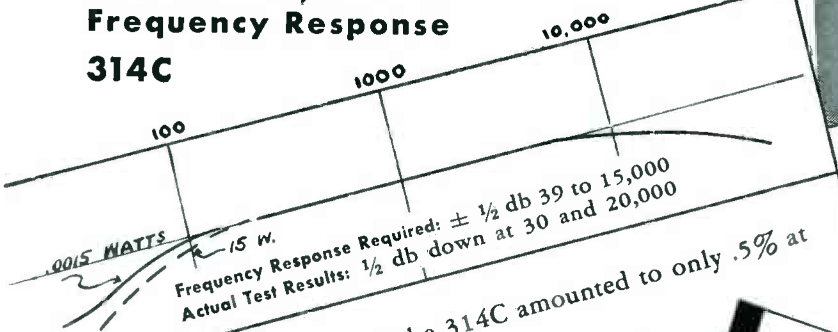
TWO **ADC** output transformers taken from stock were tested with the following results . . . check these results in your own laboratory with your present transformer. Then check **ADC** transformers in your lab too. Note the difference in quality

ADC *Quality Series*
Frequency Response
314C

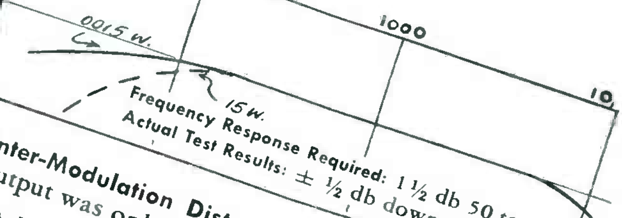


Frequency Response Required: ± ½ db 39 to 15,000
Actual Test Results: ½ db down at 30 and 20,000

Inter-Modulation Distortion on the 314C amounted to only .5% at 12 watts output.
Total Harmonic Distortion including that from output tubes at 50 cycles was as follows:
1.33% at 10 Watts **2.5% at 12½ Watts**
4.4% at 15 Watts

No. 1

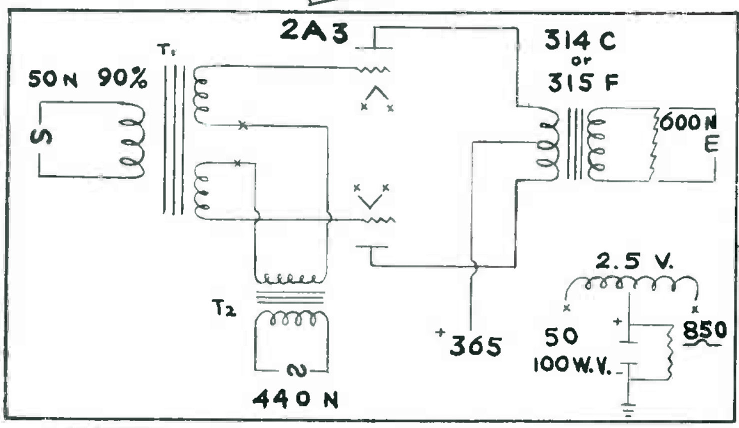
ADC *Industrial Series*
Frequency Response
315F



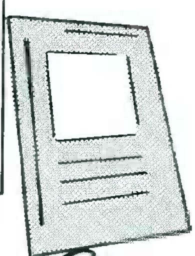
Frequency Response Required: 1½ db 50 to 10,000
Actual Test Results: ± ½ db down at 50 and 20,000

Inter-Modulation Distortion on the 315F at 12 watts output was only .71%.
Total Harmonic Distortion including that from output tubes at 50 cycles was as follows:
1.3% at 10 Watts **4.8% at 12½ Watts**

No. 2



Omit T_2 Distortion Measurements



WRITE TODAY for new **ADC** Catalog giving complete performance data on all **ADC** Transformers and other audio components.

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Audio Develops the Finest

As Advertised in the Saturday Evening POST

THE WARD *Magic Wand* AERIAL

makes any receiver work better

Scientific tests prove that quality FM or Television reception is difficult, if not impossible, without a good outdoor aerial. So, don't blame your receiver if reception isn't up to par. Do install a Ward Magic Wand Outdoor Aerial and see for yourself the almost magical improvement that results.

These new Ward outdoor FM and television aerials are available in either straight or folded dipoles (reflector kits also available) for the 88 to 106 mc FM band, and the 44 to 88 mc television band. They do away with bothersome weak spots, and your set functions at full efficiency even on distant stations.

New foolproof design adapts easily to the requirements of each installation. Universal base permits mounting at any roof or wall angle. Sturdy vertical element revolves in base to easily orient dipole for maximum gain. Dipole is of corrosion-preventive aluminum, other parts weatherproofed inside and out. Ring provides for attaching guy wires. Sixty-foot polyethylene-insulated lead-in of 300-ohm colinear transmission line included. Standoffs of exclusive design guide transmission line down mast, and to receiver, minimizing capacity to ground and eliminating line reflections. Complete, step-by-step installation instructions included with each aerial.

Get your Ward Magic Wand FM or Television Aerial today, or mail the coupon below for free catalog and name of your nearest dealer.

THE WARD PRODUCTS CORPORATION
1530 East 45th Street, Cleveland 3, Ohio
DIVISION OF THE GABRIEL COMPANY

IN CANADA: Atlas Radio Corp., 560 King Street, W., Toronto, Ontario, Canada
EXPORT DEPT.: C. O. Brandes, Mgr., 4900 Euclid Avenue, Cleveland 3, Ohio

ATTENTION DEALERS:
Powerful Ward national advertising in the Saturday Evening Post, and leading newspapers, now is educating over 33 million present (and future) owners of FM and television receivers to their need for Magic Wand Aerials. Write for free details on how you can best capitalize on this advertising in your locality.

MAIL COUPON TODAY

WARD PRODUCTS CORP.
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Please send me free catalog on Ward Magic Wand Aerials for FM and Television, and name of my nearest dealer.

NAME____________________

ADDRESS____________________

CITY AND STATE____________________

MY JOBBER IS____________________

WHAT MAKES A GOOD RECORDING BLANK *GOOD** ?

No 2

RECORDING LACQUER

- *The 'Broadcaster'* 10" 12" 16"
- *The 'Playback'* 6½" 8" 10" 12" 16"
- *The 'Audition'* 6½" 8" 10" 12" 16"
- *The 'Maestro'* 12" 13¼" 17¼"

- Everyone is familiar with lacquer in some form or other. Only a handful of chemists, however, are tops in the field of *recording* lacquer.
- Recording lacquer consists basically of cellulose nitrate, a plasticizer to control the consistency, and a dye to blacken it. Minor constituents and specialized procedures complete the compounding. The development of recording lacquer has been going on for over twenty years. Fortunes have been spent improving it.
- A good formula must combine properties that, offhand, seem irreconcilable. It must be soft to cut, hard to resist wear; heavy for quietness, light for smooth application; lubricated for low friction, oil-free for processing. To a high degree the Soundcraft formula reconciles these requirements. *But that is only half the battle.*
- Developing the formula was indeed no small task, but *controlling* it in commercial quantities is a delicate undertaking, too involved to describe here. Suffice it to say, however, that, confident of its formula, Soundcraft puts the emphasis on control so close that the recording engineer can *predict* performance.
- When a better formula is available, Soundcraft expects to have it. In the meantime Soundcraft doesn't experiment on *you.*

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

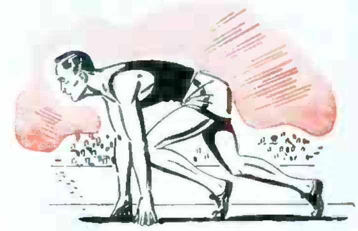
Soundcraft

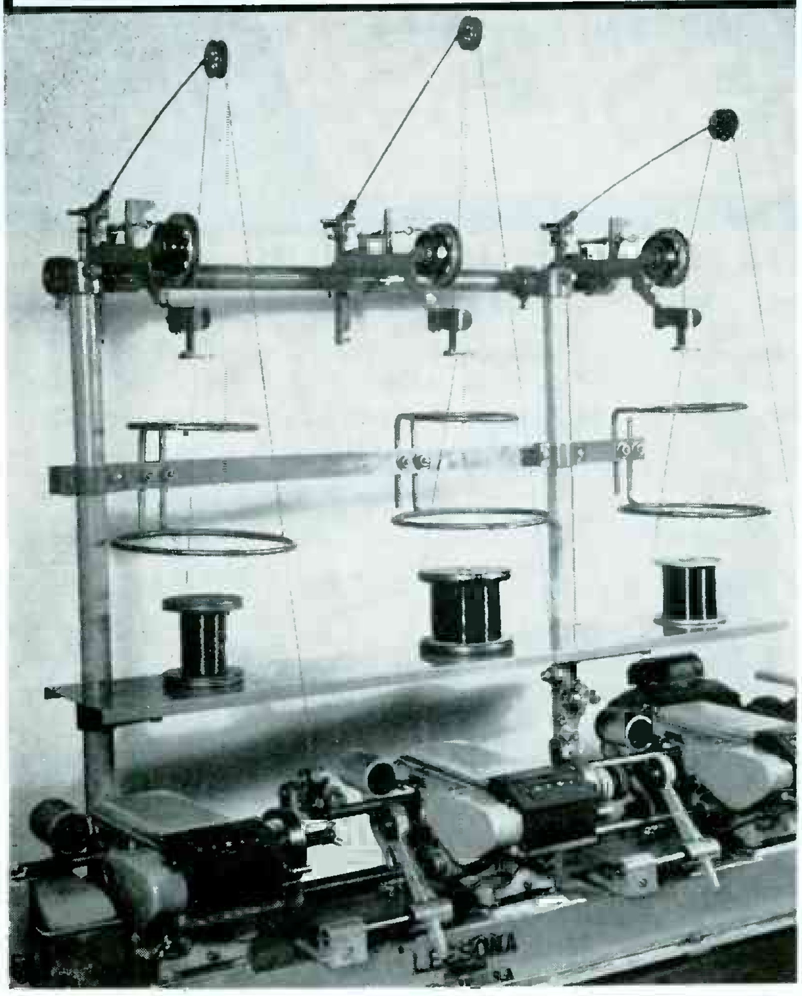
REEVES SOUNDCRAFT CORPORATION
10 EAST 52nd STREET • NEW YORK 22, N. Y.

NEW!

"Insto-Start" Over-End Tension

SPEEDS COIL WINDING





Drawing wire over the *end* of the supply spool instead of from an unrolling supply overcomes the problem of spool inertia at the start of winding.

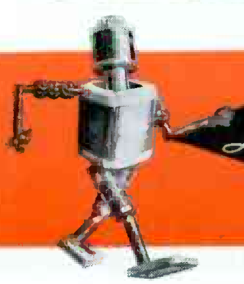
With the "Insto-Start" Over-End Tension, winding starts at top speed. The operator doesn't have to "coax" the spindle . . . and moves to the next spindle without delay.

Unlike existing types of Over-End Tensions, control of the wire on the "Insto-Start" is maintained by a compensator. The retention of this time-proven principle assures the production of tightly wound, uniform coils. Compensator control is calibrated to permit recording of settings, which speeds up adjustments for different wire sizes.

Guards control the "balloon" of the wire coming off the spool.

The "Insto-Start" Over-End Tension accommodates wire sizes from No. 47 to No. 23 AWG. It was designed primarily for the No. 102 Universal Machine but is adaptable to other makes as well.

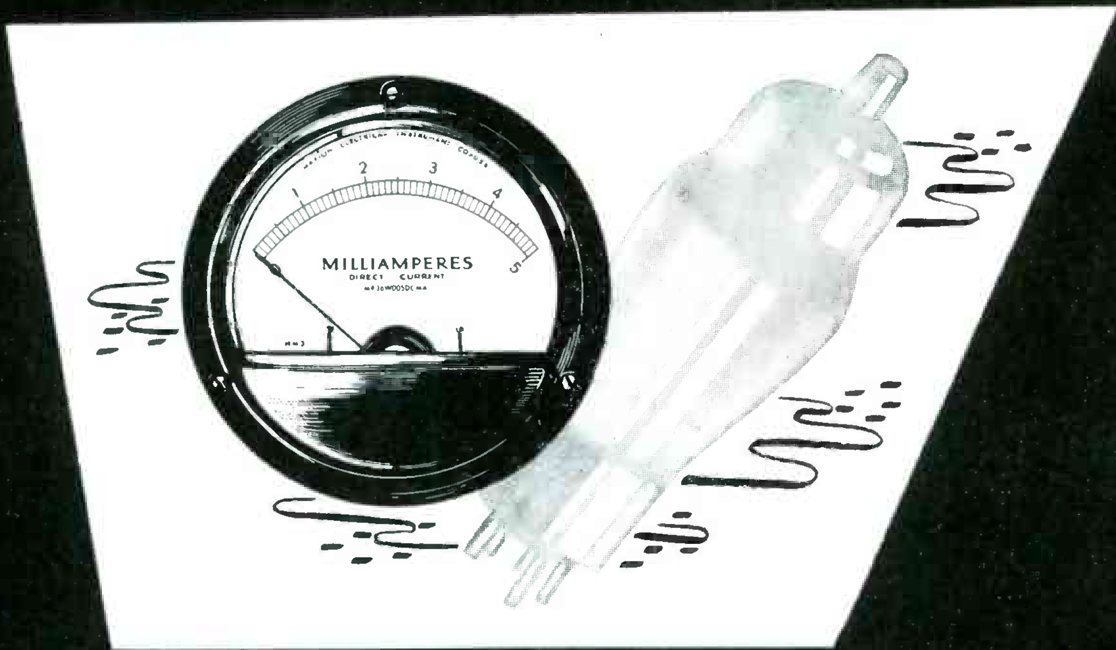
For further information write Universal Winding Company, Department L, P. O. Box 1605, Providence 1, R. I.



LEESONA REG. U.S. PAT. OFF.

FOR WINDING COILS IN QUANTITY
ACCURATELY . . . AUTOMATICALLY
USE UNIVERSAL WINDING MACHINES

In Step with Electronic Progress . . .
Modern Hermetically Sealed Instruments



SEALED LIKE A VACUUM TUBE
100% GUARANTEED!

Progressive manufacturers of electronic equipment declare an hermetic seal is as important in a meter as it is in any other product component. That's because meters are just as susceptible to the harmful effects of dust, moisture, corrosive fumes and other destructive factors as resistors, capacitors or transformers. Therefore, hermetically sealed meters are a "must" in achieving top product performance.

MARION HERMETICS ARE NOT PREMIUM PRICED

Marion glass-to-metal hermetically sealed meters offer you the accuracy, superiority and extended life of an hermetically *sealed* component at a price no higher than most competitive *unsealed* instruments. All Marion hermetically sealed instruments are 100% GUARANTEED.

LOOK AT THE FEATURES OF MARION "HERMETICS"

DURABLE . . . Unaffected by extremes of heat or cold . . . permanently protected against dust, dirt, moisture . . . instrument malfunctioning minimized.

SHIELDED . . . Heavy steel case gives magnetic and electrostatic shielding so important in modern high frequency equipment.

INTER-CHANGEABLE . . . The Marion case, with its high conductivity plating, eliminates the need for separate shielding and permits interchangeability on any type panel without affecting calibration.

MARION "4 for 1" FEATURE Interchangeable Round and Square Colored Flanges . . . one instrument can thus fill four different needs:

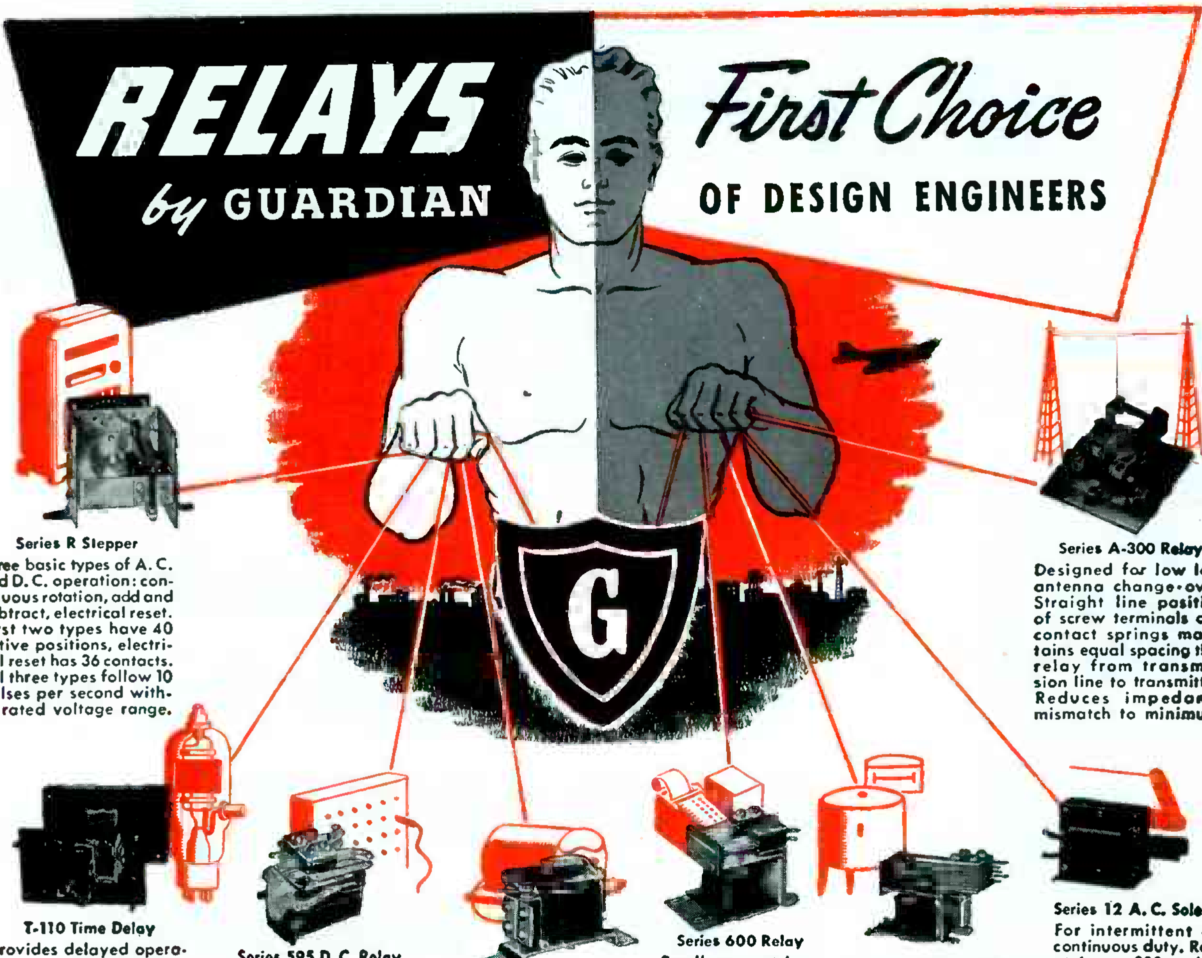
1. Round
2. Round for Steel Panel
3. Rectangular
4. Rectangular for Steel Panel

WRITE FOR FURTHER INFORMATION.

THE NAME "MARION" MEANS THE "MOST" IN METERS

MARION ELECTRICAL INSTRUMENT COMPANY
Manchester, New Hampshire

THOUSANDS OF SUCCESSFUL *Control* APPLICATIONS PROVE



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

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

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

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

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

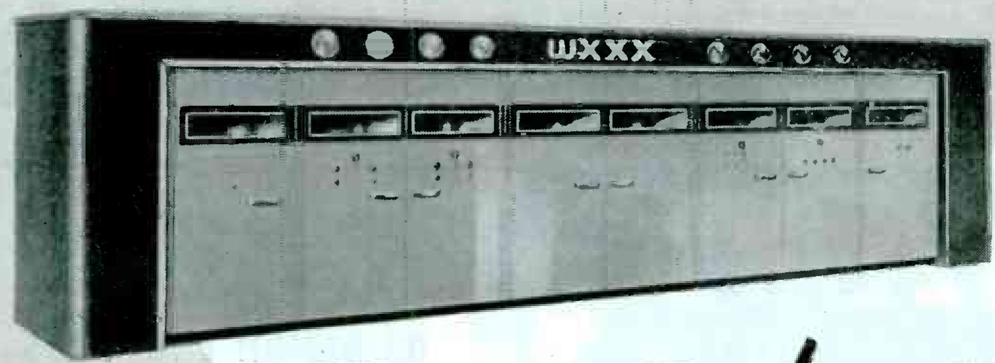
Series 600 Relay
Small, compact, low-cost. Size: 2 1/8" x 1 1/2" x 1 1/8". Contact combinations up to 4 P. D. T. Power consumption, 6 V. A. Max. cap., 8 amps, 3 v. to 230 v. A. C., or 3 v. to 110 v. D. C. Coil and contact assemblies interchangeable.

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

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

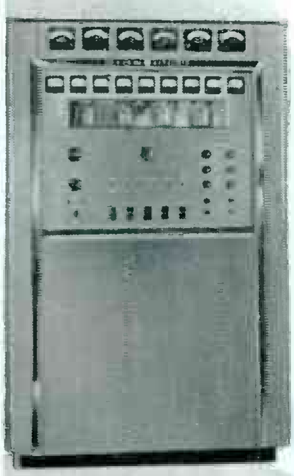
Faced with responsibilities for the design and successful performance of their companies' products, American design engineers are eagerly turning to Guardian Electric *first* for relays and complete control assemblies. They find at Guardian a vast wealth of application and performance data, an expert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

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



50 KW—One of the larger members of the G-E transmitter family. Note wide doors, providing full accessibility for "walk-in" maintenance. Like all high-power G-E transmitters, this model uses transformers filled with a non-inflammable liquid. This eliminates necessity for fireproof vault and lowers installation costs and insurance.

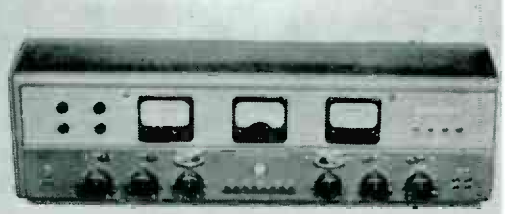
POWER for every



1 KW—Compactness is an outstanding quality of this sturdy equipment. Reliable, high-standard performance makes it an ideal transmitter in its power class. Now in stock and ready for immediate delivery.

General Electric's complete new line of AM TRANSMITTERS—now in production

10 KW—Tube switching from the front panel minimizes program outages. This model is a unified assembly of exciter-modulator, power amplifier, and rectifier-control units.



TRANSMITTER-CONTROL CONSOLE

This versatile unit can be used to control a transmitter of any power rating. The de luxe version includes a separate clock panel for timing transmitter interruptions; also, an executive type desk and chair of matching color.

broadcast need!

250 Watt—Highest quality performance at lowest operating cost—you profit both ways with this 250-watt AM transmitter. Simplified circuits. Numbers and types of tubes minimized. *Immediate delivery from stock.*

HERE are five outstanding AM units that will help you profit from your station investment. Featuring lower cost per hour of broadcast service, these transmitters are built to one high standard of quality, backed by one source of responsibility. Every detail of this completely new line reflects the unequaled engineering and operating experience of the General Electric Company.*

The G-E line of broadcast equipment covers all your station needs—transmitters from 250 watts to 50,000 watts, complete studio equipment, the AM station monitor and accessory units to fit every requirement.

Whether you are planning a new station or modernizing an existing one, take a big step in the right direction by calling your nearby General Electric broadcast representative (see list below), or write to Transmitter Division, General Electric Co., Electronics Park, Syracuse, N. Y.

*G.E. built its first commercial broadcast transmitter in 1922. Since that time the company has produced broadcast transmitters whose combined power ratings total over 2,500,000 watts.

5 KW—An exclusive G-E feature of this transmitter is the spare tube switching of all high-power stages from front panel. Air-cooled throughout, as are all G-E standard broadcast transmitters.

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CONSTANT VOLTAGE

puts the "safety" in safety controls

Without CONSTANT VOLTAGE protection, this self-sustaining link in the chain of relay points that chart the nation's airways, could not successfully perform its safety function.

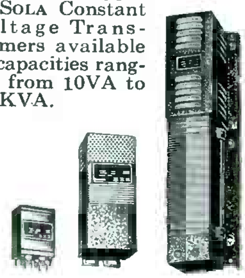
It is remotely located, at times almost inaccessible to service personnel and solely dependent on local power service. Were it not for a SOLA Constant Voltage Transformer, its delicately engineered electronic and radio equipment would be constantly at the mercy of periodic and unpredictable surges or low voltage levels.

Throughout the entire cross-country system SOLA Constant Voltage Transformers maintain operating voltages at a constant, predetermined level and the nation's air-men fly their courses with confidence.

If you are building electrically energized equipment to operate at precise voltage levels, remember this: *it is more economical to include Constant Voltage protection in your design than to install it later as a remedial measure.*

Revised Bulletin DCV-102
available on request.
Write for your copy.

31 standard types of SOLA Constant Voltage Transformers available in capacities ranging from 10VA to 15 KVA.



SOLA *Constant Voltage* TRANSFORMERS

Transformers for: Constant Voltage • Cold Cathode Lighting • Airport Lighting • Series Lighting • Fluorescent Lighting • Luminous Tube Signs
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"The fate of the world sits on this rug"

— JOHN L. LEWIS

NOTE: Paste this editorial in your hat. Re-read it as you start to shiver the next time John L. Lewis cuts off the nation's coal supply.

"Labor monopoly" will mean much more to you then. But if you are worried enough you will get after your Congressman to do his part now — before the shivering starts.

★ ★ ★

"The fate of the world sits on this rug."

The men on the rug: John L. Lewis, President of the United Mine Workers, who made the remark; Benjamin Fairless, President, United States Steel Corporation; George M. Humphrey, Chairman, Pittsburgh Consolidation Coal Company; Harry M. Moses, President, H. C. Frick Coke Company; Charles O'Neill, President, United Eastern Coal Sales Corporation; the late John O'Leary, International Vice President of the United Mine Workers; and John Owens, President, District No. 6 United Mine Workers.

The place: Room 800, Carlton Hotel, Washington, D. C.

The time: Last July during the "negotiation" of a new soft coal contract.

The outcome: Another whopping increase in wages and the price of coal, another hike in the cost of living, and a "contract" which binds the United Mine Workers only as long as they are "willing and able to work."

Mr. Lewis was right. The fate of the world did sit on the rug. In fact, it sat at Mr. Lewis' feet, for, as this editorial will explain and as the outcome shows, his power over coal is absolute.

Without coal modern industrial civilization collapses. Without Mr. Lewis' assent coal can not be mined. He has the nation and, in the years 1947-48, the world at his mercy.

The Taft-Hartley Act, good as it is, does nothing to check this kind of monopoly.

I

The Taft-Hartley Act fails to protect the public in many major particulars.

Here are some of them.

1. Labor monopoly is promoted and protected by its continued exemption from the federal antitrust laws. Management has no such exemption and should not have.

2. Industry-wide bargaining, a kind of second-degree monopoly, is left virtually undisturbed. So is union-wide bargaining which extends the power of national unions far beyond a single industry.

3. Featherbedding, the art of getting paid for doing nothing, is left largely intact.

4. The menace of having local utility strikes wreck the health and safety of a community is left untouched. Postponement and persuasion are the only instruments provided to deal with strikes that would wreck the nation.

My purpose in citing these omissions from the Taft-Hartley Act is not to belittle the act or its framers. They did a most courageous and constructive job. They made a real start toward restoring a workable balance in industrial relations in the United States, so far as the law can do it. But they have not completed the job. Among their omissions the two discussed in the next sections of this editorial stand out above all others.

II

The most serious Taft-Hartley shortcoming is its failure to deal with labor monopoly.

Labor monopoly exists wherever a union is so strong that bargaining becomes a sham and the union virtually dictates its own terms.

If an employer or group of employers secures a monopoly or anything approaching a monopoly, prosecution for violation of the federal antitrust laws is in order. That is as it should be, for monopoly means death to economic and political freedom.

But if a labor union secures complete monopoly control over an industry through control of its workers, that union remains above and beyond the antitrust laws. "The fate of the world sits on this rug." By that imperial attitude John L. Lewis fully demonstrated how obsolete is the notion that labor unions are weak and, therefore, need exemption from the antitrust laws. Through the United Mine Workers, Mr. Lewis controls about 90% of the coal miners. (No company controls more than 5% of the nation's coal output.) Wherever he sits he has at his feet the welfare of the whole nation.

Great international unions exercise a comparable measure of monopoly control in other basic industries — steel, transportation, and automobiles, for example.

These labor monopolies can destroy the nation if they are not themselves broken up. Witness the plight of France. There the Communists have found in the great labor monopolies an instrument for shaking the nation to its foundations.

III

The Taft-Hartley Act also leaves untouched industry-wide collective bargaining, which is a kind of second-degree monopoly.

When all or almost all of the employers in an industry get together with the union leaders to agree on wages and working conditions (that is called industry-wide bargaining) they set up a monopoly control. It is a less concentrated monopoly than when the terms are dictated by either side, as Lewis dictates them in coal. But, nonetheless, competition is eliminated and monopoly control is established over wages, which are by far the largest element in the cost of production. It follows that public regulation of collective bargaining — *which means the end of free unions and free management* — is not far behind.

Some employers defend industry-wide bargaining as their only defense against industry-wide unions. Other employers like it because it makes wages and hours uniform for their whole industry.

For those employers who are forced into industry-wide bargaining in self-defense the road to relief is clear. Congress owes it to them and to the public to free them from the necessity of dealing with a monopolistic union. The best way to do that is to remove the exemption of labor unions from the federal antitrust laws.

To those employers who engage in industry-wide bargaining because they like it the proper answer is also quite clear. They (and the union involved) are maintaining a private monopoly which is offensive to the public interest. It should be prevented by law.

IV

Congress should finish the job of eliminating labor monopoly and industry-wide bargaining.

In the course of enacting the Taft-Hartley law last spring the House acted to eliminate the exemption of unions from the federal antitrust laws and to make industry-wide bargaining illegal. The Senate, however, refused to go along.

The principal reason advanced in the Senate for deferring action was that more knowledge is required to legislate intelligently. To get the needed information, a joint Congressional committee was created.

It is standard Congressional practice to stall off tackling a difficult job by creating a special committee to study it. The new joint committee is not likely to prove an exception to this rule — *unless the voters loudly demand of Congress that it get on with its job of protecting the public interest in the conduct of labor relations — a job which is nowhere near done.*

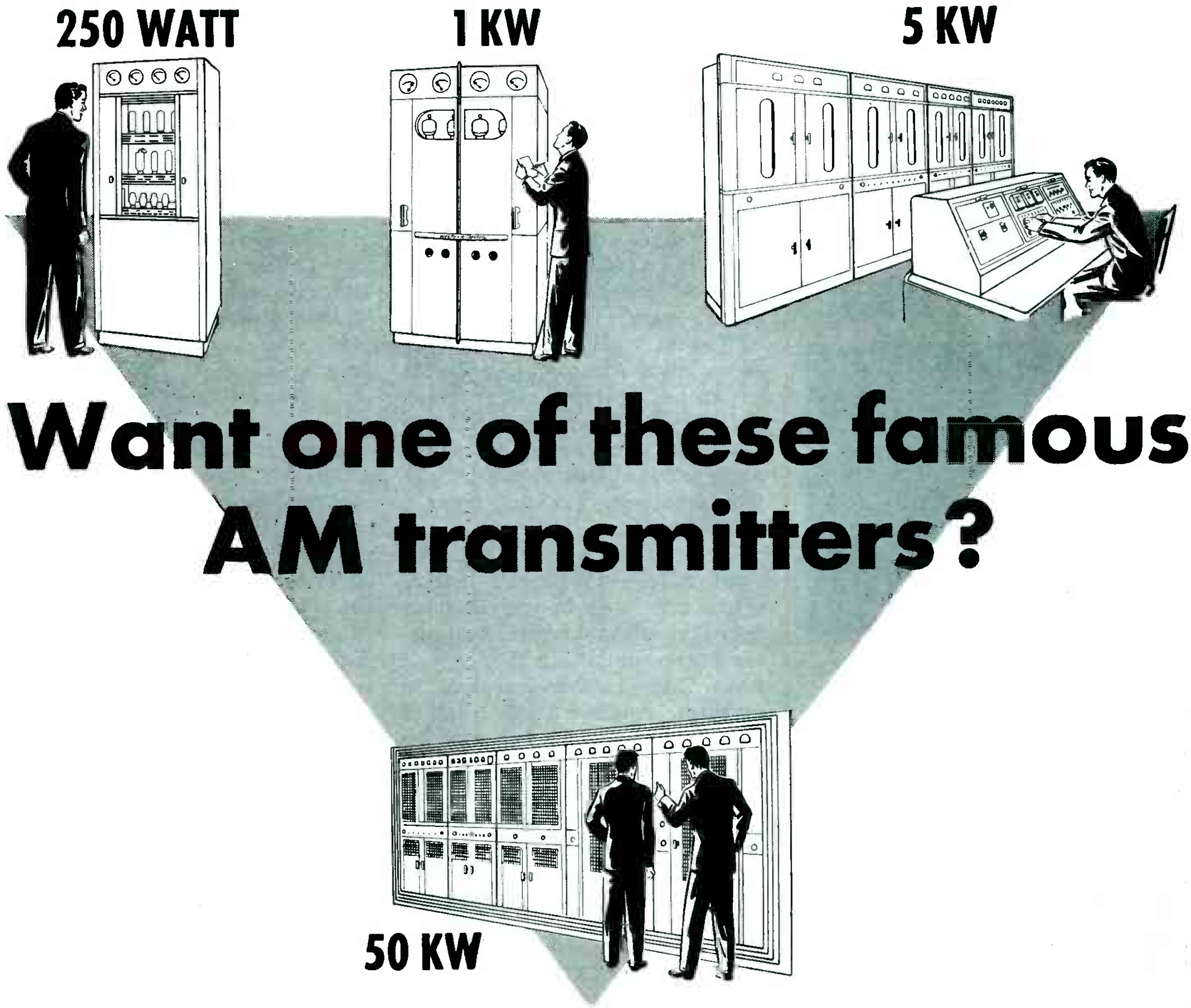
Helpful and effective as many of its provisions are, the Taft-Hartley Act does not face squarely the central principle of industrial relations in a free society. That principle is this: *Neither employers nor organized workers, separately or in combination, shall exploit the public by establishing a monopoly.*

Do not let your Congressmen go to sleep on the job of solving that problem or hide from it because of fear. The perfect solution may be hard to find. But the problem can be largely solved by making organized labor subject to the federal antitrust laws just as management is now subject to them. If that problem goes by default your children and your grandchildren will really know what slave labor means.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 64TH OF A SERIES



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BUSINESS BRIEFS

By W. W. MacDONALD

Most Columnists stick their necks out around this time of the year and we are no exception. It seems to be catching.

Seller's market will change to buyer's market for most electronic equipment sometime in 1948, in our opinion. Already being pushed by manufacturers rather than pulled by customers are table-type radios, some upper-bracket phono combinations. New things may be the exceptions, television being a good example.

Despite the predicted transition from seller's to buyer's market prices are likely to remain at or near their present levels. One reason is the continuing high cost of labor, with further increases in prospect. Another is the cost of materials, which will for the most part be in ample supply but will command high prices.

Business will be good because people have money and need merchandise, but high prices will make it necessary for the industry to do a sales job.

On February 15 it becomes mandatory for all transport aircraft carrying passengers at night or under instrument conditions to have absolute terrain proximity indicators. Electronic types being installed warn pilots of their altitude at 2,000 feet, 1,000 feet, and any predetermined height between 300 and 500 feet.

Machine-Tool Builders in particular and designers of motor-driven industrial devices in general have repeatedly asked electronic engineers to devise more economical and efficient methods of controlling the speed of small a-c motors. And the boys are beginning to come up with answers. See p 106.

Completely Automatic Factories are still far off, but the trend will accelerate in 1948, according to Harold W. Sweatt, president of Minneapolis-Honeywell. Progress, he says, is particularly noticeable in the chemical and petroleum industries.

Basic metal, utility, food, textile and ceramic industries are making increased use of instrumentation to lower costs and improve products. At the present rate of growth, industrial instrumentation will increase 30 percent by 1950.

Tape can handle two and possibly even three simultaneous recordings, experiments in progress indicate. Here, perhaps, is the approach to sound systems with real audio perspective. And how about recording a program as one channel, control voltages capable of operating volume expanders, noise reducers etc. on a second channel?

Movie Production Costs may be cut as much as $5,000,000 a year when use of tape recorders becomes more widespread, think several Hollywood technicians.

Portable Tape Recorder mentioned in these columns back in December (p 77) intrigued quite a few potential manufacturers, and we've forwarded their letters of inquiry to the designer. Anybody else out there we can help in a similar manner?

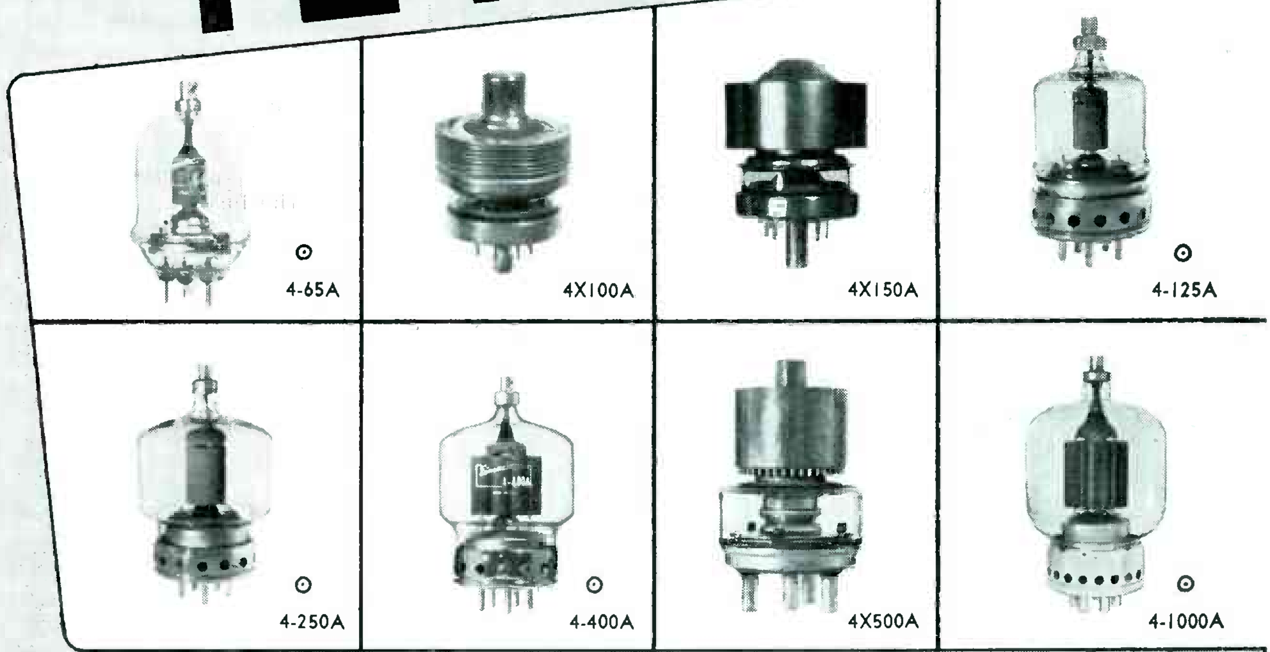
Classified Ad: "If you own a wire recorder, like philosophy, are not dogmatic, and enjoy calm discussion, I'd like to know you. No lonely hearts, religious or anti-religious cranks, please." (*American Freeman*, Girard, Kansas).

Here's a 1948 twist on the old letter-swapping idea, and one that could sell a lot of electronic equipment if it clicked.

Television Today: 54 cities in 29 states are involved in current television broadcasting authorizations and applications. An FCC tabulation December 1 showed 6 stations licensed, 65 construction permits (11 already on the air), and 43 applications pending (25 of these are in hearing).

More details will be found in

EIMAC TETRODES



...PERFORMANCE LEADERS

⊙ THESE TUBES HAVE PYROVAC PLATES

4-65A

Tops for high power VHF mobile transmitters, type 4-65A is the smallest of the Eimac radiation cooled tetrodes. Conservatively rated at 65 watts plate-dissipation, the tube is but 4¼" high and 2" in diameter. The 4-65A is capable of operation over a wide voltage range, for instance at 600 plate volts one tube will provide 50 watts of power-output with less than 2 watts of grid drive. At 3000 plate volts a power-output of 265 watts is obtained.

4X100A

Designed for high frequency applications in which horizontal forced-air cooling would be an equipment design advantage. The characteristics of the 4X100A closely resemble those of the 4X150A except for slightly lower plate dissipation, 100 watts.

4X150A

An extremely compact tetrode of the air-cooled external anode type. Rated at 150 watts of plate dissipation it can be operated at maximum ratings up to 500-Mc. When operated as a doubler, the 4X150A is the standout answer to the STL (studio- transmitter-link) vacuum tube problem . . . excellent performance is had up to 1000-Mc.

4-125A

Forerunner of the Eimac tetrode line, the 4-125A is probably the most universally accepted power tetrode yet designed. Its Pyrovac plate and processed grids impart a high degree of operational stability, resistance to overloads and exceptionally long life. Rated at 125 watts plate dissipation, one 4-125A will handle 500 watts input with less than three watts of grid drive.

4-250A

Higher power version of the 4-125A, type 4-250A also incorporates a Pyrovac plate, and processed grids. In typical class-C operation one tube with 4000 plate volts will provide 1 kw of output power, with 2.5 watts of grid drive.

4-400A

Specifically created for FM broadcast service, two 4-400A tetrodes in typical operation, at frequencies in the 88-108 Mc FM broadcast band, will provide 1200 watts of useful output power, at 3500 plate volts, while the dissipation from the Pyrovac plate is considerably under the maximum rating of 400 watts per tube.

4X500A

A small, but high power VHF, external anode type tetrode, rated at 500 watts plate dissipation. The low driving power requirement presents obvious advantages to the equipment designer. Two tubes in a push-pull or parallel circuit provide over 1½ kw of useful output power with less than 25 watts of drive.

4-1000A

Currently the largest of the Eimac tetrodes, its pyrovac plate is rated at 1000 watts dissipation, the 4-1000A has the inherent characteristics of all Eimac tetrodes—dependability, stability, optimum performance and economy of operation. Type 4-1000A is ideally suited for high-level audio service as well as r-f applications.

Complete data on these tetrodes and other Eimac tube types may be had by writing direct.

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TUBES
The Power for R-F

this issue, back in the "News of the Industry" department, on p 148).

Television Tomorrow: NBC's Frank Mullen thinks that television, in all its branches, will someday contribute as much as $6,000,000,000 to the national economy in a single peak year, providing employment for 250,000 people.

Philco's Larry Gubb believes that $5,000,000,000 will go into television in the next few years for the building and equipping of stations and networks and for the purchase of receivers.

Television Broadcasters Association comes up with this prediction of station equipment and receiver production:

	1948	1949
Stations	$10,350,000	$12,000,000
Receivers	387,000,000	460,000,000
	(750,000)	*(1,106,000)*
	$397,350,000	$472,000,000

It Is Generally Known that television receivers using cathode-ray tubes having screens 7-inches in diameter and smaller have not sold well by comparison with those employing screens 10-inches or more in diameter. What has not been known is whether this means that the 10-inch type provides the smallest picture with which the public is content, or that the price differential has so far been too small.

The point is about to be clarified. quite a number of television receivers having cathode-ray tubes 7-inches in diameter are now coming on the market, at prices down near the $200 mark.

Baby Sitters in Chicago are refusing to do their stuff unless the home is equipped with a television receiver, according to *Tide.*

Radioactive Isotopes have an important future in industry as well as in research, but the speed with which they are adapted to manufacturing operations generally is largely dependent upon further reduction in cost.

Originally turned out by cyclotrons in quantities almost too small to be seen with the naked eye, such isotopes cost millions of dollars per gram. Today they may be produced by atomic piles for thousands of dollars. When someone finds a way to again reduce the cost by a factor of ten they will really come into their own commercially.

Employee Suggestions have saved General Instrument 730,000 man hours since 1944.

Writes R. W. Hutchinson of General Motors, Detroit, relative to our plea for more complete broadcast station weather reporting for small boat owners (November, p 77):

"Throughout the summer of 1947, WJLB offered a special weather report to small boats and small aircraft operating on the Detroit River, and in Lake St. Clair and Lake Erie. Temperature, pressure, relative humidity, ceiling, visibility, wind velocity, and wind direction were given."

Other stations please copy.

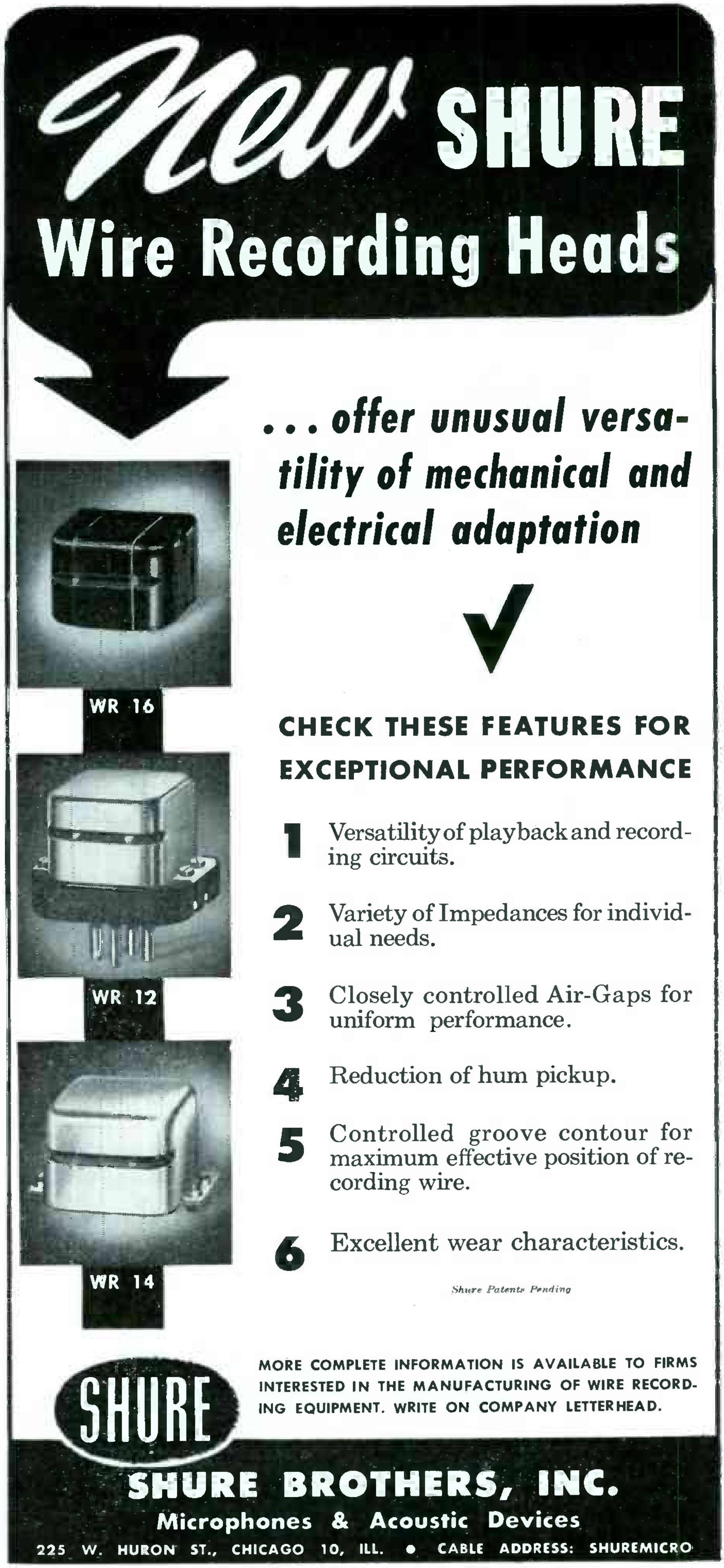
Marine Radar Licenses issued by the FCC, as of October 4 last, totalled 288.

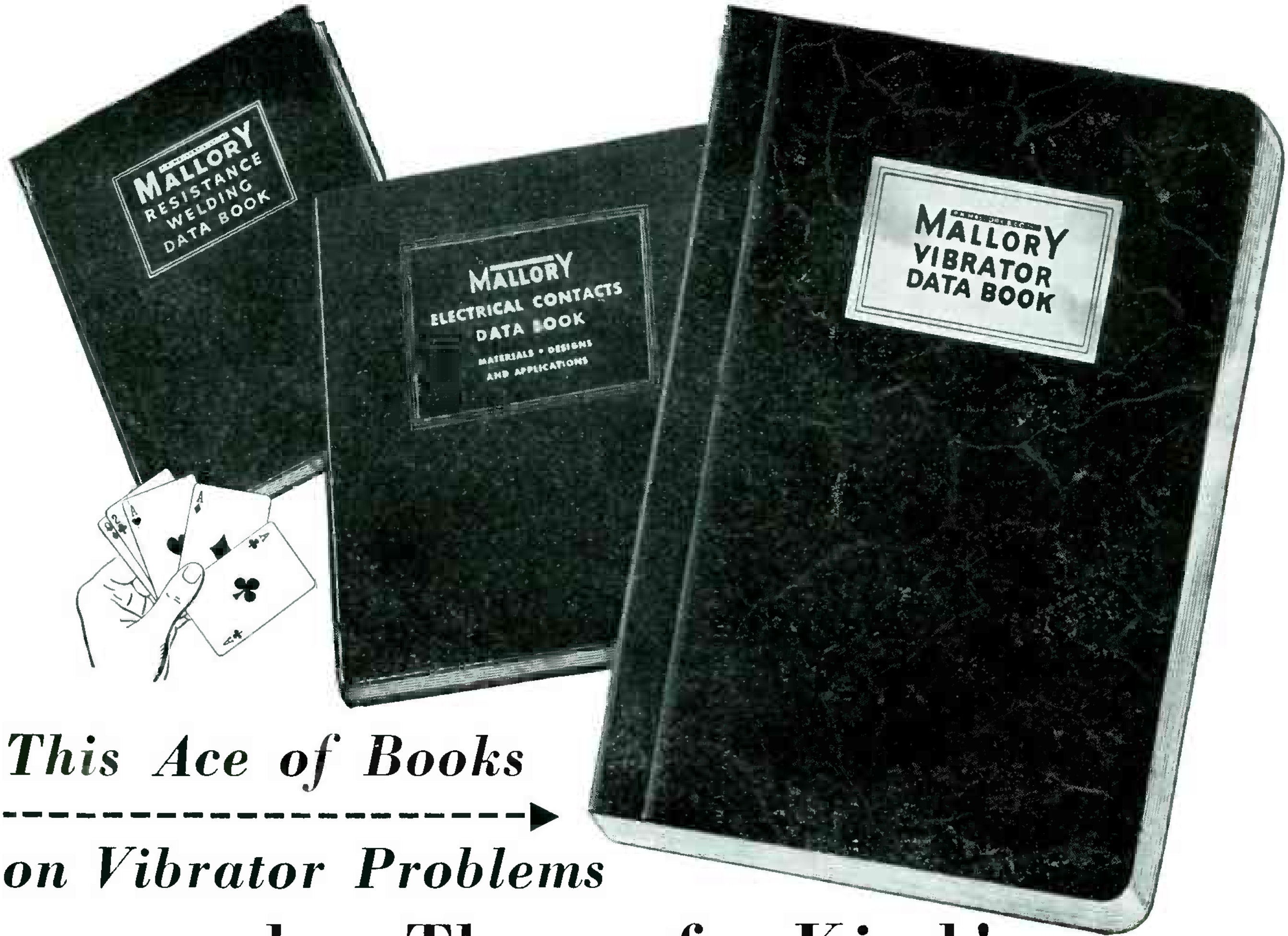
As Most Readers Know, we publish a special directory and buyers' guide issue each year. Work is already under way on the next one, scheduled to mail in mid-June.

Questionnaires have been mailed to all the manufacturers and consultants we know in the business, asking what products are made and what services rendered. If you are a manufacturer or consultant better check up around the organization to see if one has been received. If so, play safe and see that it is filled in and sent to us at once. If not, write directory manager Jack Quint.

Speaking Of The Directory, we think we have a particularly hot idea for the reference material this year, one that will make the book even more valuable than in the past to many readers. More later, when we've worked out the details.

Sign over market research department: *"What do you want to prove?"*





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CROSS TALK

▶ **BLIND** . . . A man's life was lost when a freighter rammed a tanker in fog off Point Sur, California, October 24th last. The tanker had radar, but her crew did not know of her danger because the oncoming freighter, by a misfortune fateful in its improbability, was within the radar shadow cast by the tanker's foremast, blanking out a three-degree sector. That such blind spots may exist was well known from wartime experience. But the crew either did not know about it, or discounted it because of the extremely narrow region into which they could not see. So one man died and many more barely escaped death. The moral is clear: when lives depend on electronic equipment, or any other type of equipment, the improbable contingency must not be discounted. When radar is used for running through fog, there must be *no* blind spot ahead, no matter how narrow.

▶ **WORDS** . . . We beg leave to add our weight to the growing dignity of two new words: kilomegacycle and electronism. The kilomegacycle (abbreviation kmc) is a real help in writing about the superhigh frequencies. Ten centimeters is 3 kmc, a somewhat neater designation than 3,000 mc. Electronism is a general term for any electronic device, in the same sense that mechanism applies to any mechanical device. When we first heard the word we thought it sounded somewhat stilted. When mechanism was a new word, 200 years ago, no doubt it seemed stilted, too. But it has a very useful place in the language today. As electronics takes its place alongside mechanics, electronism has its place.

▶ **LORAN** . . . The recent reallocation of frequencies has forced the Coast Guard to discontinue its experimentation with low-frequency loran on 180 kc and to begin new investigations in the vicinity of 100 kc. This lower frequency brings with it many new problems, and adds the burden of enlarging an already cumbersome antenna system. So it may be many months before the low-frequency version is ready for active use. Meanwhile it is a pleasure to report that the use of standard loran on 2 mc grows apace. Nearly 1,000 scheduled transoceanic flights per month are made with loran by ten or more international airlines. And scores of merchant ships use loran regularly. It is to be hoped that the Coast Guard will secure, in its forthcoming appropriation, the necessary funds to maintain this vital service.

▶ **SMELL** . . . We've heard some stunning theories in our time, and once thought we could pick the wheat from the chaff. But we give up. From an impeccable source, Professor W. R. Miles of Yale University, we have it that the sense of smell is closely akin to radar. Professor Miles, speaking before the National Academy of Sciences, reveals experiments with roaches and bees which show that these animals detect odors by means of electromagnetic radiations in the infrared region, from 8,000 to 10,000 millimicrons. Roaches have a particular predilection for oil of cloves. Placed in a hermetically sealed container, this substance caused roaches outside the container to react with a characteristic motion of their antenna. With an opaque infrared filter in place, or with the chamber evacuated, the antenna relapsed into the heterogeneous activity of a non-smelling roach. With the filter removed, the characteristic motion recommenced. Similar experiments with bees, using honey as the odor source, show the same results. Honey behind an airtight window, which passed the infrared rays, attracted the bees; an identical window opaque to infrared went unnoticed. All of which would indicate that our insect friends were smelling infrared vibrations. But Dr. Miles says that, in reality, the insects are sending out infrared radiations from their olfactory organs, thus heating the smelled substance and causing it to return a complex spectrum of infrared which permits identification of one substance from another. It appears that the human nose also operates in this fashion. The final item was the one that forced us to give up: seven males of a rare moth species were released from a train at seven points one mile apart. Within hours, all seven had found a female of the species who was, at the time, languishing in a hermetically sealed tube. Fantastic!

One of the P-80 jet-powered airplanes used in trials of new AAF speed course. New AAF streamlined localizer receiver antenna, a part of the airborne speed-measuring equipment, is installed beneath the nose

Precise Measurement

WITH the military trend toward speeds approaching the transonic and supersonic ranges it becomes of increasing importance to provide an accurate means of measuring true airspeed. Prior to the war, performance guarantees made by contractors were based upon the contractor meeting his estimated high speed within 1 percent. This requirement was waived during the war, but reinstatement is anticipated. It is also of vital importance to know the exact maximum speed of new-type aircraft to evaluate new designs properly.

Airspeed Measuring Methods

The airspeed system is susceptible to instrument errors, position errors, and compressibility errors. The present and most accurate system of airspeed measurement is based on the relation of the total and static pressures to the true speed of the air stream. In order to calibrate this type of system it is necessary to know the error obtained in measuring the true static and total pressures relative to the free stream conditions. This error, which is commonly called position error, is primarily a function of angle of attack and Mach Number (relation of speed of aircraft to speed of sound at location of aircraft). Since sonic velocity and dynamic pressures decrease with altitude, the highest Mach Number will be reached at the highest altitude. It is necessary, therefore, to obtain calibrations at these high altitudes and high Mach Numbers.

Various methods for true airspeed measurement at high altitude have been proposed and devised, few of which have shown any promise. Radar tracking units set up from standard Signal Corps stock equipment have proved only moderately successful. Results in level-flight tests from calibrated ballistic cameras have proved them to be too unwieldly for flight test work. The recently developed Army Air Forces all-altitude speed course is the only known successful means

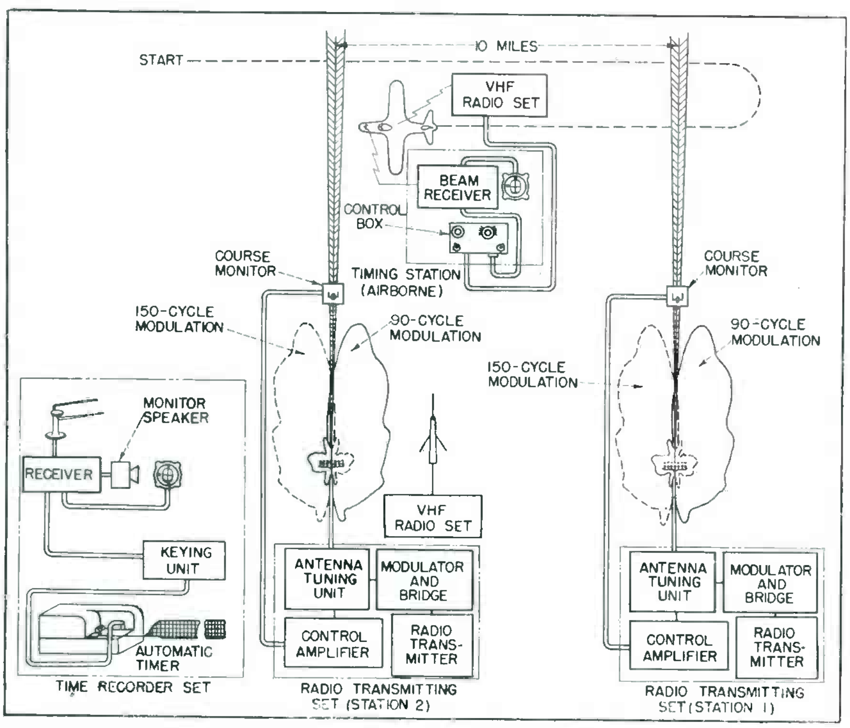
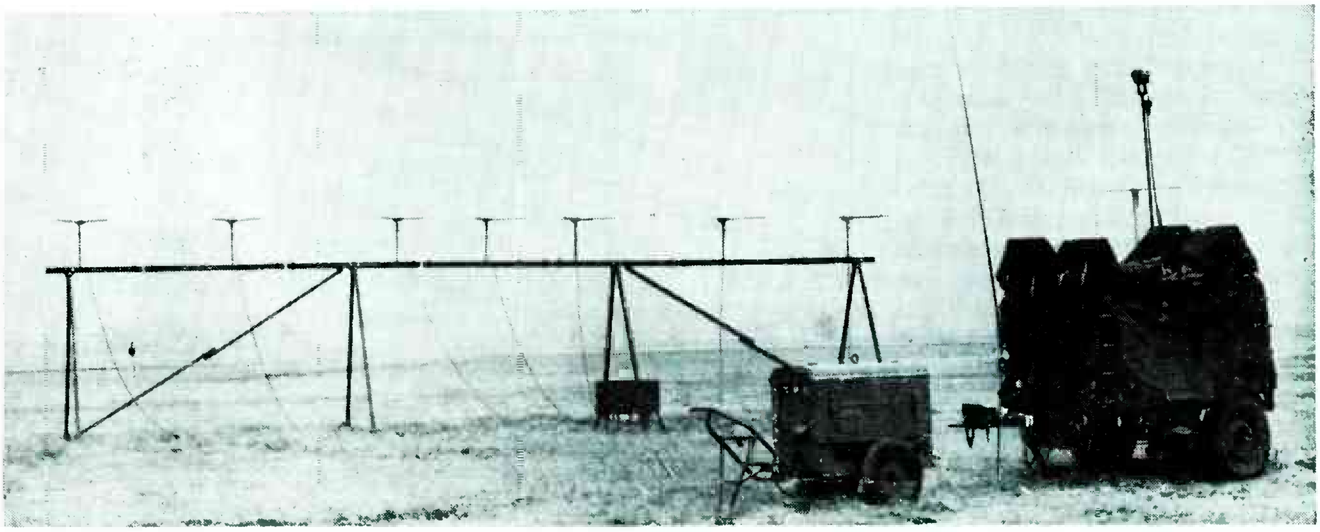


FIG. 1—Block diagram showing relationship of airborne and ground units of new AAF all-altitude aircraft speed course



Trailer-mounted localizer (radio set CRN-10) set up for operation at Wright Field as part of AAF instrument approach system. In slightly modified form, this same equipment is used for beam production in the new AAF speed course

# of Aircraft Speed

New AAF system for measuring true airspeed employs two modified instrument landing beams to create equisignal vertical planes ten miles apart through which an airplane can fly at any altitude. Airborne radio equipment sends signal to ground receiver and electronic chronograph at instant of passage through each beam

By CHARLES S. FRANKLIN

Radio Engineer and Chief of Instrument Landing Unit
Communications and Navigation Laboratory
Electronic Subdivision, Engineering Division, Air Materiel Command
Wright Field, Dayton, Ohio

at present of obtaining calibrations at high speeds and at high altitudes with the accuracy required by the Army Air Forces.

The Army Air Forces all-altitude speed course is defined by two parallel radio beams a fixed distance apart. The test airplane flies at the desired altitude and on a heading perpendicular to the two beams. True ground speed is obtained by measuring the elapsed time required for an airplane to fly this known distance.

Ground Station Transmitters

Ground radio transmitting equipment consists of two radio transmitting sets. This equipment is similar to instrument landing system (ILS) beam transmitters which were originally designed to serve as multifrequency instrument landing localizers. Each set is essentially a radio transmitter and a radio-frequency radiating system as shown by the block diagram in Fig. 1. The desired frequency is obtained by inserting an appropriate crystal unit and retuning the transmitter circuits.

The radio-frequency section essentially consists of a crystal oscillator-tripler stage, a first multiplier (tripler) stage, a second multiplier (doubler) stage, and a straight power-amplifier stage. The power-amplifier stage employs two tubes in a push-pull class C circuit arrangement, and is capable of delivering approximately 100 watts of unmodulated radio-frequency energy.

Before this energy can be made to produce a course, it must be modulated, phased, and fed into the radiating system. It is the function of the cross-modulation bridge and mechanical modulator to divide the energy from the transmitter into two equal portions, modulate one part at a frequency of 90 cycles per second, the other part at a frequency of 150 cycles per second, and then recombine the energies to feed the antenna system for providing an equisignal vertical plane.

The cross-modulation bridge not only divides the power into two equal portions but also serves to prevent interaction between the two modulating troughs of the mechanical modulator. The antenna bridge serves to combine and deliver the proper amounts of carrier and sideband energy to the antenna tuning unit, from which it is passed on in proper amplitude and phase relation to all antennas. The antenna system is designed to function with three sideband antennas on each side of the center carrier antenna, the sideband antennas being energized with a phase difference of 180 electrical degrees.

Proper operation of the antenna array required that the inner pair of sideband antennas receive the largest amount of sideband power, the second pair much less, the third or outer pair still less, and each antenna of the pair must receive an equal amount. Each antenna element is essentially a dipole bent to an angle of 60 degrees, with a similarly-bent parasitically-excited director. The antenna radiates a horizontally polarized signal with a front-to-back ratio of 6 db in the horizontal radiation pattern.

The carrier power plus half of the sideband power is radiated by the center antenna. These radiations are in phase in all directions from the array. The remaining half of the sideband power is radiated by the three pairs of sideband antennas. The phase of these radiations is the same from 0 degree (on course) to 180 degrees and of opposite phase from 180 degrees to 360 degrees. Thus, it is seen that the sideband signals will add to the carrier signals on one side of course and subtract on the other side.

The sideband signals which consist of the 90-cycle and 150-cycle modulations are equally divided between carrier pattern and sideband pattern and are phased so that the 150-cycle modulated signal cancels, and the 90-cycle signal adds, to the right of course. To the left of course, the 90-cycle signal cancels and the 150 cycle signal adds.

The seven antenna arrays produce the radiation patterns shown in Fig. 1. The equisignal locus of the 90-cycle and 150-cycle modulation constitutes the course.

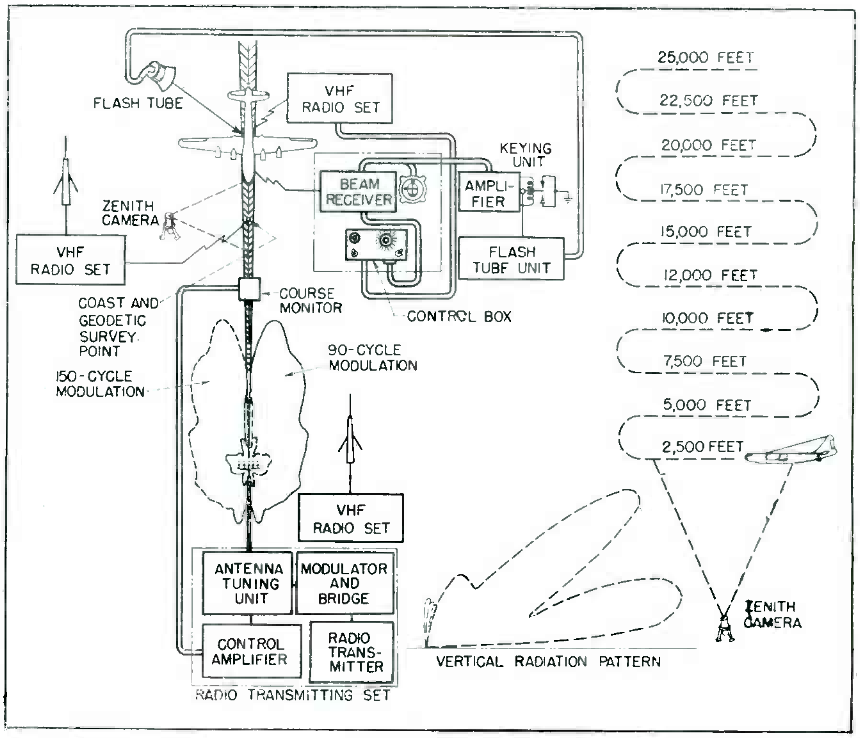
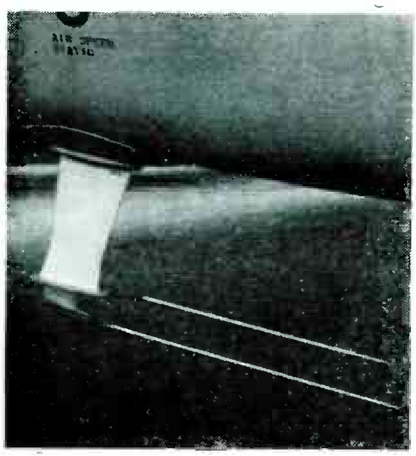
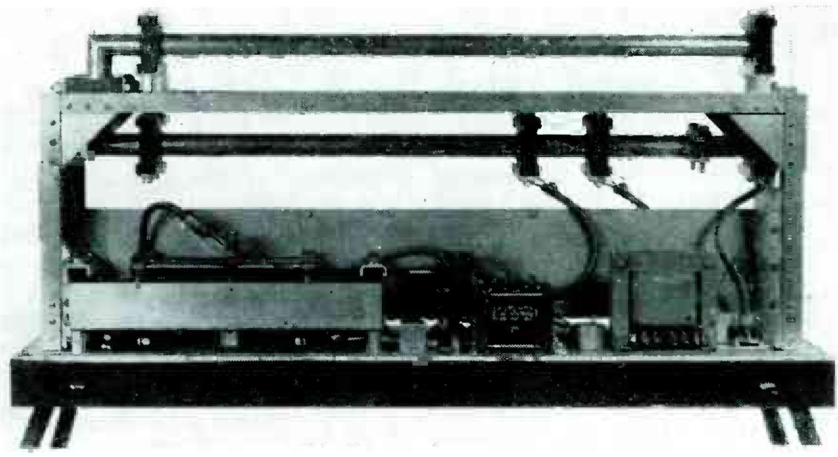


FIG. 2—Method of using flash tube in airplane and zenith camera on ground for checking alignment of ILS beam at various altitudes during initial calibration of speed course. Beam is adjusted for 5,000 feet and calibrated for other altitudes

A course monitor receiver is placed on the surveyed azimuth line at a distance of 400 feet from the transmitter. This receiver is a vhf crystal-controlled 10-tube superheterodyne. If the received signal consists of equal amounts of 90- and 150-cycle modulation corresponding to the equisignal locus, output from the two filters will be balanced and d-c output of the receiver will be zero. Any shifting of the course will result in an unbalance of the received 90- and 150-cycle modulation, with resulting d-c output from the course monitor receiver. This output is fed to an amplifier which converts the d-c to a-c and energizes a two-phase induction motor. This motor drives a sliding contact arm back and forth on a tuning stub which serves to shift the position of the equisignal locus. The direction of rotation of this motor is dependent upon the polarity of the monitor receiver unbalance and is always in a direction to reduce the unbalance to ± 1 microampere or to ± 1/150 degree course width. This



Closeup of new AAF streamlined localizer receiver antenna installed on P-80 for speed course trials



Tuning stub drive for shifting position of equisignal locus of beam automatically in response to d-c output of course monitor receiver, to maintain on-course beam position to within 8 feet at 12 miles from transmitter

method of course control is sufficiently accurate to maintain the on-course beam position to within ± 8 feet at a distance of 12 miles from the transmitter.

Airborne Equipment

Airborne speed course equipment consists of a timing station, the output of which is fed to vhf radio set ARC-3, as shown in Fig. 1. Radio receiver BC-733-D in the timing station is a 10-tube superheterodyne consisting of an r-f amplifier, an oscillator section, a mixer, two stages of i-f amplification, a second detector, an automatic volume control stage, an audio amplifier, a visual amplifier, and an output filter and rectifier section. This beam receiver also utilizes a bias oscillator as an isolated supply for negative voltage.

After amplification in the beam receiver, the signal is fed to the second detector and avc stage where it is rectified and the audio component is recovered. The avc bias is applied to the r-f and i-f stages.

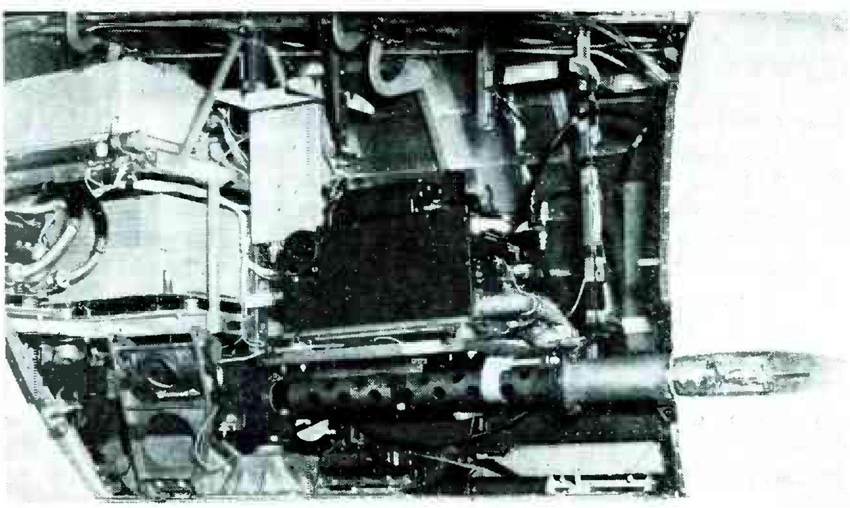
From the second detector the signal is fed simultaneously to the audio amplifiers (aural and visual). The output of the visual amplifier simultaneously passes through two 90- and 150-cycle band pass filters and is rectified. The two resulting d-c outputs oppose each other in the visual indicator circuit. If the two outputs are equal, current to the cross-pointer indicator will be zero and the vertical pointer will remain centered; any difference in the relative 90- and 150-cycle filter output will cause an unbalance that will cause the needle to deflect to one side or the other.

The audio output from the aural output stage passes through an equalizing filter in the control box of the airborne timing station, and is transmitted to the ground timing station by means of vhf radio set ARC-3. A switch on the modified control box, labeled Communication—Speed Course, is used to switch the vhf transmitter input from the conventional microphone circuit to the audio output of the beam receiver.

Time Recorder

The modulated 90- and 150-cycle signal transmitted from the test airplane is received by the time recorder set located at station 2. Radio receiver BC-733-D here is identical with the airborne beam receiver except that it operates on a frequency corresponding to the carrier frequency of the airborne vhf transmitter. The combination of airborne vhf transmitter and ground beam receiver merely serves as a means of telemetering the radio beam signal from the test airplane to the ground.

The sensitivity adjustment of the visual output stages of both the airborne and ground beam receivers is set at near maximum value in order to obtain an over-all course width of 2 degrees. The beam course width of 2 degrees corresponds to a receiver output of + 150, 0, − 150 microamperes. A sensitive relay that makes contact at ± 2 microamperes is placed across indicator I-101-C or ID-48/ARN. When the test airplane passes through the on-course position this relay operates and momentarily ungrounds the output of an oscillator, thereby serving to trigger the electronic chronograph.



Installation of beam receiver (black box at center of opening in fuselage) used in speed course trials. This radio receiver BC-733-D feeds the airborne vhf radio set through the airborne timing station to actuate ground timing station equipment

A monitor loudspeaker system can be used either for receiving voice or course modulation from the vhf airborne transmitter or it can alternately be employed to monitor the 1,000-cycle signal used to trigger the chronograph. This latter equipment records impulses on paper tape which serve to indicate the elapsed time required for the test airplane to traverse the distance between the two beams.

The chronograph is built in two sections. One section contains a hermetically sealed 240-cycle tuning fork which is sustained in oscillation by means of feedback from a 2:1 stepdown multivibrator stage. A second 2:1 multivibrator stage reduces the 120-cycle energy to 60-cycle energy, which is then amplified sufficiently to drive a small synchronous motor. This motor in turn drives both a paper feed sprocket drum and a 360-degree spiral stylus.

The second section of the chronograph consists of a 65-db audio amplifier stage preceding a thyratron tube which, when conducting, discharges a capacitor through the printing mechanism. The printing mechanism momentarily presses the moving paper against an inked ribbon and the rotating spiral stylus, thus recording the triggered pulse as a dot. The paper tape moves at the rate of 1 inch per second and can be read to 0.01 second and estimated to ± 0.001 second. The tuning fork is accurate to 1 part in 100,000 and has a temperature coefficient of 0.5 part in 1,000,000 per degree C.

Azimuth Alignment

An all-altitude speed course becomes valuable only after it has been demonstrated that accurate results will be obtained from its use. Consequently, it is of vital importance that an exact azimuth alignment be established and maintained and that the position of the on-course indication at all usable altitudes be known. This latter factor can be considered as a determination of the characteristics of the vertical plane of the two end beams, such as whether or not they are true planes and whether they possess any lean. The accomplishment of this objective necessitated the development of special equipment and the working out of special techniques.

The initial azimuth adjustment is made by lining up each of the beam transmitters with their respective course monitors. While this method alone results in a good approximation, it is not sufficiently accurate nor is there any proof of exact course alignment in the region where it is to be employed.

A very satisfactory method of checking both azimuth alignment and course lean is by means of airborne flash tube equipment and a zenith camera located at surveyed ground positions, as indicated in Fig. 2. The flash tube employs a xenon gas lamp that can be triggered on and off depending upon the position of the airplane relative to the course. The zenith camera provides an accurate method of recording the triggered light flashes and computing deviation from surveyed ground positions.

The output of the beam receiver is fed to an amplifier, the output of which operates a polarized keying relay. This relay grounds the output of the oscillator-keyer except when the airplane is on-course or very near the on-course position.

Flash Tube Unit

When the output of the oscillator-keyer equipment is ungrounded, the flash tube unit is automatically keyed at a selected rate of from 1 to 6 times per second. This is accomplished by grounding and ungrounding the grid of a strobotron tube which, when ungrounded, permits the spark coil to function as a gas igniter. Instantaneously following the ignition of the gas tube, a capacitor charged to a high voltage discharges through the flash tube, thus providing the required energy for a high-intensity flash having a duration of approximately 200 microseconds.

A zenith camera, as its name implies, is one designed to photograph objects directly overhead. It employs a 24-inch f/6 camera objective and records the image on a 4 x 5-inch plate. The camera can be leveled precisely to an accuracy of the order of one second of arc by means of a mercury-pool artificial horizon reflecting an image of a cross wire in the levelling eyepiece formed by an optical collimating system. On each photographic plate an image of these cross wires is impressed by the collimator system to designate the exact optical center of the plate. This optical center is stationed directly over the Coast and Geodetic surveyed point located exactly on-course and approximately 12.5 miles from the beam transmitter. The accuracy of measurement of position of the airborne flash tube at an altitude of 10,000 feet is of the order of two feet.

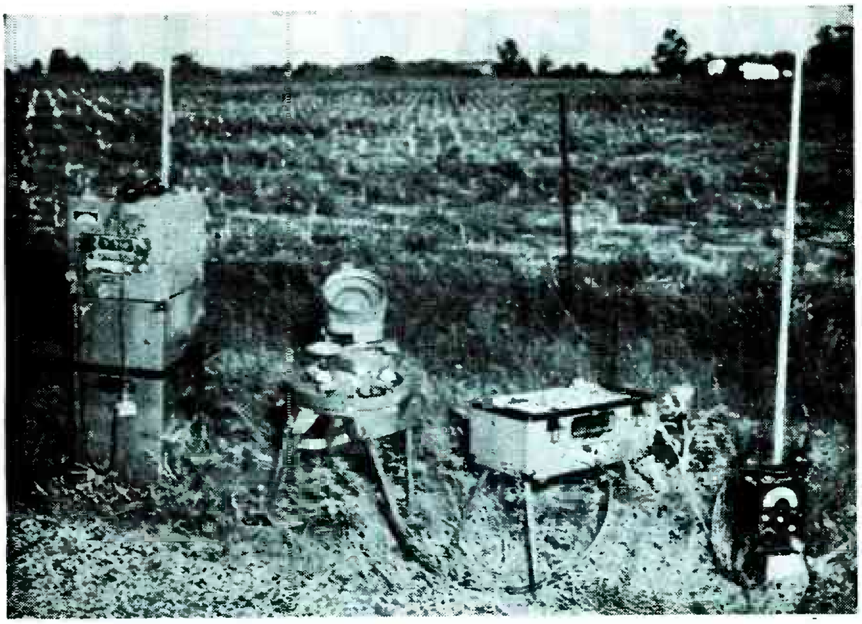
Precision electronic chronograph used to measure time interval between radio signals corresponding to passage of airplane through first and second equisignal beams

The airplane carrying the flash tube unit is equipped with an automatic coupling unit between the beam receiver and the automatic pilot, thus making it possible for the airplane to be kept exactly on-course or to slowly oscillate about this position. The test airplane is flown at night and the zenith camera shutter kept open during each flight. Since the flash tube unit operates only when the aircraft is exceedingly close to the on-course position, it follows that a centerline drawn through the recorded dots on the photographic plate represents the actual position of the on-course signal in space.

Initial Adjustments

Azimuth alignment is accomplished by determining the true position of the beam signal in the manner described, then shifting the course until its position coincides with the surveyed position. Zenith camera photographic plates are developed in the field, course deviation is quickly computed, and this information transmitted by radio to the beam transmitter where the course is shifted the desired direction and amount. The course monitor antenna, located 400 feet from the beam transmitter, is then moved to this established line-of-position and is henceforth used as an electronic benchmark to maintain azimuth alignment. Once the azimuth alignment is determined at the initial altitude of 5,000 feet, the test airplane makes passes at successive altitudes up to its ceiling. Zenith camera records of these flights plotted against altitude determine course lean.

Other important factors that enter into the accuracy of this system are siting, transmitter antenna alignment, receiver course centering, and the equalization of course width. In selecting sites for the beam transmitters, care must be taken to select level terrain free from reflecting objects such as buildings, trees, or power lines. Un-



Communication equipment for contacting test plane and beam transmitter personnel, and zenith camera used for azimuth and course lean measurements

less this is done it is possible that there will be bends in the course that will materially reduce the overall accuracy of the system.

The virtual origin of an antenna array is the point through which the equisignal locus passes. In placing the antenna array over the surveyed bench work, care must be taken to locate and align the virtual origin properly with the benchmark. All receivers are adjusted for centering using the same test set and making comparison with a selected standard. It has been found that receivers need only be periodically checked in order to maintain a satisfactory course centering adjustment. Time delays resulting from the receivers, relay, and associated equipment are constant and cancel out. Inasmuch as the recording chronograph is keyed slightly before the on-course position on the first beam, it is important that it be keyed the same amount before the on-course position on the second beam. In order to avoid any differential error resulting from different beam widths, both beam transmitters are adjusted to the same over all course width by varying the percent modulation.

Test Run Procedure

Making a test run on the speed course is a comparatively simple operation. The pilot first sets the channel selector on the control box to correspond with the frequency of the first beam to be crossed. After the test airplane has reached the desired altitude the pilot communicates with the ground operator located at station 2, announcing the first run. He then flips the toggle switch on the control box from Communication to Speed Course; as the airplane crosses the first beam on a heading 90 degrees to that of the beams, the ground chronograph will be automatically triggered and both the airborne and ground visual indicators will move from one side to the other, indicating that the first beam has been crossed. The pilot then changes the channel selector to the second beam, which when crossed automatically keys the recording chronograph a second time. Two passes are made in opposite directions in order to compensate for wind velocity. The elapsed time is read from the chronograph tape.

Accuracy of Measurements

Although several possible sources of error exist in the present all-altitude speed course, the total errors add up to considerably less than 0.5 percent. The heading of the aircraft over the course will not be exactly as desired, but it is reasonable to assume that its direction may be held with less than a three-degree variation. Any heading other than that which is perpendicular to the direction of the two beams will result in flying a longer course than that for which the speed is computed. Computed speeds will be lower than actual speed and will vary with heading as follows:

Heading Variation	Error in Computed Speed
1°	0.015%
2°	0.061%
3°	0.137%
4°	0.244%
5°	0.381%

Distance between the two beams has been determined by a Coast and Geodetic Survey which is accurate to one part in one million. Because of the curvature of the earth, the two beams are not parallel, but spread apart slightly as a function of altitude and of beam separation. On the basis of a ten-mile beam separation, this spread with altitude amounts to 151 feet at an altitude of 60,000 feet. The beams are aligned and maintained to within ± 50 feet at a distance of 12.5 miles from the transmitter. On the basis of a course run of 10 miles and both beams off the maximum amount in opposite directions, this error amounts to 0.190 percent. The error introduced by chronograph timing is ±0.008 second. On the basis of a speed of 600 mph and a course run of ten miles, this error is 0.0133 percent, which is negligible. Using maximum errors that can be reasonably assumed, such as 3-degree variation in heading, beam alignment in error by 100 feet (two beams off in opposite directions) and a 0.008-second timing error, the maximum error on a basis of 600 mph and a run of 10 miles is 0.340 percent. The probable error is less.

It is contemplated that radar tracking equipment will be used to direct the pilot over the course at extreme altitudes and in times when visibility is restricted. Special radar equipment is being developed to accurately measure speed of aircraft in dives, pull-outs, and turns.

The all-altitude speed course is now in operation in the vicinity of Wright Field, and a second installation is scheduled for Muroc Army Air Field, California. These facilities are to be made available to all branches of the Armed Services as well as institutional activities such as the National Advisory Committee for Aeronautics.

UNDERWATER

Control panel employed up on the surface

The underwater television camera, inclosed in its steel cylinder. The glass porthole through which it operated may be seen in the cover

By CHRISTIAN L. ENGLEMAN
Project Officer, Bikini Scientific Resurvey
Captain, USN

OCEAN DEPTHS heretofore impenetrable to even the most skillful deep-sea divers may soon be open to scientific investigation and observation through the medium of underwater television.

At Bikini, scientists and military personnel during the past summer successfully used television at depths as great as 180 feet. Topside, aboard the control ship, observers watched the images of fish, portions of sunken ships, and divers, play across the television screen in newsreel-like sequence.

Naval airborne television equipment, built around the 2P21 multiplier-orthicon tube manufactured by the Radio Corporation of America, and modified for underwater application by the Cornell Aeronautical Laboratory, was used.

The Navy's interest in underwater television was twofold: First, it hoped to determine the feasibility of such equipment in undersea investigations; second, it was interested in testing the equipment as an aid to diving operations.

The equipment consisted of a straightforward television system using 350 lines per frame, no interlacing, and producing 40 frames per second. It provided a high order of response to low light levels.

Basically, the problem was to modify a television camera enclosed in a waterproof housing so that while resting on the lagoon bottom or suspended over a sunken object it could be adjusted for best optical and electrical performance by an operator at the surface.

Building the housing was relatively simple. A cylindrical container made of ¼-inch heat-treated mild steel with a tensile strength of 125,000 lb was designed. Overall measurements of the housing were 30 inches long and 17½-inches inside diameter. With all equipment installed, the housing weighed 250 lb. Underwater it had an actual weight of 65 lb. The camera was secured on six rubber insulation mounts to protect it from shock. A ¾-inch-thick plate-glass window in the housing constituted a porthole through which the camera televised underwater scenes.

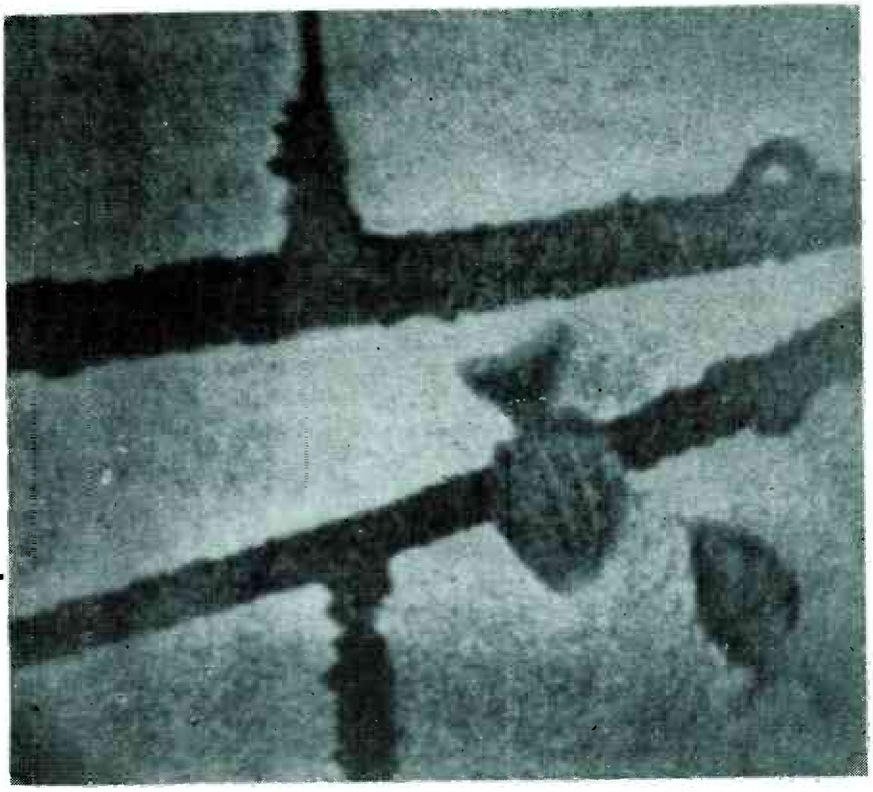
Three cables between the submerged camera unit and the control panel and monitor equipment on the surface entered the housing through separate sealing glands built into the rear of the housing. These glands were of a type similar to those used in naval mines during the war. The three cables consisted of, (A) a 19-conductor line that transmitted power and control voltage from the surface down to the camera unit, (B) the video coaxial line and, (C) the sync coaxial line. A supporting line (2,650 lb test) was married to the three cables.

Remote Control Focusing

The camera's focusing control was regulated remotely by means of an electrical mechanism. A worm drive, attached to a metal bracket secured to the camera lens, was geared to a reversible 28-volt d-c motor attached to the front of the camera. By means of a single-pole double-throw switch, direction of

TELEVISION

A camera, inclosed in a watertight cylinder and remotely controlled from the surface, was tested at depths down to 180 feet in Bikini lagoon. Future military, scientific, and commercial applications of the system are explored



Photograph made from the receiver screen during the Bikini test. Fish are seen passing over debris on the deck of a sunken ship

the current through the field winding of the motor could be reversed to change the direction of the rotation. A solenoid-released friction brake stopped the shaft from rotating the instant power was removed, insuring that the camera's lens would not be moved too far forward or too far back.

Adapting the camera for remote control required other modifications. These included orthicon target control, beam control, image focusing, orthicon focusing and multiplier focusing. Of these controls one, image focusing, was found to be quite stable and modification will not be required in future operations.

The remote-control television system required transmission of video and sync impulses over 400 feet of cable in contrast to the shorter lengths used in normal surface operations. To compensate for the attentuation, engineers designed and built a video-sync amplifier matched to coaxial cable type RG-41/U, with characteristic impedance of 68 ohms.

The unit included separate sections for the video and sync signals. Each section contained two stages of amplification and the video section had a cathode-follower coupling stage to effectively feed the input of the monitor unit video amplifier whose impedance was 200 ohms.

Electrical Problems

Primary source of power for the television equipment and its lights was to have been the ship's 120-volt d-c generator. Arrangements were made to decrease that power to the required voltages of 28 and 36 by means of a series of dropping resistors. For regulation, storage batteries were floated across the reduced voltage supplies.

It became necessary to abandon the idea of using the ship's power system because of circulating currents. The television unit required a ground on the negative side of the power line. Using batteries to supply all the power, it was noted that the electrical focus potentials drifted slowly as the batteries discharged and occasional refocusing was necessary. Effective stabilization of the focusing potentials in the camera and remote control circuits is a requirement for extended use of the system.

Object Lighting

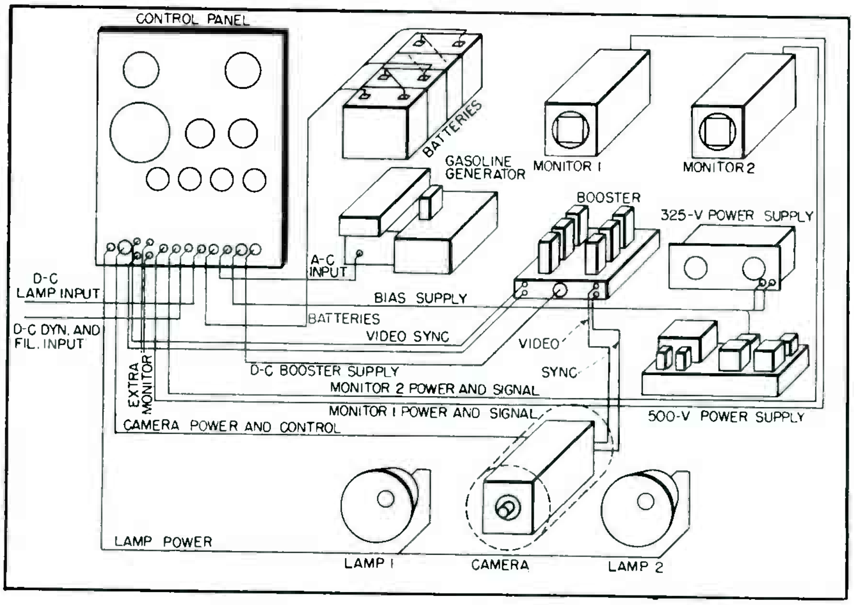
The original equipment used at Bikini had two 1,000-watt standard Navy diving lights, attached on arms protruding from the sides of the water-tight camera housing. These lights, operated from the ship's 120-volt d-c power system, were rigged through the remote control panel with rheostats capable of reducing intensity of illumination when necessary.

In the strong tropical sunlight and unusually clear water encountered in the central Pacific, diving lights proved to be unnecessary and were removed from the gear after two tests. However, from the experience gained in those tests, it was found that lights can be used

ROBOTS DON'T GET BENDS

Examination of submarine objects prior to raising, repair, or construction, is a difficult, slow, and often dangerous job for divers.

Preliminary studies of how things stand below can be accomplished by television, safely, and at great depths



Block diagram of underwater television system

most effectively if they are positioned so as not to illuminate objects suspended between the camera and the subject to be televised.

Camera

The camera used in the tests was equipped with an f/3.5 Woolensak vellastigmat lens. The camera had a maximum angle of view of 24 degrees across the diagonals of the image rectangle. This narrow field proved to be a hindrance in underwater work from the standpoint of orientation. An angle of 75 degrees would have proved more practical.

The maximum distance the camera was designed to cover was 20 feet. However in tests on the sunken submarine Apogon the equipment photographed objects 30 feet away and transmitted images clearly.

The remote lens-focusing controls, regulated from the ship, operated too slowly to hold a swimming fish in focus. However, there is no mechanical reason that would prevent an increase in the focusing speed. A more satisfactory solution would probably be an increase in sensitivity of the pickup tube to allow the lens aperture to be stopped down, with resultant increase in depth of focus.

Test Results

Five underwater television tests were conducted with the equipment, in weather varying from cloudy overcast to bright sunlight and in depths of water from 80 to 180 feet. In one test two cameras were used, one resting on the deck of a sunken ship and the other suspended above the deck and focused on the other unit.

One of the senior scientists participating in the Resurvey, sitting in front of the monitor screen in the afterhold of the control ship, was able to identify and accurately catalog several dozen varieties of fish photographed by the camera in the depths of the lagoon.

The television unit's green screen took on the appearance of an aquarium window whenever fish chanced to swim past the lens of the underwater camera.

Military Possibilities

Remote-control television, as demonstrated at Bikini, has many possible adaptations of military significance, particularly in submarine salvage work.

Cameras focused on the hull of a sunken ship could, if properly lighted, within a short time project a picture of damage to the screens topside for technicians to study. Relying on the eyes of the submerged cameras, experts could formulate a workable salvage plan in a minimum amount of time. In subsequent operations television would be invaluable in checking results and reporting salvage progress. It would also permit surveys for longer periods of time at extreme depths than is possible through the use of divers.

It is within the realm of possibility that television could provide an eye-on-a-stick method for quick and accurate examination of underwater portions of a ship's hull even when that ship is at sea. The equipment's possibilities in bottom examination of harbors and channels, provided proper lighting methods can be achieved, are unlimited.

Commercial Uses

In the field of science, underwater television opens many new channels of investigation. Marine life conceivably can be studied in water depths never before penetrated by man.

Geologists look upon the equipment as a potentially useful tool in conducting underwater studies of bottom formations and submerged reef areas. To oceanographers television has many possible uses, particularly in the study of currents at varying depths.

Several possible commercial adaptations can be anticipated. Salvage companies will find underwater television as useful to them as it promises to be to the military. In harbor work or other engineering or construction projects, where undersea examination is necessary, it can provide a fast and comparatively easy method of conducting extensive subsurface examinations.

Acknowledgments

Credit should go to the Physics Department of the Cornell Aeronautical Laboratory, Buffalo, N. Y., including particularly Karl D. Swartzel, Lloyd R. Everingham, Richard E. Frazier, and John P. Gould, who worked at Bikini; and Charles Kiefer, James W. Ford, Edwin Lindsay, John Haldane, and Harry Iddings, who planned and directed much of the modification work. Charles Stec, of the Bureau of Ships, Navy Department, and others in his organization contributed much in planning the modifications, procuring equipment, and facilitating test operations. Fred Ewing, Lt. Comdr. USN, Officer-in-Charge of undersea investigation of target ships for the Bikini Resurvey, directed the tests from the U.S.S. Coucal.

Superregenerative Circuit Applications

Survey of equipment utilizing superregenerative circuits includes iff gear, telemetering systems, radar beacons, remote-control devices and f-m receivers. Difficulties in analyzing basic circuit performance necessitate the empirical design considerations outlined here

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THE TECHNICAL TERM superregeneration was introduced in 1922 by E. H. Armstrong, who is also credited with the invention of the superregenerative receiver[1]. In simultaneous work, other engineers utilized the basic concept of superregeneration, intentionally or unintentionally, as illustrated by the contemporary patent literature. The collected patents and the few papers published outline the history of superregeneration up to the beginning of World War II. During the war, the most important applications were classified. Consequently, the war archives of the U. S. Government are now the repository of the complete and accurate story of the development.

Superregeneration can be defined as the condition in a regenerative system that produces a growing transient of oscillation, prevented from becoming a sustained oscillation by means of a repeated quenching action. The envelope form and repetition rate of the transient or wave train depend upon the initial conditions, which may be controlled by a modulated wave in such a manner that later rectification of the transient yields the modulation signal. Simplified diagrams of self- and externally quenched superregenerative detectors are shown in Fig. 1.

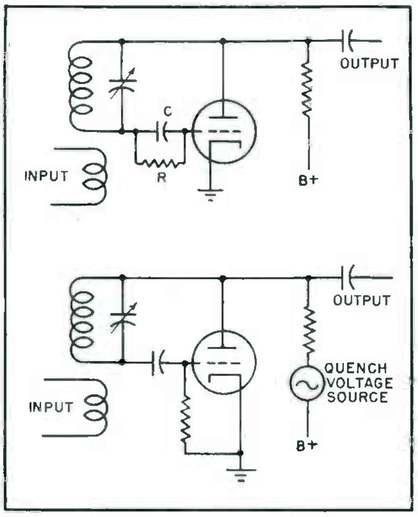

FIG. 1—Simplified circuit diagrams of basic superregenerative detectors. Relation between *R* and *C* permits periodic blocking in self-quenched detector (top); oscillation in externally quenched detector (bottom) is turned on and off by separate quench-voltage source

An equivalent circuit can be drawn for the superregenerative detector, taking into account the inductance, capacitance, and resistance of the tank circuit, the varying impedance presented by the periodically quenched tube, and external impedance introduced into the circuit, as for example, reflected antenna impedance. Then, if a signal voltage is assumed to be impressed on the circuit, one can write a differential equation involving the instantaneous tank-circuit current and its derivatives. Finding solutions for this nonlinear differential equation is a difficult process, a fact that has hindered the superregenerative receiver designer.

The complexities that arise in a rigorous mathematical treatment of this extremely nonlinear type of circuit may be bypassed by the use of graphical methods related to bench measurements. These methods are similar to those employed in the treatment of class-C amplifiers, large-signal detectors, and frequency converters. In many special phases of the general problem, however, advanced analytical methods are justified.

Many of the design requirements are contradictory to one another, so that the final design must often be a poor compromise among high sensitivity, high selectivity, high fidelity, efficient avc operation and fast recovery time. One reason for this vagueness in design is that not enough is known about the basic mechanism of superregeneration. The sometimes unpredictable behavior of these circuits is often due to incomplete information about circuit and tube fundamentals, such as the variation of effective dissipation during the quenching cycle, the influence of circuit Q, and the effect of variation of tube coefficients.

Inherent Noise

Although the superregenerative receiver is famous for high gain, its noise-muting sensitivity generally is not high enough. In addition, the characteristic noise produced in the

OLD IDEA, NEW INTEREST

Wartime research produced wide military applications of superregenerative circuits. As a result of this experience, they are again being studied, this time for possible use in f-m reception.

The author reviews some applications of these circuits that are now unclassified, and points out problems yet to be solved if their full utility is to be realized

From a lecture on Superregeneration, National Convention of IRE, New York, March 3-6, 1947.

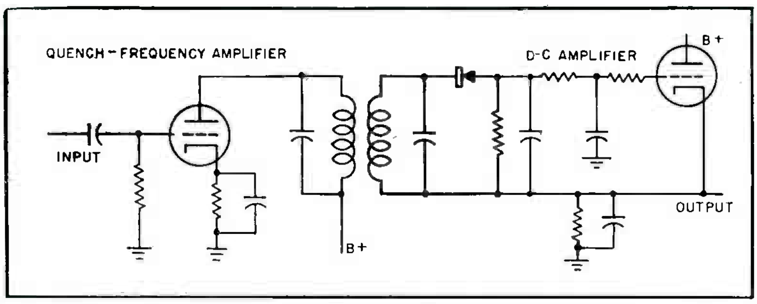

FIG. 2—Automatic gain stabilization (ags) circuit. When superregenerative-detector bias voltages drift, this feedback circuit acts to correct the deviation

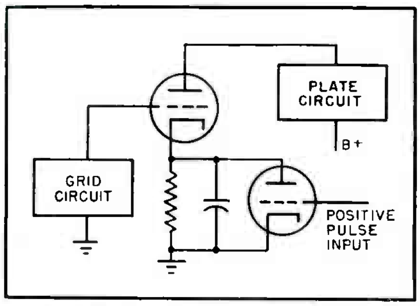

FIG. 3—Positive pulses fed to righthand triode speed transmitter-circuit recovery

superregenerative circuit in the absence of a signal or in the presence of a weak signal, is a serious defect. Such noise can be reduced by automatically or manually lowering the sensitivity of the circuit. Unfortunately, the use of a preamplifier does not generally improve the signal-to-noise ratio as shot effect and beating of an incoming signal with noise components reduce the noise-muting sensitivity to about the same value as is obtained without the preamplifier.

Radiation

Radiation is a typical defect, particularly noticeable when several superregenerative receivers operate close together. These effects can be minimized by reducing antenna coupling, quench-frequency voltage amplitude, and amplitude of oscillation. Such ameliorating changes generally result in poorer operation in other respects. A preamplifier ahead of the superregenerative circuit will reduce, and in some cases almost eliminate radiation.

A frequency converter can precede the superregenerative circuit to act as a buffer. Such an arrangement may not appreciably reduce radiation because of the recombination of sum and difference components inherent in a converter.

Bandwidth

Inherent avc in superregenerative circuits regulates the gain when the circuit is detuned from the mid-frequency of a given signal. This and other effects generally cause poor selectivity at medium and high frequencies. Multiple-resonance phenomena cause broad and nonuniform response, although this is not necessarily a disadvantage in some applications.

The quench frequency required increases with carrier frequency. Accordingly, the absolute bandwidth increases with carrier frequency. The important characteristic, however, is the bandwidth relative to the signal frequency. In general, a superregenerative receiver can be said to compare more favorably with other receivers at higher signal frequencies.

High distortion is a classical limitation of superregenerative circuits, particularly in logarithmic mode. Since the output of the superregenerative detector varies logarithmically with the degree of modulation of the signal, volume expansion occurs when the modulation rises above approximately 60 percent. This effect is undesirable in communications and broadcast receivers. In pulsed systems, distortion of the pulse shape occurs, limiting accuracy of triggering and coding and inhibiting fast operation.

Sources of Instability

Changes in antenna loading, which can occur when rotational antennas are used, as well as changes in the loading presented by the video or audio amplifier coupled through a rectifier to the oscillating circuit, can inhibit the superregenerative action.

In pulse reception, the sensitivity of the superregenerative circuit must be closely controlled so that uniform response to incoming pulses is secured and operation on weaker pulses and disturbances avoided. This control is accomplished by the automatic gain stabilization (ags) circuit, an example of which is shown in Fig. 2. The ags circuits regulate the amplitude of the noise-initiated oscillations by controlling either the bias of the superregenerative circuit or the quench-voltage amplitude.

The superregenerative circuit is subject to a number of forms of instability. One undesirable form is jitter, encountered in pulse reception and transmission circuits. Jitter is characterized by a nonuniform starting rate of the oscillation wave trains. Even slight mismatching between antenna and line, or line and receiver, can cause such disturbances because of reflection of wave-train oscillations at the point of mismatch. When the reflected oscillations arrive at the receiver, they start an additional wave train which interferes with proper operation of the receiver.

Centimeter-Wave Operation

In the centimeter-wave region, lighthouse tubes, reflex klystrons and magnetrons permit superregenerative operation and provide useful signal reception. At these frequencies, however, such receivers have serious limitations, such as high noise level and the need for extra tubes for control purposes.

The superregenerative receiver can be considered as an intermittently operating transmitter, and indeed the receiving-tube circuit is frequently used for transmission in transmitter-receiver equipment. Although such a design reduces size and weight, it has many shortcomings, particularly when the transmitter and receiver must be tunable within different frequency bands and when the transmitter must operate with high frequency stability. Automatic gain stabilization may not be applicable for pulse reception in a superregenerative transmitter-receiver because of troublesome time constants in common circuit elements.

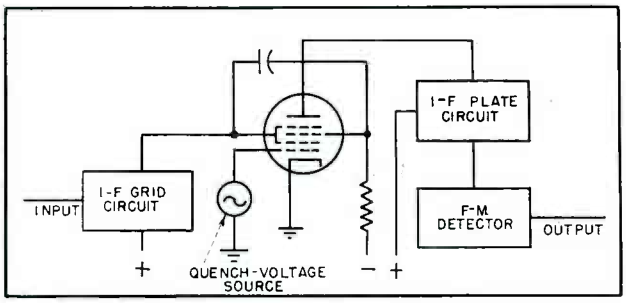

FIG. 4—Superregenerative i-f limiter circuit. Quench voltage of suitable waveshape permits nearly complete limiting

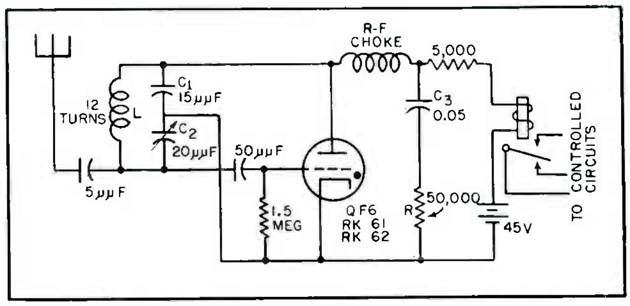

FIG. 5—Typical superregenerative gas-tube circuit affords compact, lightweight means of actuating relay by radio signal

Beacon and iff equipment, utilizing a common, transmitter-receiver, superregenerative circuit, may have a period of insensitivity, or dead time, amounting to several milliseconds following reply to a challenging signal. This large dead time is caused in part by the use of a single tube for receiving and transmitting. Fast-operating circuits have been designed to remedy this condition and can be arranged, for example, rapidly to discharge transmitter bypass capacitors, as shown in Fig. 3. The need for fast recovery enters into many applications of superregenerative circuits and is sometimes one of the hardest requirements to satisfy.

F-M Circuits

Superregenerative circuits can be utilized in many different ways for f-m reception, but not always with advantage. Slope detection can be utilized but may produce an undesirable form of the multiple-resonance curve and the response of the circuit to amplitude variations. For f-m receiver applications, a converter can be used to obtain an i-f that is higher than the frequency of the incoming signal, and a superregenerative amplifier can then be utilized in a lock-in type of circuit. A second converter provides the following discriminator with an input of sufficiently low frequency. Possibilities exist for developing good superregenerative f-m receivers, based on simplification of the designs suggested here, or on other approaches.

The use of superregenerative amplifier circuits as either r-f or i-f limiters in f-m receivers is of particular interest. An example of such a circuit is shown in Fig. 4. By the use of special quench wave forms, practically complete limiting can be obtained.[2] Cascade circuits with a second, time-delayed, superregenerative amplifier have proven useful. All these circuits operate on the basic principle that the percentage of a-m appearing in the r-f output of a superregenerative amplifier will be smaller than that existing in the incoming wave.

Gas-Tube Relay Circuits

Properly modified superregenerative circuits of conventional form are used to operate relays, particularly for the control of target aircraft. Superregenerative gas-tube circuits, using thyratrons, are also used for similar purposes, but have the following limitations: unreliable control due to lack of precision in gas-tube operation, dependence of tube on ambient temperature, critical bias voltages, and short tube life. Hard-tube superregenerative circuits can be designed to give sufficient plate-current variation with a small interrupted signal, or for a given amplitude or frequency change in a c-w signal.

Figure 5 shows a circuit diagram of one form of modern gas-tube superregenerative relay.[3] The tube in combination with the plate-voltage source, resistor R and capacitor C_3 constitutes an a-f sawtooth oscillator. Normally, a relatively large d-c flows through the relay winding and keeps the relay energized. In addition to its sawtooth oscillation, the tube also quenches at a superaudible rate, and therefore maintains an average negative potential on its grid. A third oscillation is present in the tank circuit L, C_1, C_2, consisting of wave trains of constant energy. When a sufficiently strong signal is impressed on the tank circuit through the antenna, the wave-train energy and repetition rate change so as to make the grid slightly more negative. This change in grid voltage prevents the tube from firing, so that the relay current drops to a very much smaller value, tripping the relay. The device can be operated with signal on or off for rest position of the relay.

Although small size and light weight are particular advantages of superregenerative circuits, their increasing use in balloon transceivers, guided missiles, and the like, now necessitates new inventions to reduce their weight still further.

The superregenerative circuit has important applications in remote control of missiles, telemetering of missile control data, target seeking, radar beacons, iff equipment, and a variety of circuits for remote control of switches and relays. Means for rapid coding, reception of secret messages, and insensitivity to certain types of interference and jamming are inherent advantages of the superregenerative circuit that are important for these applications. On the other hand, since such applications also give rise to more rigorous requirements on receiver stability and reliability under adverse weather conditions, the need for improvement in superregenerative receivers has become very great. A rich field for exploration is open here to the serious research worker and development engineer.

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(2) U.S. Patent 2,273,090, issued to M. G. Crosby.
(3) U.S. Patent 2,333,119, issued to R. H. Packard.

F-M Transmitter

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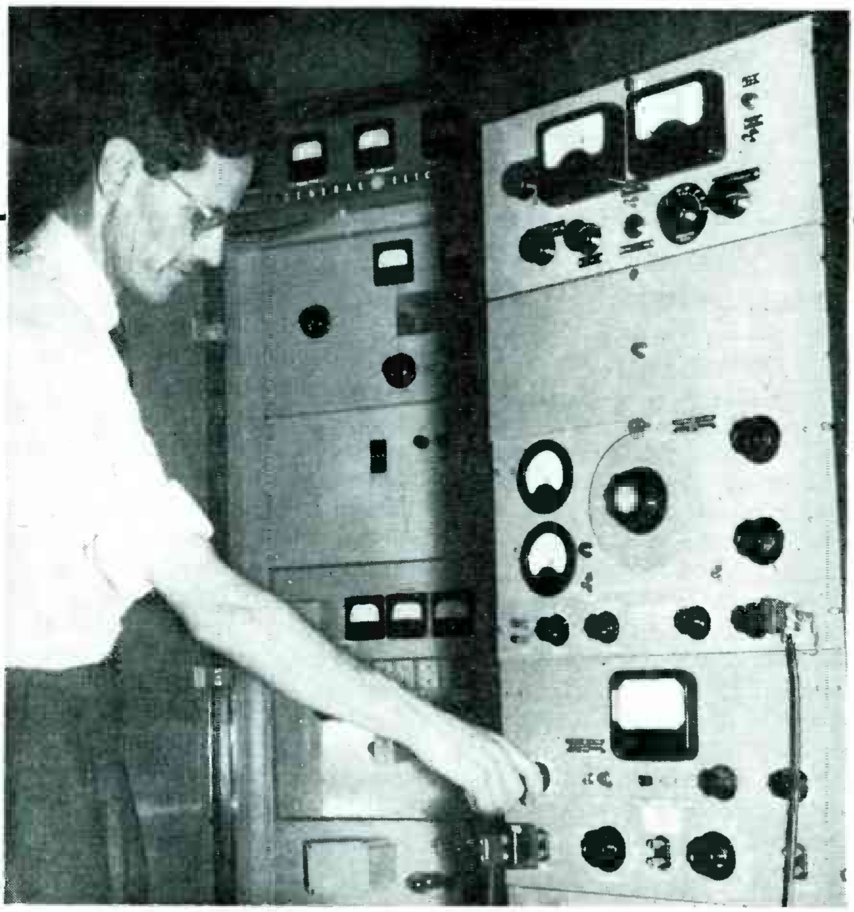

Rack containing complete equipment used for transmitter performance tests. Author Thomas adjusts the noise and distortion meter; above are the audio oscillator and f-m station monitor

THE PERFORMANCE of f-m broadcast transmitters is based primarily on the requirements of the Federal Communications Commission which specify the overall performance of the entire transmitting system from microphone input to antenna output. No definite portion of the total system degradation is assigned to the transmitter proper, although in the case of harmonic distortion it is recommended that the transmitter should not contribute more than half the total.

When the system is made up of studio equipment and some circuit such as a telephone line or radio link between the studio and transmitter it would be desirable to have the transmitter contribute less than one third of the total. The Radio Manufacturers Association has established minimum transmitter performance specifications which approach this degree of system perfection, as shown in Table 1.

Audio Input Signal

The equipment necessary in order to measure the audio frequency characteristics of the transmitter is shown as a block diagram in Fig. 1. The source of audio input must cover the frequency range from at least 50 to 15,000 cycles with low harmonic and hum output, and have an audio output level of at least +20 dbm (7.7 volts rms in 600 ohms). The output should be balanced to ground if a balanced input is to be used in the transmitter.

Following the audio oscillator some method must be provided of measuring input level, such as a calibrated vu meter or vacuum tube voltmeter that will read correctly at all frequencies from 50 to 15,000 cycles. This instrument should read over a voltage range of at least +20 to −10 dbm, or should be used in combination with an adjustable calibrated attenuator to give the same range of input voltages.

A pad of at least 10 db should precede the transmitter input in order to provide isolation between the audio input equipment and the transmitter input.

Output Detector

An f-m detector to convert the transmitter output to an audio frequency signal must be used to monitor the transmitter. This element of the measurement system is of considerable importance as it must have low harmonic distortion, low noise level, and a flat frequency characteristic in order not to affect the measurements of transmitter performance. There also should be sufficient limiting in the f-m detector to prevent small amounts of amplitude modulation of the transmitter carrier from affecting the readings. A minimum of 20-db limiting is considered necessary, and between 30 and 40 db is desirable. Fortunately, f-m station monitors are now available that have sufficiently good performance to meet the needs of this element of the measuring system, and since a station monitor is required equipment at every commercial f-m transmitter, it is normally available for measurement purposes. The use of the f-m station monitor also makes determination of the percent modulation of the transmitter very simple as a calibrated meter is provided which reads this value directly.

A de-emphasis circuit having the standard 75-microsecond time constant is necessary in order to translate back to a flat system. This is

Performance Measurements

Frequency response, harmonic distortion, a-m and f-m noise in f-m broadcast transmitters must be held within legal limits. Techniques of using standard test equipment in meeting FCC requirements for proper performance are described in detail

normally provided in the f-m station monitor, in which case it does not need to be provided separately.

Noise and Distortion Analyzer

The instrument for reading harmonic distortion and noise level at the output of the de-emphasis circuit should have a response to at least 30 kc so that the second harmonic of 15 kc can be measured. This device should preferably be of the type which balances out the fundamental audio frequency either by an infinite rejection filter or by reintroduction of some of the input signal properly adjusted in magnitude and phase. In both types, the residual signal consists of harmonic distortion and noise, and if the noise level is 60 db or more below the 100-percent modulation level, a reading of the residual signal, made with a vacuum tube voltmeter and suitable attenuators, is a good measure of the total rms distortion of the system. In all cases the true harmonic distortion is of a value slightly less than the value determined by this measurement.

The block diagram also shows a cathode ray oscilloscope connected to the output of the noise and distortion meter. Although not essential, it is of assistance in analyzing the character of the distortion or noise being measured.

The procedure for measuring frequency response is merely to read the input voltage required to maintain a given percentage modulation as indicated by the station monitor. The input can be read directly in db if an input attenuator or vu meter is used for measuring input level, or voltage readings can be converted to db so that the response can be plotted in db to give a curve as shown in Fig. 2, which is of the form required by the FCC standards of good engineering practice.

Data on harmonic distortion are taken by passing the input signal from the audio oscillator through the system, balancing out the fundamental frequency in the noise and distortion meter, and reading the residual distortion components by means of the vacuum tube voltmeter in the instrument. These readings can be made at various percentages of modulation, as indicated by the station monitor modulation level indicator. An example of one such curve is shown in Fig. 3.

The f-m carrier noise level is read by modulating the transmitter to 100-percent modulation (±75 kc swing) with a tone of any frequency below the point at which the pre-emphasis is appreciable, usually 400 cycles or less, and setting the noise and distortion meter to read any convenient level, say +30 db under these conditions. Then the modulating tone is removed, and a reading of the residual noise taken on the noise and distortion meter. This procedure usually permits a noise level reading to be made down to about −70 db. If readings are to be made of noise levels even less than −70 db, a modulation level 10 or 20 db below 100-percent modulation can be used for the input sig-

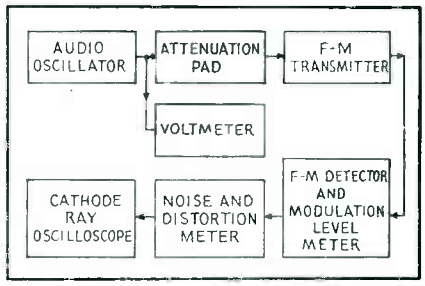

FIG. 1—Block diagram of measuring apparatus used in checking audio frequency characteristics. Pre-emphasis network in transmitter and de-emphasis circuit in monitor are not shown

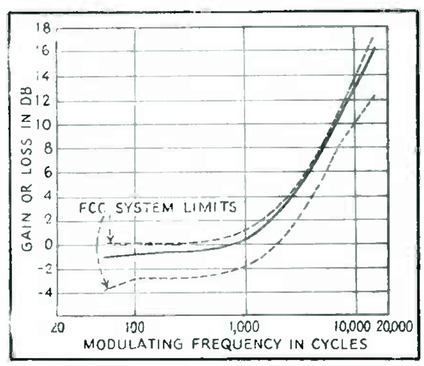

FIG. 2—Frequency response of a typical f-m broadcast transmitter for 100-percent modulation (75-kc deviation)

Table I—Transmitter Performance Requirements

	FCC System	RMA Transmitter
Frequency response (departure from 75 Usec)		
50 Cycles	+0,–4 db	±1 db
100–7500 Cycles	+0,–3 db	
15,000 Cycles	+0,–5 db	
Harmonic distortion		
50–100 Cycles	3.5%	1.5%
100–7,500 Cycles	2.5%	1.0%
7,500–15,000 Cycles	3.0%	1.5%
F-M Carrier noise level	−60 db	−65 db
A-M Carriers noise level	−50 db	−50 db

nal while still setting the noise and distortion meter to +30 db.

Amplitude-modulation carrier ripple is measured by using an ordinary diode detector with a standard 75-microsecond de-emphasis circuit, connected to the transmitter output, and measuring both the d-c and a-c ripple voltages developed across the detector load resistance. The noise level is then the ratio of the square root of two times the rms a-c voltage to the d-c voltage. In db, it will be 20 times the logarithm to the base 10 of this ratio.

Checking Measurement Equipment

There are certain checks on the performance of the measuring equipment which can be made fairly easily. By connecting the noise and distortion meter input terminals across the transmitter input terminals, a reading of harmonic distortion will be obtained that is essentially the harmonic content of the audio oscillator output.

Measurements on the linearity of the f-m detector are not easily made, but its performance is usually guaranteed within certain limits by the manufacturer. Any very serious misadjustment of the discriminator will usually show up as a large apparent shift of the transmitter center frequency with modulation, as shown by the monitor's center frequency indicator. This indication is a definite sign of discriminator nonlinearity in the case of a phase modulated transmitter where the center frequency is definitely crystal controlled even in the presence of modulation. The Armstrong and Phasitron types of transmitters are in this class. Frequency shifts 200 cycles or less, represent only a very small nonlinearity.

In some cases the ability of the measuring system to measure exceedingly low values of f-m carrier noise may be questioned. The capability of the system in this regard may be checked by altering the transmitter in such a way as to definitely minimize f-m carrier noise and then noting if the measuring equipment will read this low value. This can be accomplished in most phase modulated transmitters by driving the multiplier stages directly from the crystal oscillator without passing through the modulator stage, and with sufficient signal to minimize noise in the early multiplier stages. In this check a reference level for the measuring equipment must be set up before the modulator is disconnected.

Determining Frequency Deviation

To check the percent modulation readings of the monitor requires the use of a highly selective communication type receiver, preferably one having a crystal filter and an S meter. The receiver is tuned and coupled to the i-f of the monitor. When the transmitter is modulated with a fairly high audio frequency the receiver, if it possesses sufficient selectivity, will pass only the carrier frequency. As the amplitude of the modulating frequency is increased it will be possible to recognize readily the points where the carrier amplitude goes to zero by the almost complete lack of signal. Certain combinations of modulating frequency, percent modulation, and the number of the carrier null are given in Table 2. For example, if we want to check the 100-percent modulation indication, we can modulate with a tone of 5,020 cycles and slowly increase the amplitude of the modulation until the receiver indicates that the fifth point where the carrier disappears has been reached. This will be exactly ±75-kc deviation or 100-percent modulation. Similarly 50-percent modulation will occur when the fifth carrier null is reached with a modulation of 2,510 cycles.

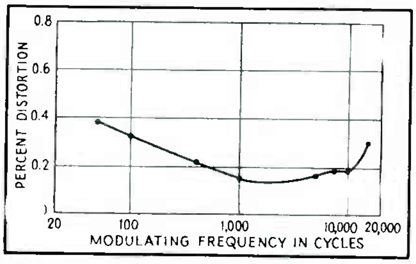

FIG. 3—Harmonic distortion at 100-percent modulation in a typical f-m broadcast transmitter

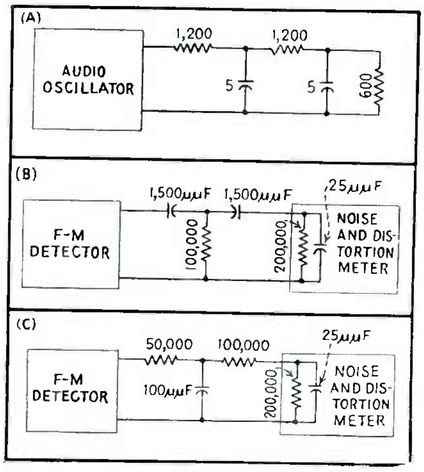

FIG. 4—Easily constructed circuits for facilitating transmitter measurements: (A) 50-cps low pass filter; (B) high pass RC filter for high frequency distortion measurements; (C) low pass RC noise filter

Special Techniques

There are a few methods which can be used to help overcome some of the difficulties encountered in making these transmitter measurements. For instance, when making harmonic distortion measurements, two difficulties are normally encountered. One is that many audio frequency oscillators have a considerable amount of harmonic content, particularly at the low frequency end of the audio range. It is possible to employ such an oscillator in spite of this trouble by using a filter connected between its output and the transmitter input which will pass the fundamental frequency and attenuate the harmonics. A plain low pass filter is suitable for this purpose. In some cases it is possible to improve conditions considerably by using a two section RC filter as shown in Fig. 4A. For example, two sections each consisting of 1,200 ohms and 5 microfarads, feeding a 600 ohm transmitter input will reduce the second harmonic of 50 cycles about 7 db, and the third harmonic about 12 db. Such a filter attenuates the fundamental considerably (in this case about 19 db), but this condition is not serious if the oscillator has sufficient output.

The other difficulty occurs when measuring distortion at high modulation frequencies and low percentages of modulation, when power frequency hum begins to be in the order of magnitude of the distortion being measured. For example, suppose it is desired to measure distortion at 15,000 cycles and 25-percent modulation, and the transmitter is good enough so the actual distortion is in the order of 0.5 percent. The harmonic level will then be 12 db down from 100-percent modulation owing to the modulation level, 46 db farther down if it is 0.5-percent distortion, and 17 db more because of the de-emphasis in the monitor at 15,000 cycles or a total of 75 db. This will be in the order of the noise level of even a good f-m system. It is allowable in this case to use a high pass filter which will attenuate hum frequencies, but which will have no appreciable effect on the higher audio.

In Fig. 4B is shown a simple high-pass RC network consisting of two 1,500 micromicrofarad capacitors in series with the high side of the monitor output, and 100,000 ohms from the center point of these two capacitors to ground. This RC network, when working into a noise and distortion meter having about 200,000 ohms input resistance attenuates the hum frequencies sufficiently to allow these high frequency distortion measurements to be made. Numerically this circuit provides less than 1 db attenuation at 5,000 cycles and above, but 45 db at 60 cycles and 34 db at 120 cycles.

High-Frequency Noise

When making noise measurements of f-m transmitters, in which an appreciable part of the noise may be of a random nature, improved readings can be obtained by cutting off frequencies beyond 15,000 cycles. This is allowable since these components are beyond audibility and do not contribute to audible noise although they may add considerably to the reading of a noise and distortion meter which has a frequency response extending well beyond this frequency. A sharp cutoff filter could be used but it is difficult to realize for impedances in the order of several hundred thousand ohms. It is possible to work at low impedance with a filter and then use a transformer to step back up to a high impedance for the input of the noise and distortion meter, but this requires a considerable amount of equipment. We have found that we can use an RC de-emphasis type of circuit, as shown in Fig. 4C, having a time constant of 5 microseconds. This will give less than 1 db attenuation at 15,000 cycles, and will provide sufficient attenuation at the higher frequencies to give an appreciably improved noise reading when the noise is of a purely random type.

Table II—Carrier Null Method of Determining Frequency Deviation

Carrier Null	Modulating Frequency for 100 percent Modulation (Cycles)
1	31,140
2	13,580
3	8,660
4	6,360
5	5,020
6	4,150

For modulation percentages other than 100 percent, multiply the modulating frequency in this table by the modulation factor.

Accuracy of Measurements

The accuracy with which the frequency response can be measured depends largely on the accuracy of the attenuators and voltage indicating instruments employed and can be in the order of 0.1 db without great difficulty.

The accuracy of harmonic distortion readings is limited by the harmonic content of the audio oscillator and the distortion in the f-m detector used for demodulating the transmitter. One commercially available audio oscillator gives in the order of 0.1 percent harmonic content. Commercial f-m station monitors have distortion in the order of 0.25 percent, so the normal accuracy of distortion readings may not be better than ±0.35 percent. In other words, readings less than 1 percent are sometimes open to question, for even a 1 percent figure may actually mean from 0.65 to 1.35 percent, and a figure of 0.5 percent may actually be 0.15 to 0.85 percent. It would be possible to increase the accuracy of these readings by using a filter at the audio oscillator output, which might reduce the harmonic content to about 0.02 percent. By using a counter type discriminator, the f-m detector distortion can be made as low as about 0.1 percent, which would give a total inaccuracy of ±0.12 percent. However, the counter type discriminator has a very low output, which makes it difficult to avoid running into hum pick-up troubles when making very low distortion readings. This will again decrease the accuracy, although it is not possible to set a definite limit on the possible accuracy of low distortion readings.

Errors From Noise

The errors in measuring carrier noise levels are largely in the direction of making the noise voltages greater than in actuality because any stray hum pick-up, noise in the test equipment, or other introduced noise, all tend to produce an increase in total noise voltage. If these other sources of noise are sufficiently small, the only errors of reading should be inaccuracies in the attenuators and indicating instrument of the noise and distortion meter, and should be less than ±1 db under normal conditions.

There is a possible source of error in both harmonic distortion and noise readings when using the type of instrument which employs a vacuum tube voltmeter to give rms readings, since the vacuum tube voltmeter actually reads an average voltage, although it is calibrated in rms volts. This error is zero for a single sine wave, as would be the case when reading a distortion that was all caused by a single harmonic. However, even for fairly extreme wave forms, the error is small. In the case of a 50 percent square wave the instrument will read high by 11 percent, and for a triangular wave it will read low by 3.7 percent. In most cases, this error is probably less than 10 percent of the instrument reading, and is therefore relatively unimportant.

Predetermined Counter

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Three decade units are cascaded to form complete counter. Two banks of selector switches set up count capacities so that device can control two successively occurring processes, each comprising up to 1,000 repeated operations

ALTHOUGH the general problem of exactly counting a predetermined number of periodic pulses has already been discussed [1, 2] and the necessary instruments are available commercially[3], until now no complete circuits have appeared. The device described here was originally designed to control high-speed zipper-making machinery but has numerous other applications.

Predetermined counting is accomplished by initially setting up a scale-of-N counter at some indicated count C less than N. The circuit will then count $N-C$ input pulses before delivering its first output pulse. This presetting enables a counting circuit to be used as a control device rather than merely as a high-speed pulse register. The output pulse may also be used to trigger circuits which thereupon set up the counter at some new indicated count C' instead of allowing it to revert to zero. Then $N-C'$ pulses are counted and a second output pulse is derived which, in the case of dual predetermined counting, is used to set up the initial starting count C once again, whereupon the cycle recurs.

The elements of such a system are a scale-of-N counter, preferably one using the decimal system, an electronic switch to determine the succession of starting counts C, C', C'', . . . C^M and means for automatically injecting setup pulses, without interfering with normal counting, into whatever counter stages are required to total the particular value of C.

Modified Eccles-Jordan Circuit

The decade counting circuit described here is based on the familiar triode, Eccles-Jordan type, scale-of-two, trigger pair. Potter[5] pointed out and eliminated the cause of instability which has always troubled this circuit. The usual method of interstage coupling is to feed the input pulse from a common source through two separate capacitors to the two grids of the succeeding Eccles-Jordan stage. Unfortunately, these two capacitors mutually couple the two grids within the triode Eccles-Jordan stage, effectively inhibiting the reversal action characteristic of the circuit. To avoid the resulting instability, various forms of tetrode and pentode binary stages were devised which employed one pair of corresponding grids in the reversal networks and another pair for pulse injection alone.

A way of decoupling the grids in a triode Eccles-Jordan stage during reversal, evidently due to RCA, is shown in Fig 1. Resistor R is of the order of 5,000 to 25,000 ohms and is inserted to simulate a relatively high plate-supply impedance in order to prevent short-circuiting the input pulse. The same purpose is served by replacing resistor R with an inductor of the order of 0.5 to 10 millihenries and with minimum shunt capacitance. This modification provides a high impedance to steep input pulses, but inserts only a negligible IR drop in available plate supply voltage. In the Potter version, resistor R forms the common grid return. Here again, R may be replaced by a small inductor. The action of the triode Eccles-Jordan circuit has been explored by Phelps,[4] who has shed light on the frequently misunderstood function of capacitors C_A and C_B.

The circuit of Fig. 1 is not critical with respect to any parameter, and remains stable over an exceptionally wide E_{BB} range. It is sensitive chiefly to negative input pulses and discriminates against equivalent positive input pulses by a ratio of about 3 to 1. This polarity discrimination is further enhanced

for Process Control

Embodying advanced techniques surveyed here, counter controls two-stage zipper-making process by counting rapidly repeated operations in each stage. Extension of techniques to control of more complex processes and to computers is indicated

in cascade operation because the positive swing at the plate of either triode is not as steep as the negative plate swing. Thus, the positive swing, after differentiation by a low time-constant *R-C* coupling circuit, appears as a positive pulse of lesser amplitude than the negative pulse derived from the negative plate swing. Interstage coupling diodes or amplifiers are therefore unnecessary.

Binary-Type Counters of any Scale

Lifshutz[6] has pointed out that counters of scale 2^N may be variously modified to provide any lesser integral scale, usually with notable tube economy. These modifications cause one or more of the 2^N possible circuit transitions to develop pulses (either by means of extra coincidence tubes or internal feedback legs) which, in turn, cause anomalous reversals of selected binaries in addition to the ones reversed in normal binary counting.

Three general methods to achieve this extra, or false, count may be employed. In the first, the counter is initially filled with 2^N-1 pulses and at the 2^Nth, the output pulse, or its complement, is fed back separately to preceding binaries whose interpolation values total C, where 2^N-C is the desired scale. The counter is thereby forced to revert to an indicated count of C instead of zero and thereafter progresses in binary fashion between the indicated counts of C and 2^N-1 and then resets to C.

Initial filling of the counter with 2^N-1 pulses is avoided by either of two methods. The basic 2^N circuit is started from an indicated count of zero and progresses normally to the 2^N-1th count, whereupon the final binary reverses for the first time and all others momentarily revert to zero. This initial reversal of the final binary develops feedback pulses which, here again, turn on all preceding binaries so that their interpolation values total C. Thus, on the 2^N-1th input pulse, the counter is made to jump ahead to an indicated count of 2^N-1 plus C.

Insertion of the false count C need not be done all at once. Grosdoff[6] has described a scale-of-five counter based on the triode scale-of-eight whose feedback legs are arranged to force the circuit ahead by one extra count at the second input pulse and then by two extra counts at the third input pulse.

Neither of the foregoing methods provides easy interpolation by means of single neon lamps coupled to each stage. The first method reads high by C at all times after initial filling and the second reads correctly up to the 2^N-1th pulse and thereafter reads high by C. However, the scale of these counters is easily changed by controlling which binaries are switched onto the feedback leg, and thus determining C.

The feedback legs introduce minimum interference with normal triggering. Whichever reversal of the final binary does not cause feedback resetting, instead develops pulses which momentarily accentuate the existing condition of the circuit.

The third method allows the chain of binary stages to count in sequence from zero to $N-1$, where N is the desired arbitrary scale. On the Nth pulse, the various circuit transitions develop feedback pulses which reset the counter to zero instead of allowing it to advance to $N+1$. Ordinary interpolation lamps total the true count, but changing the scale of such a counter is somewhat involved.

If the period and placement of a

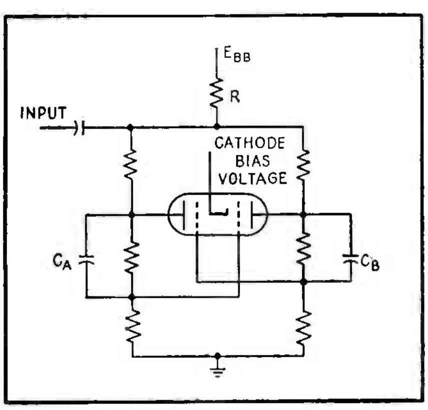

FIG. 1—Modified Eccles-Jordan trigger pair circuit provides grid decoupling

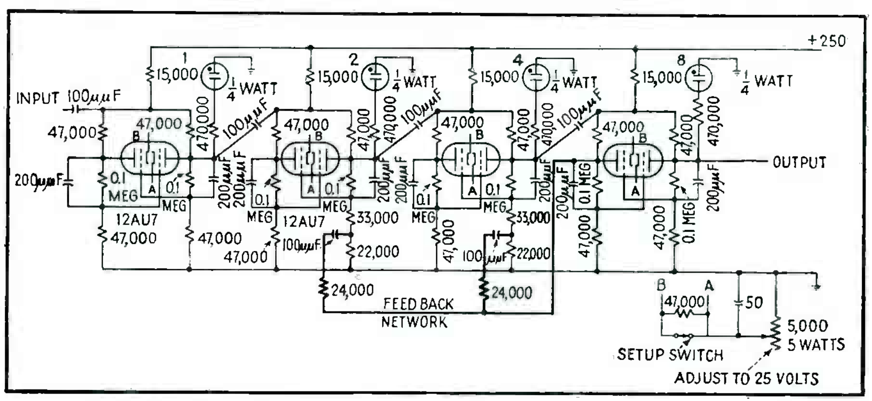

FIG. 2—Each decade unit uses four dual triodes in a scale-of-16 circuit. Feedback network reduces number of equilibrium circuit conditions to provide decade counting

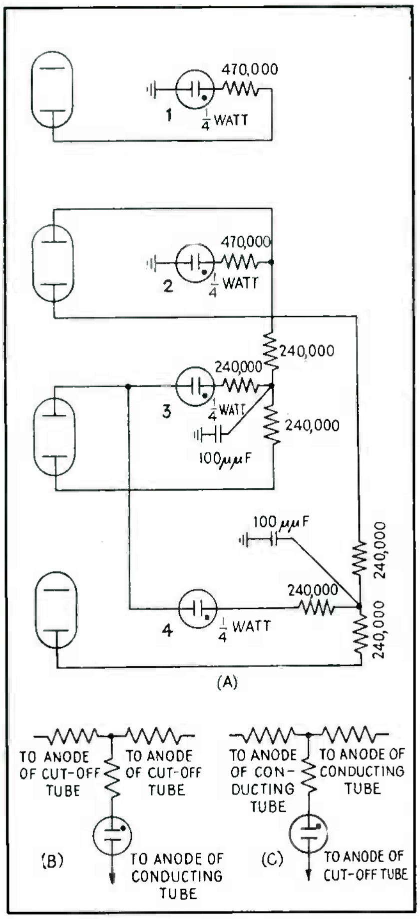

FIG. 3—Lamp networks in decade circuit of Fig. 2 are modified to give direct 0-to-9 indication. Lamps will light on occurrence of circuit conditions shown at bottom

gate represented by the rectangular waveforms occurring at the plates of counter tubes are important, special reset systems may be required.

Direct count indication for decade counters of the modified binary type is provided in the circuits devised by Grosdoff[6] and Miller[7] using resistor networks and ten neon lamps. Indication on a milliammeter is also possible.[8, 9]

If conjugate-pair counting is employed, it is better to feed input pulses to the straight binaries, as they are not subject to forced resetting, which takes finite extra time.

Decade Counter

Three identical, plug-in decade counters in cascade, form the scale-of-1,000 counter which is the heart of the dual predetermined counter. One of these units is illustrated in the photograph and its schematic diagram, less the automatic setup paths used in dual predetermined counting, is shown in Fig. 2.

The circuit of Fig. 2 will be recognized as a conventional scale-of-16 circuit that has been limited to ten equilibrium states by means of the feedback leg shown in heavy lines. In one sense this is actually a conjugate-pair counter because stages 2, 4 and 8 comprise an independent scale-of-five circuit driven by a scale-of-two.

If the circuit of Fig. 2 is started from zero (all righthand triodes conducting and all neon lamps out), it will follow the usual progression up to an indicated count of 15 (all righthand triodes cut off, all neon bulbs lit). The 16th pulse momentarily reduces the counter to zero. The fall of potential at the righthand plate of stage 8 provides a negative output pulse. Due to the feedback leg, the accompanying rise of potential at the lefthand plate of stage 8 appears as a positive pulse on the lefthand grids of stages 2 and 4, causing these triode sections to conduct, thereby lighting lamps 2 and 4 for an indicated count of 6. Thereafter the circuit progresses up to 15 and back to 6, providing reliable scale-of-10 action.

The feedback leg of Fig. 2 could just as well have been tapped onto converse points in the circuit. The feedback pulse would then have been derived from the righthand plate of stage 8 and would therefore have been negative. To turn on lamps 2 and 4, the negative feedback pulse would have been fed to the righthand grids of stages 2 and 4. The reset switch in Fig. 2 is so connected as to force the circuit into the 6th count position for starting, instead of permitting it to start from zero. Because the starting count of 6 is equivalent to zero, the indicated lamp count is always 6 units greater than the true count. This initial false count is no disadvantage in the present instrument because the interpolation lamps are not visible from the front panel and are provided only for maintenance checks. If direct indication of the total number of counts is desired, the circuit of Fig. 3A, when substituted for the lamp circuits of Fig. 2, will provide zero to nine indication. The circuit of lamp 1 remains unchanged. Lamp 2 is merely shifted to the left plate of stage 2. Lamps 4 and 8 are connected in a resistor network so that they will glow only when the circuit conditions indicated in Fig. 3A and 3B occur. Small capacitors C are provided to aid in decoupling the binary stages interconnected by this network.

The decade counting circuit of Fig. 2 has operated satisfactorily at an input frequency of 10^5 cps. If the circuit were arranged specifically for short resolving time by reduction of time constants and stray capacitance, and inclusion of small peaking inductances in series with the plate load resistances, an input frequency of better than 10^6 cps very likely could be realized. In any case, resolution of bursts of two or three pulses is always better than that indicated by the maximum steady input frequency that can be scaled.

Once the noncritical setting of the cathode bias resistor has been established, the plate voltage may vary widely without detriment to the operation of the circuit. A range of 40 to 750 volts proved entirely satisfactory during a test.

The new 12AU7 miniature dual triode is employed. This tube contains two independent 6C4 triode sections and may be used on either a 6.3-volt or 12.6-volt heater supply. In general, it is similar to the older 6SN7-GT and 12SN7-GT dual triodes, but requires the new 9-pin miniature socket.

Complete Predetermined Counter

This counter has two modes of operation, referred to as scoop and gap, which relate to the two modes of operation of the zipper-making machine which the counter was originally designed to control. In scoop, metal teeth, called scoops, are affixed to the corded edge of a cloth tape. In gap, application of teeth is suspended along a length reckoned in equivalent number of scoops. The output relay in the counter controls a heavy solenoid on the machine. Since one scoop is affixed for each rotation of the machine, counter input voltage pulses are induced in a pickup coil by an Alnico magnet imbedded in the aluminum flywheel.

A simplified block diagram of the

complete three-decade counter is shown in Fig. 4. Ignore for the moment the delay gate multivibrator, the blanking cathode-follower and the blanking bus. The sequence of mode switching can then be explained as follows: The 1,000th pulse arrives, momentarily reducing the three counter decades to zero and causing the mode selector stage to switch over, opening or closing an output relay in its plate circuit.

Mode Selector Switch

The mode selector switch is simply an independent Eccles-Jordan stage with neon bulbs on each plate to indicate in which mode the system is operating. This switching action develops a negative pulse at the grid of one setup cathode follower and a positive pulse at the other. Both setup stages are biased to cutoff and therefore only the setup cathode follower which receives a positive input pulse delivers an output pulse. This output pulse is fed to either the gap or the scoop setup line, onto which all those decades requiring turn-on pulses have been switched previously. A turn-on pulse renders a righthand triode nonconducting, thereby lighting its lamp. Thus, in a few microseconds, and well before the arrival of the next input pulse, the counter sets itself to a predetermined false count and is ready to start toward 1,000 in the new mode. The 1,000th pulse in this new mode causes reversal of the mode selector switch and repetition of the counting operation in the sequence described.

Turning on a lamp is accompanied by a positive-going pulse and does not affect the next lamp. It is the extinction of a lamp, accompanied by a negative-going pulse, which trips the following stage.

The decade counter of Fig. 2 is zeroized at an indicated count of 6 and progresses from there to 15 and back to 6 again. Thus the 1,000th pulse in this case produces a 6–6–6 configuration of lamps, translatable to 0–0–0. If setting up a predetermined count in such a decade involves simultaneously turning on some stages and turning off others, possibly adjacent ones, serious troubles appear. The turning off of the No. 2 or No. 4 lamps in any decade transfers a turn-on pulse to the following stage via normal signal channels and this transfer produces an undesired result by either actually turning on the next stage when not wanted or by bucking out a turn-off pulse.

To overcome this difficulty it was necessary to insert a blanking interval between the 1,000th pulse and the generation of the setup pulses. The purpose of this blanking process is to extinguish every neon lamp for the duration of a blanking gate so that the decades may be set up by turn-on pulses alone. This action is accomplished by the delay gate multivibrator, the blanking cathode-follower and the blanking bus. Because the top speed of the circuit is limited by the changeover time, about 1 millisecond, of a high-speed, mercury wet-reed relay, a delay gate length of 300 microseconds is unimportant.

Automatic Predetermined Setup

The process of automatic predetermined setup can be understood from the simplified signal schematic diagram and the idealized waveforms shown in Fig. 5. When the 1,000th pulse causes the potential at the plate of the last binary stage to drop about 85 volts at time t_0 as shown at A, this variation is differentiated, producing the waveform shown at B. The differentiated waveform is capacitively coupled to a one-shot multivibrator which serves as a delay gate generator sensitive chiefly to negative pulses.

Turning on the final trigger stage in the hundreds decade yields a positive pulse that does not affect the delay gate multivibrator, since, in the absence of negative input pulses, this stage is quiescent. But upon receiving a negative pulse, the delay gate multivibrator develops a 90-volt, positive, flat-topped pulse of about 300 microseconds duration shown at C. This gate is differentiated, giving the waveform at D, and fed to the blanking cathode-follower grid. Since the cathode follower is biased to cutoff, it therefore develops a positive output pulse shown at E only in response to the positive-going pulse of the pair impressed upon its grid. When the blanking cathode-follower grid is driven positive, the delay gate multivibrator is loaded, causing the leading edge of the gate to be somewhat rounded.

Thus, a positive blanking pulse of about 15 volts derived from the leading edge of the delay gate is developed across a parallel network of three 1,000-ohm resistors, each of which is in series with the ground return of its respective righthand binary-stage grid as shown in Fig. 5. This pulse drives each righthand grid positive, turning out the No. 2 and No. 4 neon lamps in each decade and preventing others from coming on.

The grid resistors in each Eccles-Jordan stage in the decades have values of about 50,000 ohms each. Returning them to ground through three 1,000-ohm resistors introduces virtually no interference with normal triggering. Only when a relatively high current pulse passes through the 330-ohm resistor, due to a positive pulse on the blanking cathode-follower grid, does blanking occur. This blanking pulse is effectively shorter in duration than

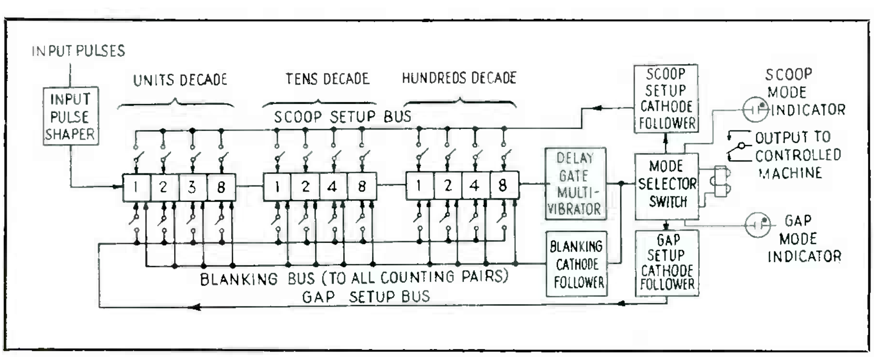

FIG. 4—Block diagram of complete dual predetermined counter

the delay gate, due to differentiation, and the blanking process is finished before automatic predetermined setup begins.

The gate from the delay multivibrator is also fed to the mode-selector switch stage, as indicated by the waveform at F. This stage is an Eccles-Jordan trigger pair with a relay coil in series with one plate. The mode selector is normally less sensitive to positive-going pulses, so that when the delay gate is differentiated, its rounded, positive-going, leading edge produces a smaller pulse than the steep trailing edge, enhancing this polarity discrimination.

The mode-selector stage therefore triggers on the trailing edge of the delay gate which arrives at time t_1, 300 microseconds after t_0 and well after the end of the blanking pulse shown at E, which begins at t_0, coincident with the leading edge of the gate. The plates of the mode selector stage each feed identical, cutoff, biased scoop and gap cathode followers with the waveforms shown at G and H.

During the mode switchover, only one of these two cathode followers receives a positive-going input pulse, the other simply being driven further into the cutoff region. The stage which receives the positive-going pulse shown at I, in this case the scoop cathode-follower, develops a positive setup pulse at its cathode. This setup pulse, shown at J, is fed to the scoop setup bus.

Injection of positive setup pulses is accomplished by dividing the normal lefthand grid resistors of about 50,000 ohms each into two parallel legs of 100,000 ohms each and returning each of these to ground either directly or via one of two setup buses, both of which are but 1,000 ohms above ground as shown in Fig. 5. By this method, the separate setup pulses are injected into the same grid in each stage but the two setup paths are effectively insolated, a change in one being attenuated about 100 times upon reaching the other.

In actual practice, 4-gang, 10-position, rotary wafer switches are used instead of the spdt switches illustrated in the simplified diagram of Fig. 5. In each mode of

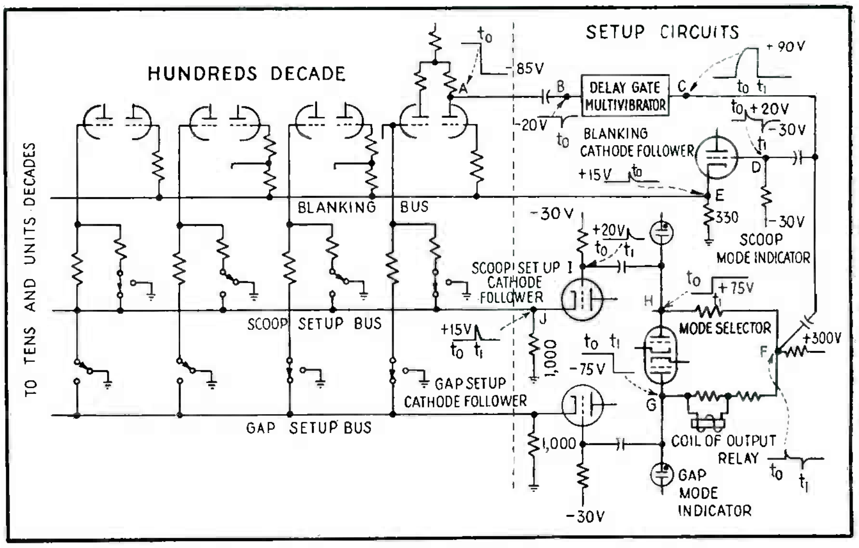

FIG. 5—Simplified schematic diagram of automatic setup circuits showing waveforms generated on arrival of last gap pulse

each decade, one of these rotary switches is provided, and for a given position it either grounds each lefthand grid resistor directly or connects it to the proper setup bus.

Fig. 6 is a complete schematic diagram of the dual predetermined counter shown in the photograph. The overall system draws a plate current of about 85 ma and operates satisfactorily up to a rate of 400 pulses per second. If the output relay were replaced by an electronic output actuator, the maximum input rate would rise to about 2,500 pulses per second, this latter limitation being due to the 300-microsecond blanking gate.

It is of interest to note that with this system (6 to 15 decade, intermediate blanking) it is not necessary that the output decade, which counts hundreds, be a decade at all. Every time it delivers an output pulse it is cleared by blanking and then set up to some externally predetermined combination equal to 6 or greater.

Input Pulse Shaper

Regener[10] has mentioned that circuits of the Eccles-Jordan type, when made deliberately unsymmetrical, are excellent pulse shapers for nearly any input waveform. The input pulse shaper stage of Fig. 6 is an example. The grid resistor unbalance normally holds the lefthand triode cut off. A negative-going input signal, greater than about 20 volts amplitude, causes forced reversal of this stage. When the input voltage drops below 20 volts, the circuit reverts to its quiescent condition, producing a steep rectangular pulse having a duration nearly equivalent to that part of the input pulse above 20 volts.

In the present application, a 12,000-ohm relay coil is shunted across the righthand grid resistor, causing the quiescent state of the circuit to be reversed. The coil is oriented near an aluminum flywheel, in which an Alnico magnet has been imbedded, so as to deliver an alternating voltage pulse for each rotation.

Setting up the Counter

After warmup, the counter is set up to count a number $1{,}000-C$ in the desired mode with the required complementary count C inserted. For example, for scoop operation, the setup switch button of Fig. 6 is pressed, forcing the counter to read an interpreted count of 999 in gap mode. The first pulse to arrive (which may be artificially generated) thus appears to the counter to be a 1,000th pulse and causes the counter to change mode to scoop and to set up the desired initial count C. Holding down the setup button freezes the counter at 999 in gap.

Since the preset switches are calibrated to read C directly, it is necessary to subtract the number to be counted from 1,000, thus ob-

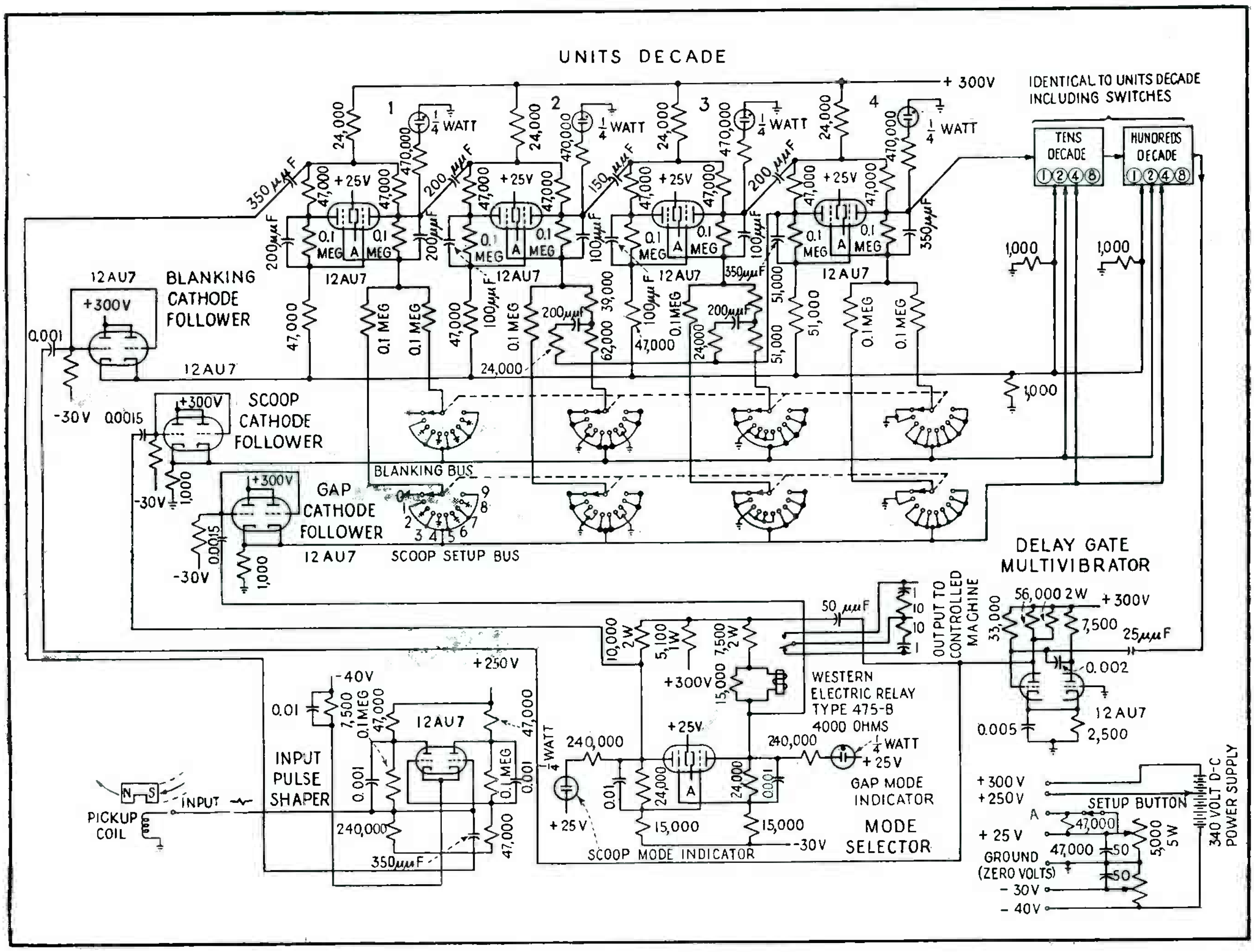

FIG. 6—Completed schematic diagram of dual predetermined counter

taining *C* and then to set up this number on the setup switches. It is not possible to calibrate switches to read 1,000—*C* directly under all circumstances because error is sometimes introduced in arithmetical "carrying". E. W. Lynn has suggested that if the setup switches for decades beyond the units decimal place were calibrated directly in terms of 1,000—*C*, and the units setup switches calibrated 10 to 1, corresponding to 0 to 9 starting counts, a count of 1,000—*C* not ending in zero could be set up directly without preliminary calculation. To set up for an initial count of, say 230, it would become necessary to set the three switches to 2–2–10, that is, 220 plus 10.

Frequency Division

Division by large prime numbers is impossible with step-by-step and synchronized multivibrator circuits, whereas predetermined counters can provide uniquely stable division by any integer. In addition, counter-type frequency dividers do not require alignment or long warmup and will stop instantly if the driving signal is removed.

When driven by a pulse generator of known frequency which can be gated on and off, predetermined counters are suited to the production of interval marker pulses of long, precise and adjustable separation, and to the precise measurement of time intervals.

Computer Applications

A straight counter driven by an oscillator whose frequency is controlled by a variable, such as a shaft position, can be used to evaluate an integral. A predetermined counter used in such an application will signal when the integral has reached a certain value.

Remote control, computing and telemetering systems can use banks of predetermined counters as inertialess stepping relays, as accumulators and as pulse code generators and detectors.

The writer is especially indebted to Mr. Alexander Konoff for his generous support and to Messrs. David Rabinow and William M. Meineke for their invaluable cooperation during various phases of this work.

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2,000-Mc Television

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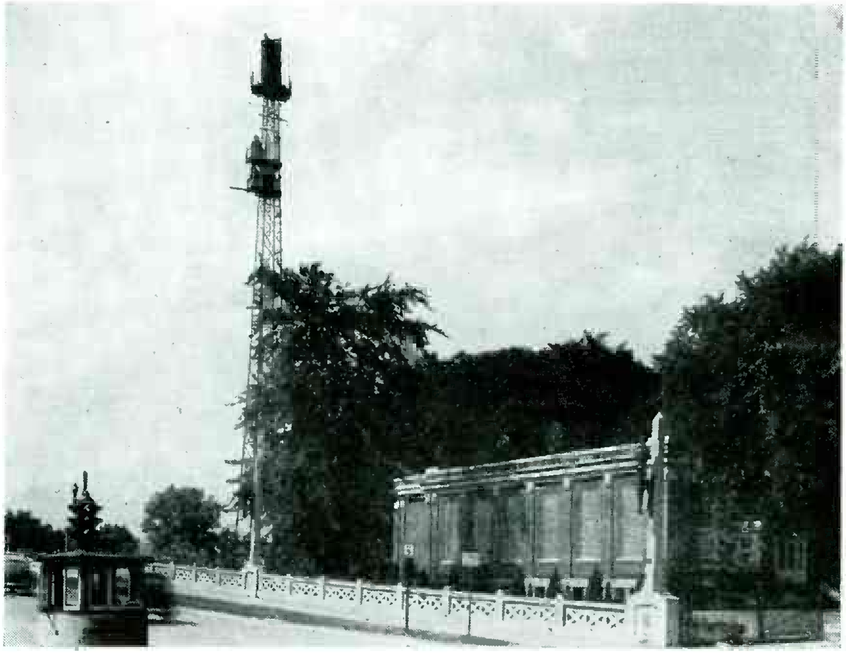


WRGB television studio in Schenectady, at northern terminus of microwave relay. Tower also carries antennas used to program main transmitter in Helderberg Mountains 12.6 miles away

THE SYSTEM ASPECTS of the 2,000-mc television relay chain over a 143-mile route from New York to Schenectady utilizing three hilltop intermediates have been described in ELECTRONICS[1]. In brief, television programs picked up atop the General Electric Building at 570 Lexington Ave. in New York City are automatically relayed to the control room of WRGB Schenectady, whence they are sent by studio-transmitter link to the main television broadcast transmitter in the Helderberg Mountains.

Transmitting and receiving equipment for each link in the chain is identical. Internal-cavity reflex klystrons are used both for the transmitter master oscillator and for the receiver local oscillator tubes. All frequency-sensitive elements are enclosed in temperature-controlled cabinets, and close spacing in the relay towers between high-gain antenna and equipment minimizes r-f losses.

Relay Equipment

The system as installed provides one-way transmission over two r-f channels, and the equipment used in each relay station is shown in Fig. 1. The apparatus operates in the 1,825-to-2,100 megacycle range, a twenty-five megacycle frequency band being adequate for each radio frequency channel, including necessary guard bands.

Improved equipment will prob-

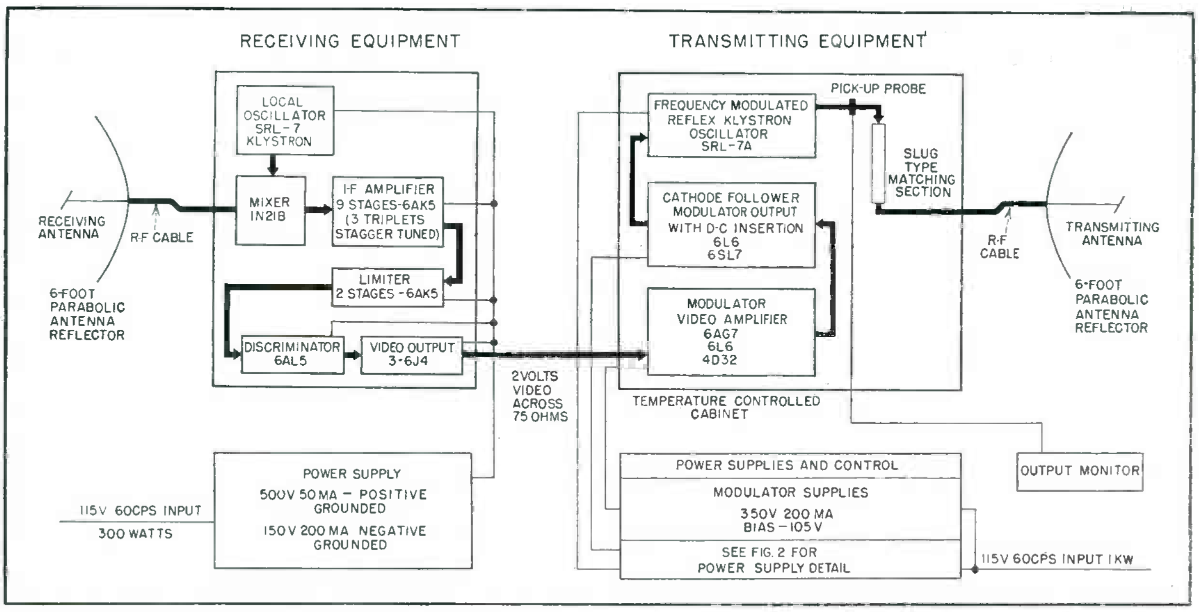
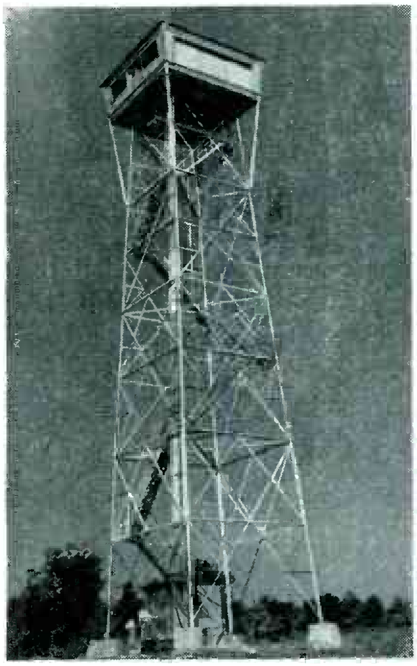


FIG. 1—Block diagram of a complete unattended microwave relay station

Program Chain

Circuit details and preliminary operational results of the 143-mile New York-Schenectady television relay using three unattended intermediate stations. Present two staggered r-f channels each 25 mc wide provide one-way transmission. Klystrons are used in transmitters and receivers to obtain frequency-modulated signal with 14-mc swing



Typical microwave relay tower 125 feet high. Room at top is large enough for other experimental equipment

ably permit reduction of the guard bands so that a total channel width of 20 megacycles will suffice. Four such channels can handle either a one way or a two way system of two channels capacity for any number of links, provided reception and retransmission from any point are in essentially opposite directions. For example, using channels A, B, C, and D, station no. 1 might receive from the south on channels A and B and transmit to the north on channels C and D, simultaneously receiving from the north on channels A and B and transmitting to the south on channels C and D. Station no. 2 would receive on channels C and D and transmit on channels A and B. Station no. 3 would repeat the arrangements at Station no. 1, Station no. 4 repeat arrangements at Station no. 2, and so on.

The transmitting equipment layout (Fig. 1) is common to the originating terminal and the three relay stations. The modulator accepts the standard video level of 2 volts into 75 ohms. Three compensated amplifier stages and an output cathode follower provide 150 volts peak-to-peak video modulating voltage for the klystron reflector electrode.

Three power supplies in series are used to furnish the operating voltages for the klystron oscillator and the cathode-follower output stage of the modulator. In order to maintain the body of the klystron and hence the r-f output line at d-c ground potential it is necessary to ground the most positive point of these three supplies. Figure 2 illustrates the arrangement employed. Power supply 1 furnishes the klystron beam current of approximately 200 milliamperes at 1,000 volts. Power supply 2 furnishes an adjustable voltage for setting the reflector voltage of the klystron a suitable amount negative with respect to the cathode. Power supply 3 furnishes 400 volts to operate the modulator output cathode follower. All the above supplies are electronically regulated to reduce ripple and transient voltages, and to prevent frequency drift due to slow variation of klystron reflector voltage.

Unmodulated klystron reflector voltage can be set between 200 and 700 volts negative with respect to the cathode to obtain fine frequency adjustment. This represents video sync peak level, and modulation is negative from this point. Coarse tuning is effected by mechanical adjustment of the klystron cavity.

Figure 3 shows the arrangement of the transmitter with respect to the antenna reflector. To provide two parallel r-f channels, two modu-

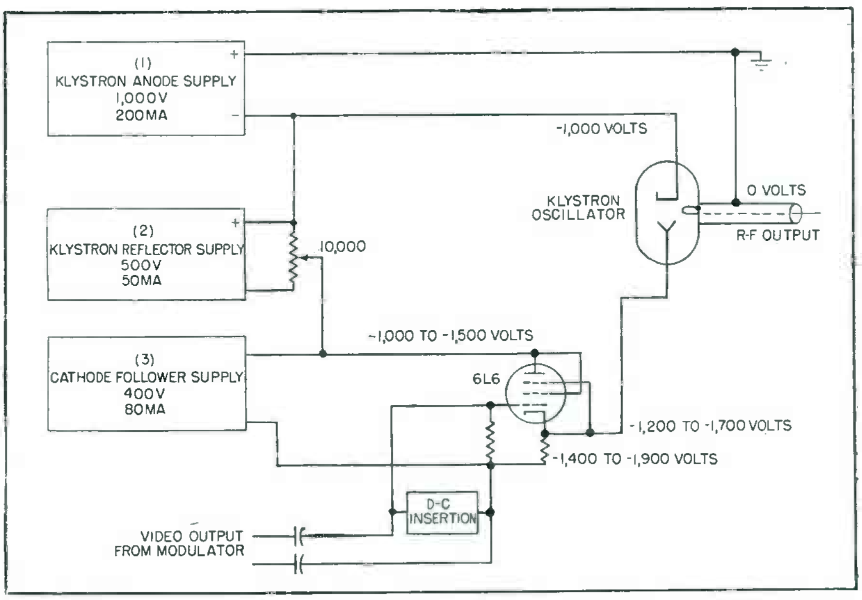


FIG. 2—Detail of klystron and modulator cathode-follower power supplies

lators are located, together with their transmitter klystrons, in a temperature-controlled cabinet directly behind the antenna reflector. A small blower is directed at each of the klystron oscillators to maintain adequate cooling, the output coupling being the most critical point. Temperature control of the cabinet within ± 1 C of a predetermined value is accomplished by a thermostat which causes exhaust vents to be opened and an exhaust fan to be started when the temperature rises above the nominal value. The vents are reclosed and the fan stopped when the temperature drops again. During operating of this exhaust fan, air is drawn in through a filter.

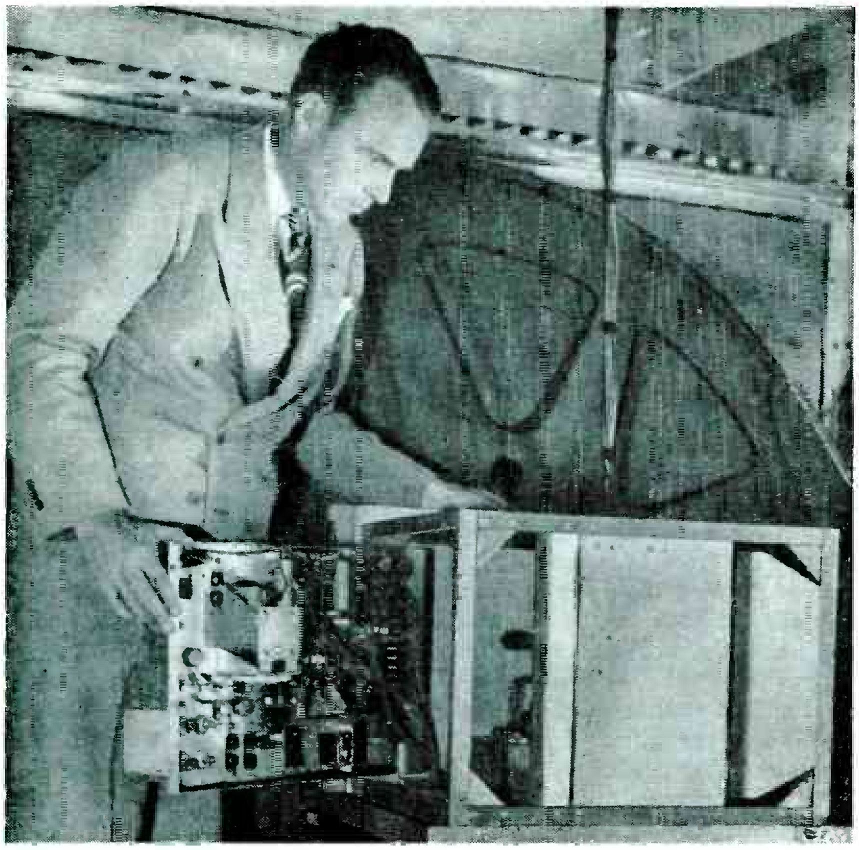


FIG. 3—The television relay transmitter is mounted in a cabinet near the dish antenna

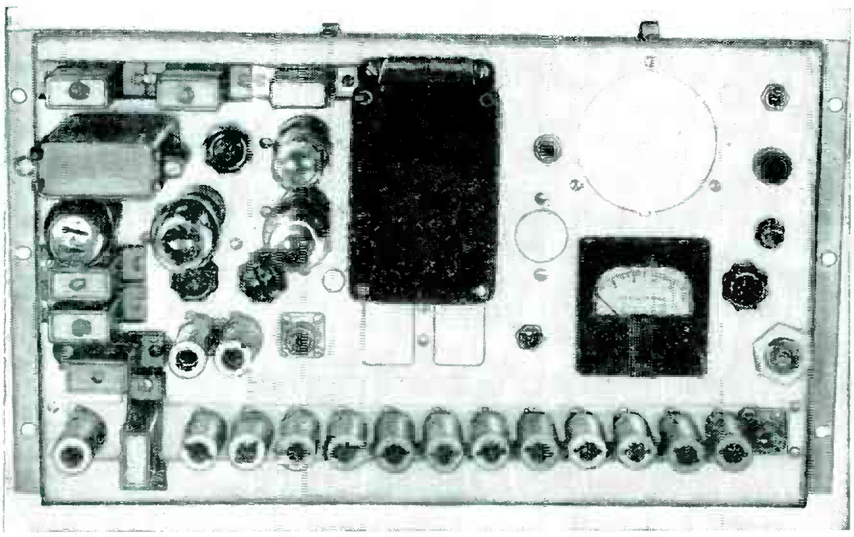


FIG. 4—The receiver chassis is mounted in a cabinet identical to that used for a transmitter

In the illustration, the cover for the cabinet has been removed and one modulator swung out on hinges for access to parts in the rear. The two transmitters feed through a double coaxial line to a dual antenna, which permits the single reflector to be used for both transmitters.

Power supplies, control, and monitoring equipment are located in relay racks adjacent to the transmitters and receivers.

Receiving Equipment

The receiving equipment layout (Fig. 1) is common to the three relay stations and the Schenectady terminal. The incoming signal is mixed in a crystal converter with the output of a local oscillator comprising a klystron identical to that in the transmitter. This tube is operated with reduced filament voltage and draws only about 40 milliamperes at 300 volts on the anode, considerably increasing life expectancy.

The 100-megacycle i-f amplifier consists of 3 triplets, each triplet stagger tuned to 92, 100, and 108 megacycles. A two-stage limiter provides a high degree of limiting, and the discriminator has a range of approximately 16 megacycles with good linearity. This allows a swing of 12 to 14 megacycles in the transmitter with satisfactory allowance for frequency tolerance between transmitter and receiver, and with good picture reproduction. A double 6J4 cathode follower output from the receiver chassis provides a 2-volt peak-to-peak signal into 75 ohms, which at the relay stations is fed directly into the modulator input.

Figure 4 shows the receiver chassis. The receiver installation at a relay station uses the same type antenna and cabinet as the transmitter with identical temperature control. The installation of the receiver chassis in the cabinet is similar to that of the modulator chassis, but no blowers are needed for the klystrons, because they are operated at reduced rating.

The rear of the i-f strip is shown in Fig. 5. Feed-through type bypass capacitors are used for all power leads, with the arrangement such that essentially no wiring is re-

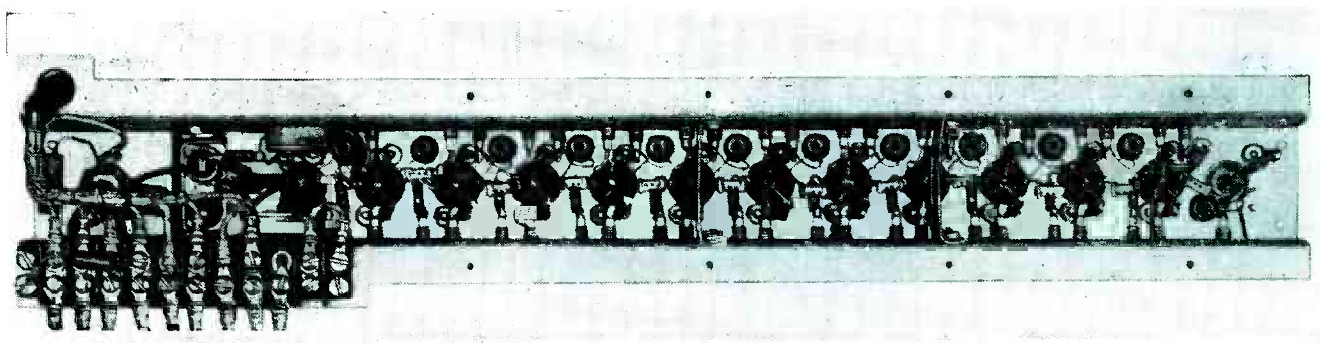


FIG. 5—Layout detail of the receiver i-f strip. Power leads are bypassed to the chassis. Miniature tubes are used

quired to interconnect the components within the strip itself. This results in good stability and makes isolating chokes in the power leads unnecessary. The compact construction is made possible by the use of miniature tubes throughout the i-f, 6AK5's for amplifiers and limiters, 6AL5 for the discriminator and 6J4's for the output stage.

In order to make it possible to turn transmitters off and on remotely at the relay stations, the pilot receiver at each remote station is equipped with a sensitive relay in the limiter screen lead. The receivers are run continuously and the incidence of a signal from the previous transmitter increases limiter screen current enough to operate the relay and, through the control system, turn on the transmitters at the station. In this way the entire system may be put in operation by turning on the transmitter at the originating terminal. The transmitters at the remote points also turn off automatically when the receiver limitier screen current drops, indicating that signal from the previous transmitter has stopped. A one minute time delay is provided before the process is completed at each station to prevent turning off the transmitter due to momentary loss of signal for any cause.

Monitoring Facilities

At each transmitter location, a monitor is provided by means of which the output of either transmitter can be demodulated, and the resultant signal waveform displayed on an oscilloscope during adjustment of the equipment or during servicing. At the relay stations, facilities are also provided to observe the waveform output of either receiver for comparison with the monitored transmitter output.

A meter on the transmitter control panel can be switched between diodes in the r-f output lines (Fig. 1) of the two transmitters to check output level against a reference value at any time. This diode output can also be observed on an oscilloscope, while using suitable test modulation, so as to check the amplitude variation with frequency of either transmitter.

Receiver input level can be checked continuously by a reading of limiter screen current on a meter provided for the purpose. By the use of a recording meter at this point, it is possible to keep a running record of propagation conditions.

Frequency measurements on the transmitters are made with highly accurate absorption type micrometer tuned wavemeters having a frequency accuracy of approximately 0.01 percent in the range used.

Operational Observations

During the first two months of operation, the following results were observed:

The frequency control of transmitter and receiver klystrons obtained by temperature-controlled cabinets was quite satisfactory. Receivers were run several hours for warmup before final frequency adjustments were made, and were run continuously thereafter, no further frequency adjustment being necessary.

Frequency drift of transmitters from the instant of turning on cold, up to normal operating temperature was of the order of 0.1 percent, about 80 percent of which occurred in the first 5 minutes. This condition occurred during winter weather when the difference between uncontrolled "off" temperature and controlled running temperature was greatest. After ten to fifteen minutes operation, frequency drift was negligible, the random change being of the order of 0.01 percent in comparison with a modulation range of about 0.7 percent.

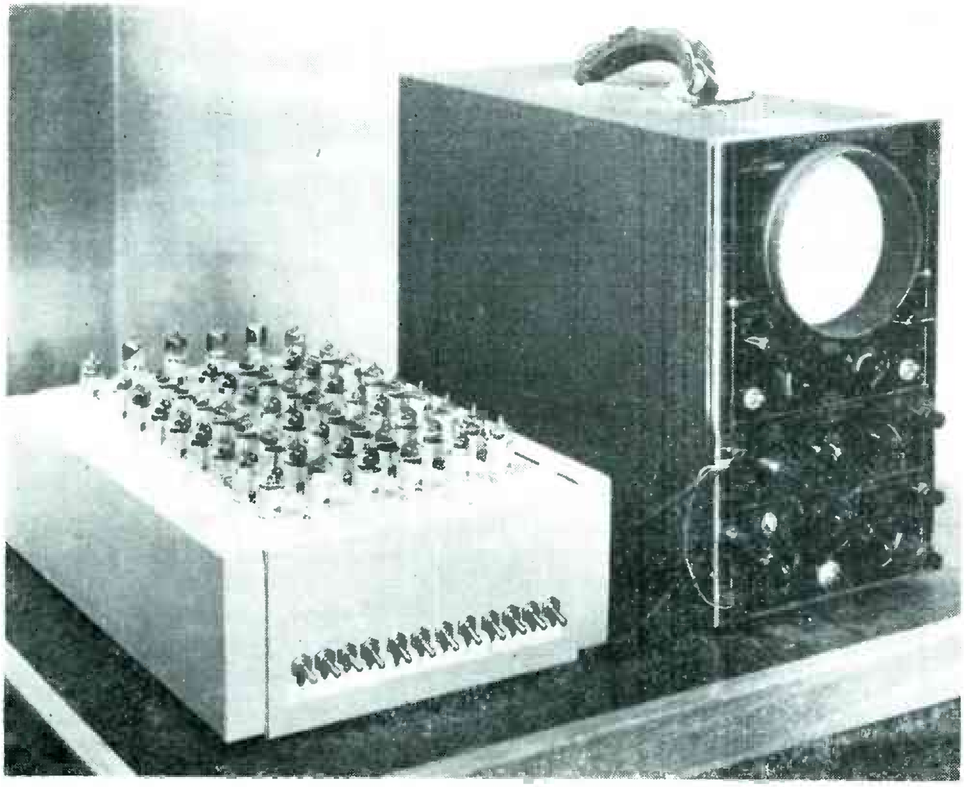
On the basis of limited preliminary data, propagation variations have not been wide enough to cause difficulty or approach limiting conditions on any of the links of the system. The signal level for the 53-mile link was of the order of 20 db above the value required for limiting with the i-f gain adjusted for barely perceptible noise under signal-off conditions. Comparison of long-term propagation variations between the 53 mile link and the 51 mile link are not yet available.

Under conditions encountered at the relay tower sites, high humidities and rapid temperature changes often result in condensation of moisture on the equipment. To avoid trouble from this cause, it has been necessary to provide sufficient heat on critical units to maintain their temperature a suitable amount above the ambient. Alternatively, it would be possible to design all equipment for operation in such a moisture-covered state.

Preliminary visual observation indicated negligible decrease in definition of a television picture having 350-line horizontal resolution when transmitted over the four link system.

Reference

(1) Microwave Television Relay, ELECTRONICS, p 152, Nov. 1947



Assembled numeroscope for single numbers from 1 to 0 and oscilloscope used for display

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Numbers as photographed from face of oscilloscope tube at shutter speed of 1/10th second. Exposures at 1/500th second are practicable

NUMEROSCOPE for

THE NUMEROSCOPE is an electronic device for tracing upon the screen of a cathode-ray tube the patterns of the Arabic numerals from one to zero. It was developed for use in conjunction with large-scale high-speed electronic calculators that are to produce results of computation with such frequency that conventional printing devices, notably typewriters, become inadequate for keeping up with the output of the machines. The numeroscope enables the building of a printer that will display upon an array of cathode-ray tubes the result of a computation, and that will record the displayed quantity on fast film.

In the investigation of methods whereby a number could be traced on the screen of a cathode-ray tube, a number was broken down into the horizontal and vertical components of displacement of the number pattern. The result was two voltage waveforms which were then analyzed for harmonic sine wave components. The analysis showed that very high order harmonics would be required to produce the waveforms, so the method of adding harmonic sine waves to get desired voltage waveforms was abandoned.

Circuit Techniques

From the standpoint of circuit design, Arabic numerals may conveniently be resolved into four general components: the straight line, as in the number 1; the broken line, as in the number 7 or the top por-

This development was made possible through contract Nord-8555, Task E, between the Bureau of Ordnance of the United States Navy and Harvard University.

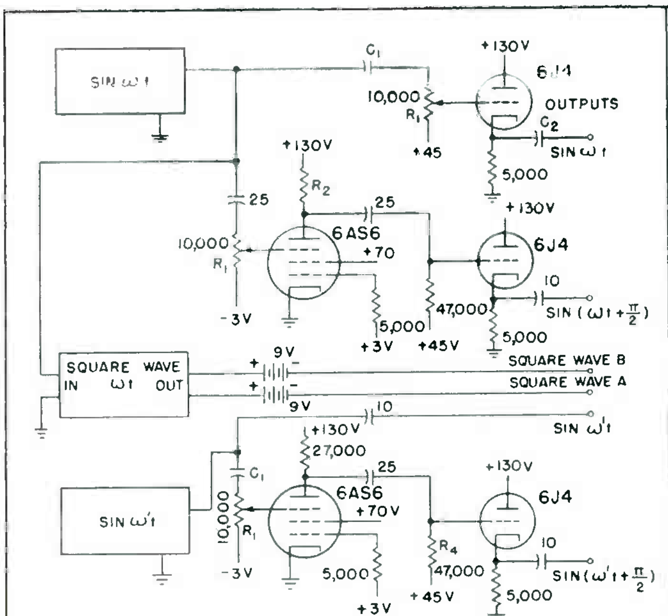


FIG. 1
INPUT CIRCUIT GIVING
SINE-WAVE VOLTAGES

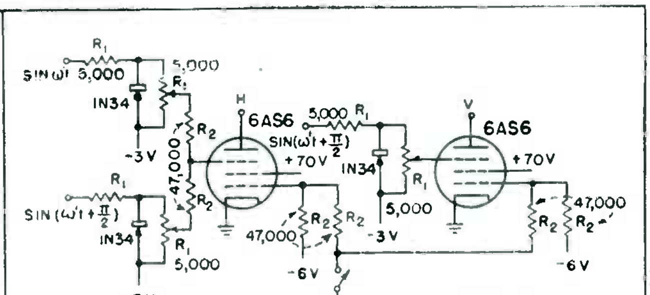


FIG. 3
CIRCUIT FOR
NUMERAL 7

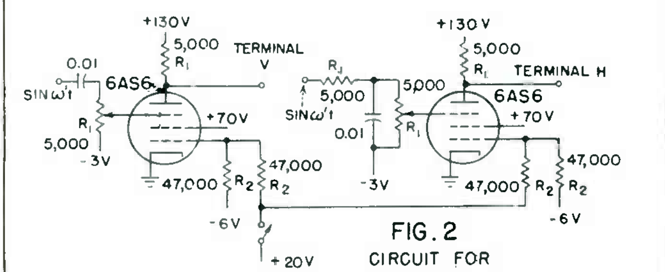


FIG. 2
CIRCUIT FOR
NUMERAL 0

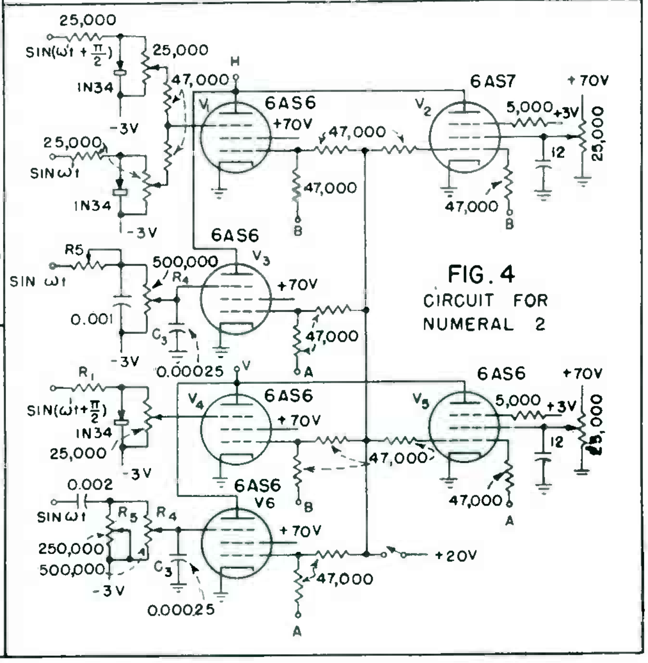


FIG. 4
CIRCUIT FOR
NUMERAL 2

Cathode-Ray Printing

Arabic numerals are automatically traced on the screen of a cathode-ray tube when triggered by a high speed electronic calculator. Fast film records numerical results at a speed far exceeding that of conventional printing devices

tion of the number 5; the ellipse, as in the number 0 or the top of the number 9; and the half-ellipse, as in the lower portion of the number 5 or 9.

The straight line is obtained by applying a sine wave voltage to the horizontal or vertical deflection plates of a cathode-ray tube.

The broken line is produced by applying to the horizontal and vertical deflection plates of a cathode-ray tube two rectified sine waves. The top of the number 5, for example, is produced by applying to the horizontal deflection plate of a cathode-ray tube a half-wave rectified sine wave in which the positive half of the sine wave is used. To the vertical deflection plate is applied a half-wave rectified sine wave in which the negative half of the sine wave is used. Under the influence of these voltages, the spot on the screen moves first to the right and returns again to its original position, then

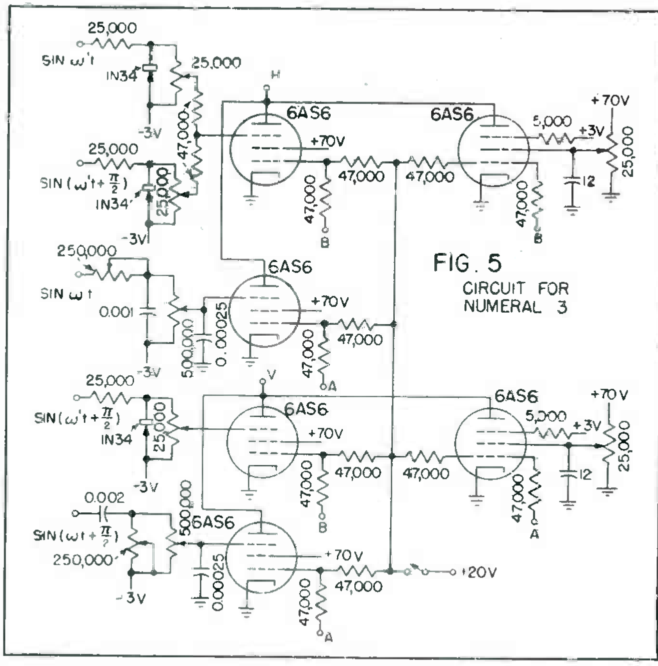


FIG. 5 CIRCUIT FOR NUMERAL 3

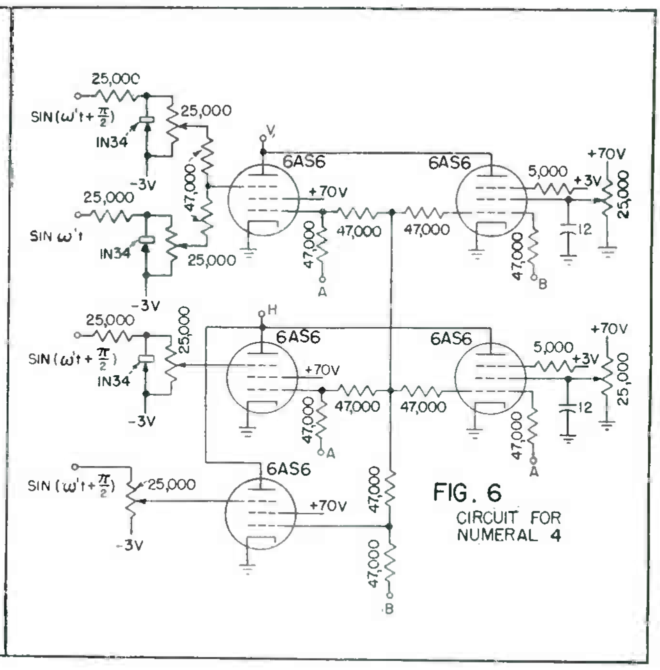
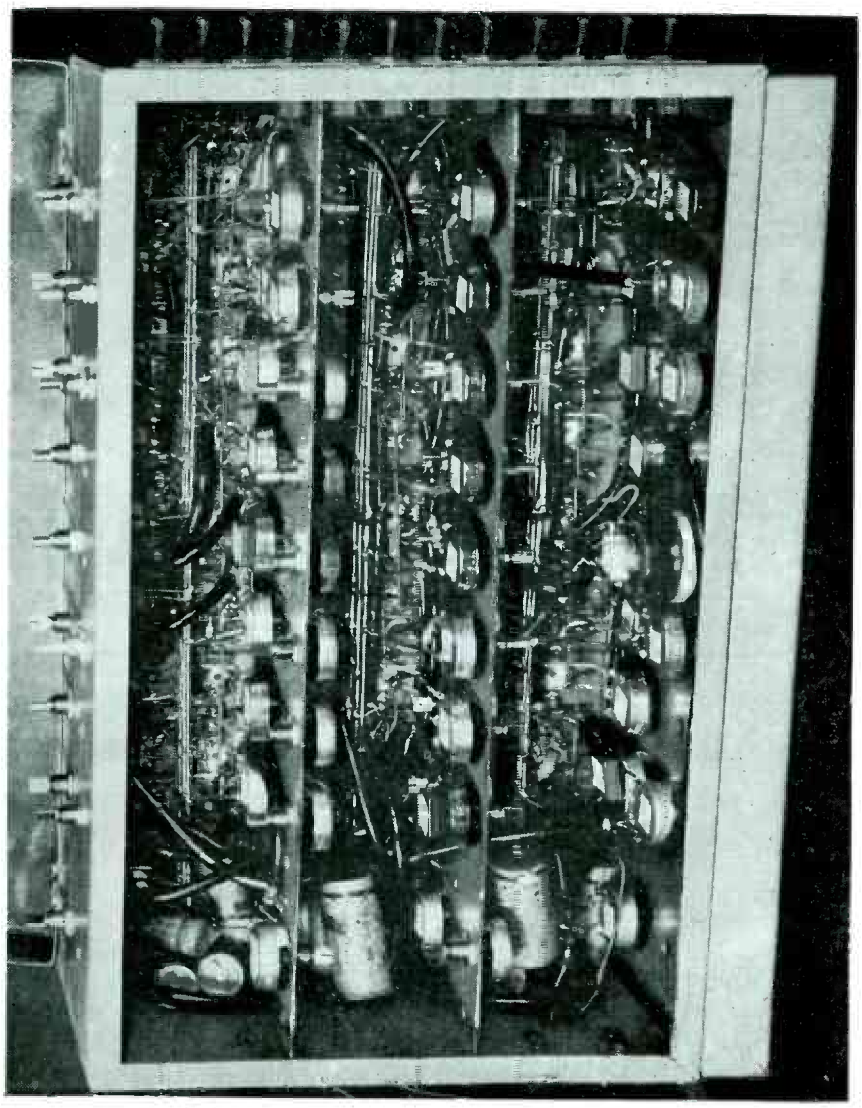


FIG. 6 CIRCUIT FOR NUMERAL 4


Three-partition layout provides electrostatic isolation and short leads in the numeroscope

downward, returning once more to its original position.

The ellipse is a standard Lissajous figure obtained by applying to the vertical and horizontal plates two sine waves, one out of phase with the other by 90-degrees. The half-ellipse is obtained in much the same way as the ellipse. The two sine waves, one shifted in phase with respect to the other, are impressed upon the grids of two tubes. The outputs of these two tubes are used to feed the deflection plates of the cathode ray tube. The result would again be an ellipse, but a square wave is now generated at a frequency equal to that of the sine waves, and this square wave is used to render the two tubes nonconducting during half the sine wave cycle. A 180-degree segment of the ellipse is thereby produced. By shifting the phase of the two input sine waves with respect to the square wave, always maintaining a 90-degree phase relationship between the two sine waves, any 180-degree elliptic segment is produced.

An electronic switching technique is used in the event that a number consists of two components. The same square wave that is used to obtain the half-ellipse is employed to display first one component of the number upon the screen of the cathode-ray tube, and then the other. The numbers that re-

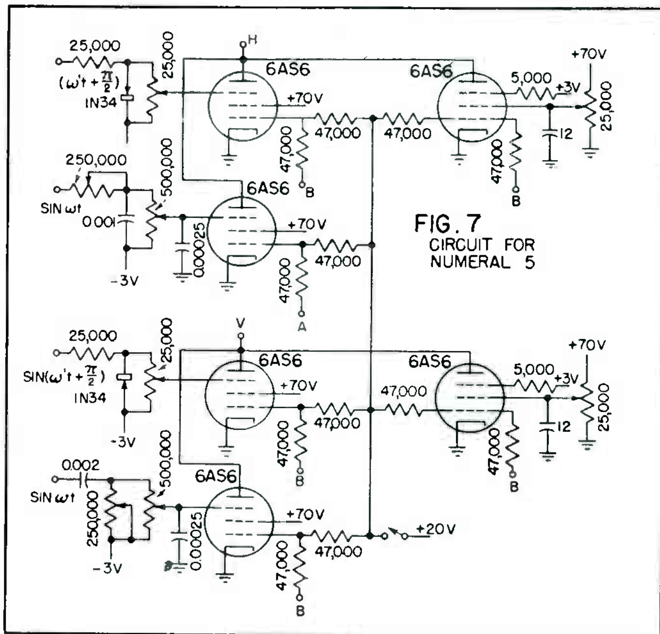


FIG. 7 CIRCUIT FOR NUMERAL 5

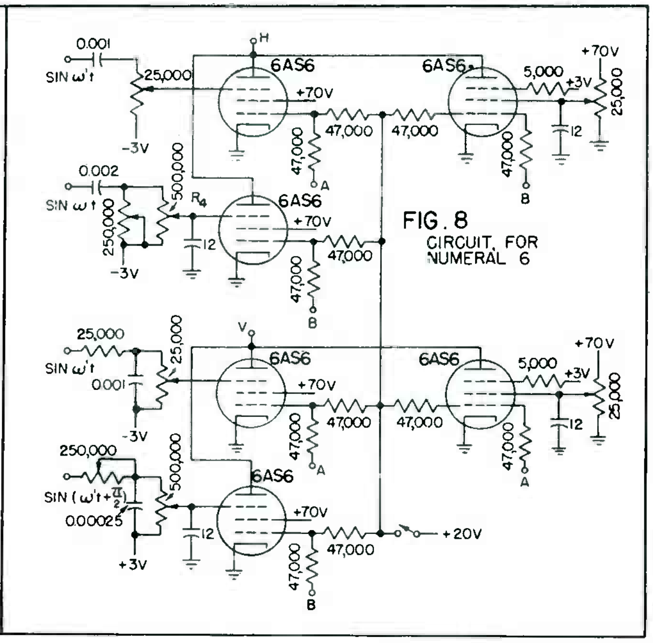


FIG. 8 CIRCUIT FOR NUMERAL 6

quire half-ellipse patterns invariably require a second component. This second component is displayed during the half cycle of the square wave in which the half-ellipse is turned off.

The last technique is that used to position on the screen of a cathode-ray tube one component of a number with respect to the other. This positioning is done with a "positioner" tube, the anode of which is connected to a second tube. The second tube is the one which generates a deflection plate voltage waveform and the positioner tube is switched on and off together with it. During the time in which the two tubes conduct, the positioner tube draws a constant but adjustable plate current through the common load resistor, and therefore sets an adjustable voltage level for the waveform. This action has the effect of shifting the position of one component with respect to the other.

Numeroscope Design

Before considering the numeroscope circuits, it would be well to mention that constant reference is made to two different sine waves. In the diagrams the two are distinguished by angular velocities ω, and ω′. The sine wave with angular velocity ω has a frequency of 2,000 cps, while the sine wave with angular velocity ω′ has a frequency of 5,500 cps.

The input circuit of the numeroscope shown in Fig. 1 uses two sine wave generators for the 2,000 cps and the 5,500 cps mentioned above. The input circuit furnishes these two sine waves to the rest of the circuit as well as the inverted sine waves of these two frequencies, all of which are needed to obtain the variety of directions and positions of the broken line and half-ellipse components of the ten numbers. Type 6AS6 vacuum tubes are used as inverters, and 6J4's as cathode followers. In the remainder of the circuits, 6AS6's are used.

Also shown in the input circuit is a square wave generator which is operated from and is therefore of the same frequency as the 2,000 cps sine wave generator.

The circuit for the number 0 appears in Fig. 2. The circuit consists of two phase shifting circuits, each with amplitude controls, R_1, for feeding two tubes with sine waves differing in phase by 90-degrees. The plate loads of the tubes are shown, from one of which the vertical deflection plate voltage for the cathode-ray tube is taken, and from the other the horizontal deflection plate voltage. In the other number circuits, the plate loads are not shown, for the same plate load is common to all plates feeding the horizontal deflection plates, and the same load is common to all plates feeding the vertical deflection plates. The switch in the circuit is for turning the number 0 on by making the normally cut off control grid go positive. This number requires no square wave switching.

The circuit for number 7 shown in Fig. 3 forms another single component broken line pattern demanding no switching or positioning circuits. Type 1N34 crystal diodes are used for obtaining the rectified sine waves. The potentiometers, R_1, are amplitude controls to adjust the size and shape of the pattern. The resistors, R_2, between the potentiometers and the suppressor grid, are decoupling resistors for the two rectified sine wave inputs.

The circuit for number 2 appears in Fig. 4. The number consists of an upper half-ellipse component, and a broken line component. V_1 and V_4 produce the horizontal and vertical deflection plate voltages, respectively, for the broken line component of the number 2; this component of the number is displayed, as can be seen from the gating connections, during the half of the square wave cycle in which terminal B of the square wave generator is most positive. The input circuit (Fig. 1) shows that the two outputs of the square wave generator are biased down to −9 volts. None

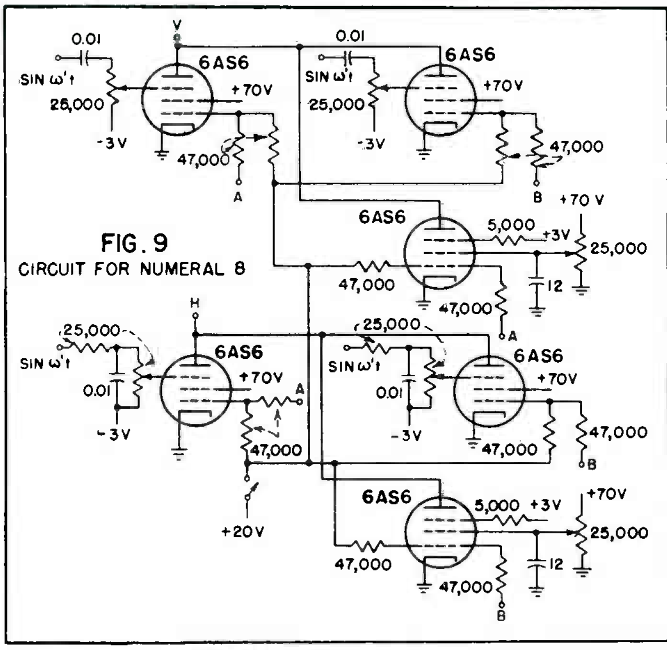


FIG. 9
CIRCUIT FOR NUMERAL 8

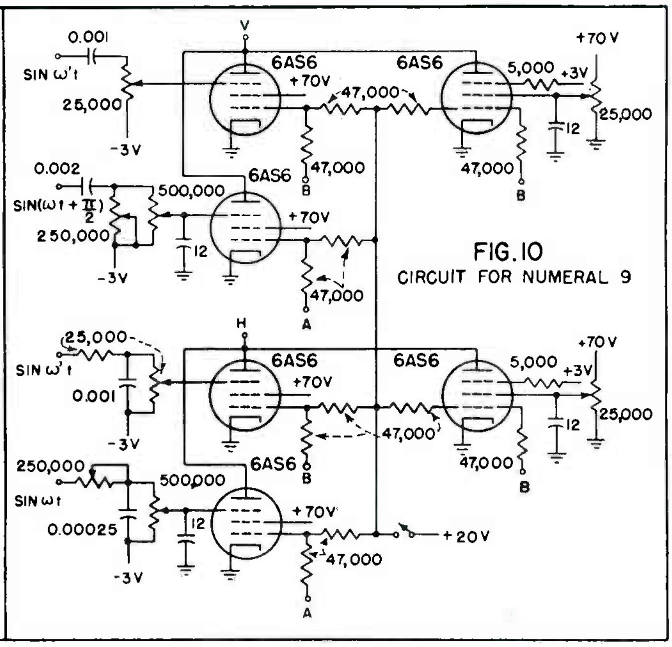


FIG. 10
CIRCUIT FOR NUMERAL 9

of the tubes in the circuit for number 2, therefore, will conduct until the switch to +20 volts is depressed. Tubes V_3 and V_6 produce the voltages making the half-ellipse component of the number during the other half of the square wave cycle. In the phase shifting circuits of both tubes, R_5 is the phase shift control, and R_4 the amplitude control. A small bypass capacitor C_3 is used to eliminate a sharp pulse that occurred when the tube commenced to conduct by the control grid going positive; the pulse was of short duration, but it nevertheless produced a noticeable distortion on the end of the half-ellipse pattern. Tubes V_2 and V_5 are the horizontal and vertical positioner tubes respectively. The screen grid voltage is used to control the anode current, and the anode current, in turn, positions one component with respect to the other. It will be noticed that the positioner tubes may only lower the voltage level of the pattern being displayed. If it happens, for example, that the voltage level of the waveform produced by V_6 of Fig. 4 is too low to adjust the position of the two components of number 2, then the gating connection of V_6 must be switched from *A* to *B* in order that the voltage level of the other component can be lowered instead.

The circuits for other numbers are given complete in Fig. 5 to 10.

A 5-inch DuMont model 208 oscilloscope is used to display the numerals, the vertical and horizontal deflection plate voltages being fed directly to the deflection plates of the cathode-ray tube by resistor-capacitor coupling. The saw tooth generator, though it is not used to provide a horizontal sweep in this circuit, is nevertheless synchronized with the 2,000-cps sine wave. The blanking pulse produced in the oscilloscope by the sharp wavefront of the saw tooth waveform serves to eliminate much of the retrace fluorescence that would otherwise surround the pattern.

Equipment Layout

Two requirements largely determine the layout shown in the under-chassis view: a low cumulative plate to ground capacitance, and electrostatic isolation to prevent stray pickup. For these reasons the three-partition layout was chosen. Controls are mounted on the partition panels for short leads. All sine wave leads from the input circuit, and all square wave switching leads are run in shielded cables.

The circuits to produce the Arabic numerals were developed to fit the need of high speed calculators for a rapid printer, but of more general interest is the fact that with the circuit techniques described, and perhaps other related techniques, increasingly complex designs consisting of many components could be built up and displayed on a cathode-ray tube completely electronically. By using an electronic counting circuit with six stable states, the two stable states of the square wave switching voltage have been replaced by six, and three numbers have been traced upon the screen of a cathode-ray tube at once.

Using the circuit techniques that have been presented, circuits for the letters of the alphabet become straightforward. Electronic-photographic printers might find application in an extremely rapid radioteletype system, or wherever a large amount of information must be printed rapidly.

Acknowledgement

The author wishes to indicate Howard H. Aiken, Technical Director of the Computation Laboratory of Harvard University, as the originator of the electronic-photographic printer. Benjamin L. Moore and Morris Rubinoff contributed to the development of the numeroscope.

Reference

(1) The numeroscope, a symposium on large-scale digital calculating machinery, Annals of the computation laboratory of Harvard University, vol 16, Harvard University Press, 1947.

Low Frequency Compensation for Amplifiers

Two unconventional interstage coupling networks for low-frequency amplifiers are developed. One has a grounded load resistor, thus providing a low impedance output; the other requires very little capacitance, thus decreasing size and cost. Design requirements of the networks are analysed

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MANY MODERN APPLICATIONS of electronics, such as radar, television, electrocardiography, industrial vibration analysis, and electrical gaging, require amplifiers that pass very low frequencies. For example, although in some applications large amplifier distortions may be tolerated because the output can be corrected by clipping and limiting, in television and facsimile where halftone shading must be faithfully reproduced even a little distortion is objectionable. Therefore, the resistance-capacitance coupled amplifiers (used because of their freedom from drift found in directly coupled amplifiers) require compensation to pass very low frequencies.

Three Types of Circuits

Figure 1A shows the usual type of interstage coupling with low-frequency coupling, called plate series compensation. The equalizing impedance $R_{1S}C_{1S}$ is connected in series with the plate load R_{2S}. Figure 1B shows the equivalent network comprising two resistances and two capacitances, one of which is shunted by R_{1S}. It is this leakage resistance across C_{1S} that causes low frequency cutoff. The limitation could be removed by providing additional leakage across the corresponding capacitor C_{2S} in the other arm. However, the resulting d-c transmission that this resistance would provide excludes this practice in most applications, except perhaps for the final stage of a video amplifier. Obviously the available plate supply voltage limits the maximum value of R_{1S} hence large capacitances are required if coupling is to extend sufficiently into the low frequencies.

These conditions are somewhat improved in the circuit of Fig. 1C. Resistor R_{1P} is in parallel with the

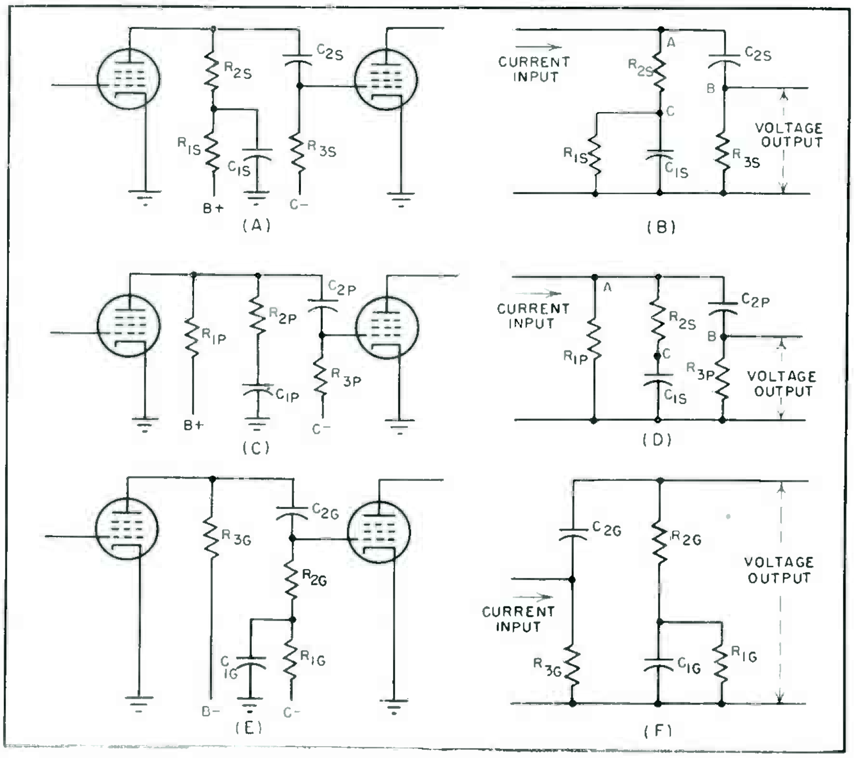

FIG. 1—At (A) is a conventional low-frequency compensating network; (C) and (E) are two other networks that provide the same response but with less compensating capacitance

*This manuscript was written and the work it describes was done while the author was with the Columbia Broadcasting System.

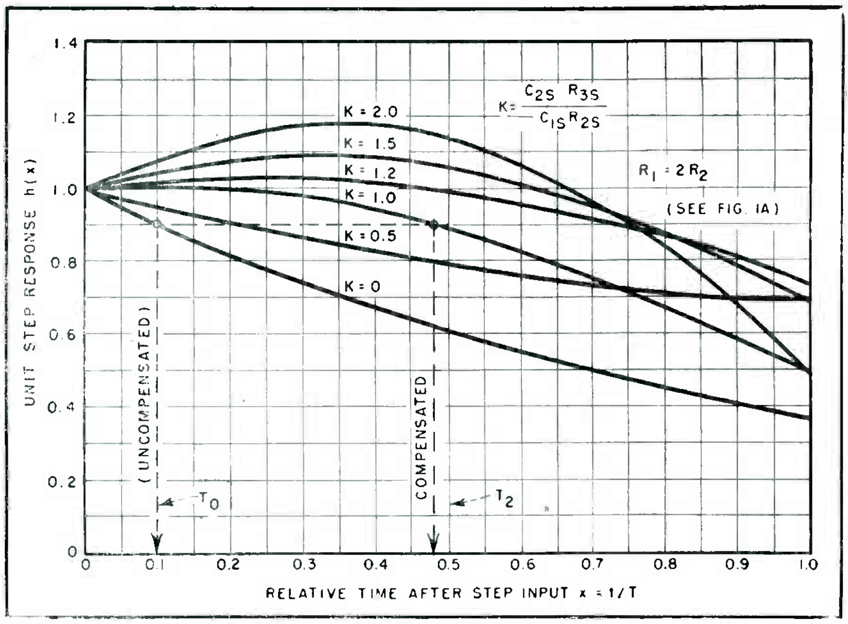

FIG. 2—Network response to a step input for various degrees of compensation is shown against time relative to circuit time constant

load resistor R_{2P}; thus the circuit may be referred to as plate shunt compensation. The equivalent network, shown in Fig. 1D, can be transformed into the equivalent plate series network of Fig. 1B, or vice versa, by the relations

$$R_{1P} = R_{2S} + R_{1S}$$
$$R_{2P} = R_{2S}\,[1 + R_{2S}/R_{1S}]$$
$$C_{1P} = C_{1S}\,[R_{1S}/(R_{2S} + R_{1S})]^2$$

Note that the plate filter capacitance C_{1P} for plate shunt compensation is considerably smaller than its equivalent C_{1S} for plate series compensation. The elements R_{2P} and C_{1P} may change places without affecting the low-frequency performance of the signal at *B*. The circuit then presents a grounded resistor at point *C*, which offers a convenient source of video signals from a low impedance but without low-frequency compensation.

Figure 1E shows a grid compensation system in which the shunted capacitor combination $C_{1G}R_{1G}$ is located in the grid branch and the plate coupling capacitor C_{2G} is assumed as ideal. The compensation resistor R_{1G} passes only small grid and leakage currents and can therefore assume higher values than its counterpart in the other two circuits. Adequate compensation is obtained with much smaller capacitances, as demonstrated by both theory and practice. If grid compensation is employed, paper capacitors can replace the larger and less reliable electrolytic capacitors.

Figure 1F presents the equivalent grid compensation network. Comparison with Fig. 1B reveals as the only difference the interchange of the points of current input and voltage output. From circuit theory it follows that, with equal elements throughout, both systems are perfectly equivalent. Therefore the following analysis of the pulse response of the series plate compensated stage is applicable to all types of low-frequency compensation.

Unit Step Response

In the following analysis the tube is treated as a constant-current generator with practically infinite impedance. The effect of screen current is neglected. Grid bias is assumed to be available from an external source and all cathodes are directly connected to ground. A unit step of current is applied at point A of Fig. 1B. The midband load resistance is

$$R = R_{2S}R_{3S}/(R_{2S} + R_{3S})$$

The transfer impedance from A to B is then

$$\frac{Z}{R} = \frac{p(p + c)}{(p + a)^2 - b^2} \qquad (1)$$

where $p = j\omega$, and the transfer impedance is the same in the inverse direction. In Eq. 1, a and b are closely related to the arithmetic and geometric means of two characteristic frequencies ω_1 and ω_2, which are in turn defined by the time constants T_1 and T_2 of the compensating and coupling networks respectively

$$1/\omega_1 = T_1 = C_{1S}R_{1S}$$
$$1/\omega_2 = T_2 = [C_{1S}C_{2S}/(C_{1S} + C_{2S})][R_{2S} + R_{3S}]$$

The mean values of these characteristic frequencies as they appear in Eq. 1 are

$$a = \tfrac{1}{2}(\omega_1 + \omega_2)$$
$$b_2 = a^2 = \gamma g^2$$
$$c = \omega_1/\alpha$$
$$g = (\omega_1\omega_2)^1/^2$$
$$\gamma = C_{1S}/(C_{1S} + C_{2S})$$
$$\alpha = R_{2S}/(R_{2S} + R_{1S})$$

Equation 1 gives, by operation, the unit step response of the network (see G. W. Carter, "Calculation of Electrical Transients", p 99, Eq. 11 and 12)

$$h(t) = \epsilon^{-at}\,[\cosh(bt) + [(c - a)/b]\sinh(bt)] \qquad (2)$$

To discuss Eq. 2 in technical terms, expand it into a power series in *t* so that

$$h(t) = 1 - (c - 2a)t + (b^2 + 3a^2 - 2ca)\,(t^2/2) - \ldots$$

The first order term should vanish because this condition indicates a horizontal tangent at $t = 0$ (step response starts flat). For this condition $c - 2a = 0$ we obtain

Flat top

$$R_{2S}C_{1S} = R_{3S}C_{2S}$$

which condition holds regardless of the value of R_{1S}.

The signal droop at the end of *T* seconds can now be assessed. Putting the condition for flat top into the power series gives

$$h(t) = 1 - g^2(t^2/a) + ag^2(t^3/3) - \ldots$$

Because the sign of the third order term is positive, the drooping of a compensated stage after *T* seconds of unit step transmission is smaller than $0.5(gT)^2$. Thus we obtain

Step droop

$$\delta \leq \frac{T^2}{2R_{1S}R(C_{1S} + C_{2S})^2}$$

Note that the droop is determined by such fundamental constants of the network as a-c impedance, d-c leakage, and total capacitance.

Figure 2 presents the unit step response of a stage with plate series compensation for various ratios of time constants in the two bridge arms, and the response of an uncompensated stage for comparison. The compensated stage handles pulses about five times wider than the uncompensated stage with equal droop. In general, the improvement through low-frequency compensation is

$$T_2^2 = 2T_0T_1$$

where T_2 is the duration of pulses handled by the compensated network and T_0 is the duration of pulses handled by the uncompensated one, with equal amounts of drooping. A high value of T_1 for the compensating arm is desirable, hence grid compensation functions much more efficiently than plate compensation. Practical design data are presented in Fig. 3.

Square-Wave Response

Before applying these results to television amplifiers, it must be shown that square-wave response of the network does not exhibit signal distortions in excess of those calculated for unit step operation. Let

$$g(t) = 0.5\,(-1)^n \qquad nT \leqq t < (n+1)T \qquad n = 0, 1, 2 \;\ldots$$

be the expression for a square-wave signal with an amplitude of one volt and a period of $2T$. Heaviside's superposition theorem then relates the square-wave response $H(t)$ to the unit step response $h(t)$ as

$$H(t) = g(t) - [0.5 + \sum_{n=0}^{\infty} (-1)^n h(\theta + nT)]$$

where θ is the time difference between the occurrence of the last unit step and the instant t of the observation. The sum represents the influence on the network of an infinite number of preceding unit steps. Fortunately this series converges to

$$H(t) = g(t) + 0.5\left[1 - \frac{\epsilon^{aT}h(t) + \epsilon^{-aT}h(t-T)}{\cosh(aT) + \cosh(bT)}\right] \qquad (3)$$

Figure 4 shows how the square-wave response H can be derived graphically from the unit step response h in accordance with Eq. 3. To obtain H at any time t, take $h(t)$ at that time, as well as a fraction ϵ^{-2aT} of the same function T seconds earlier. Superimposing these two components yields the square-wave response $H(t)$.

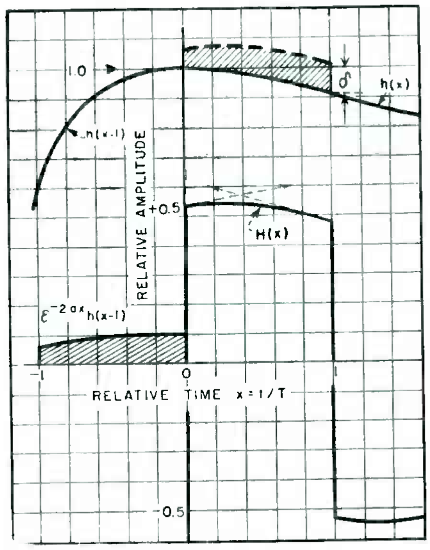

FIG. 4—Development of square-wave response from step response

In Fig. 4 the procedure is applied to a compensated network which has a step response with a horizontal tangent at $t = 0$. The square-wave response of the same network exhibits a slight positive rise at the start of each period. To correct for the rise, the network should be slightly undercompensated. Further, in contrast to the step response, which droops in one direction only, the actual square-wave output shows both positive and negative deviations from the ideal flat. The sum of the distortions, however, does not exceed the ten percent droop of the unit step response during the same time interval. Because this agreement tends to improve for smaller distortions, circuit design based on the conditions for flat top and step droop for the step function seems entirely justified for television.

Practical Conclusions

Figure 3 shows circuits designed by the above approach using the three types of low-frequency compensation. All three circuits were designed to transmit a 1/120 second pulse with a droop of less than 2 percent (1/60 second pulses with less than 6 percent). All circuits have the same d-c plate resistance of 10,000 ohms and the same a-c signal impedance of 3,300 ohms. The value of plate load yields a bandwidth of 4.5 mc if it is used as the termination of a two-section constant-k filter to obtain high-frequency correction.

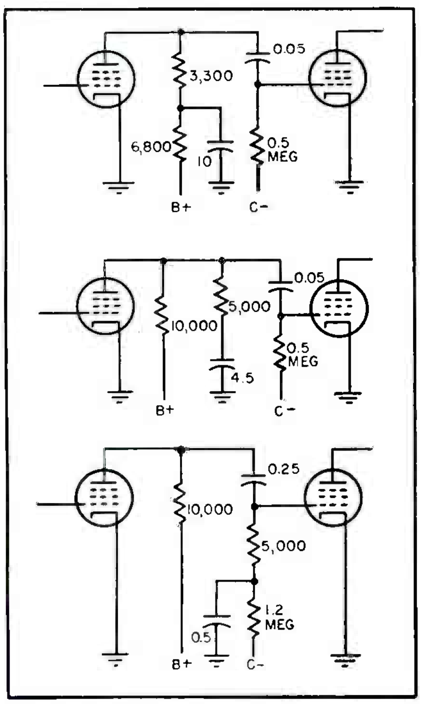

FIG. 3—Typical values of three types of compensating networks giving the same performance

The conventional plate series compensation needs an electrolytic capacitor of 10 microfarads, the plate shunt circuit uses less than half this capacitance, and the grid compensated circuit requires only 1/20th of the capacitance necessary in the plate series network, or 0.5 microfarad. Because such small capacitors are available with paper insulation, a drastic reduction in size and cost is possible with grid compensation instead of plate compensation. Also the dependability is improved and variations due to aging or overload are minimized.

Whereas the plate compensation capacitor operates at plate voltage, the grid compensation capacitor operates at the small grid bias voltage. These advantages over plate series compensation are realized to some degree by the plate shunt method.

One disadvantage of both plate shunt and grid compensation is that neither offers as much protection against hum and slow fluctuations of plate voltage as does the plate series network. The plate series circuit of Fig. 3 has 28-db attenuation for 60-cps hum between plate supply and grid, while the other two circuits have only 10-db attenuation. This decreased hum attenuation necessitates a somewhat higher investment in power supply filter capacitors, but they are less critical than those in the interstage coupling network. Video amplifiers with two and three stages have been built with the grid compensation network of Fig. 3 and were found to be very satisfactory and stable in operation. By using modern titanium dioxide dielectric capacitors the coupling networks were made unusually small.

Speed Control

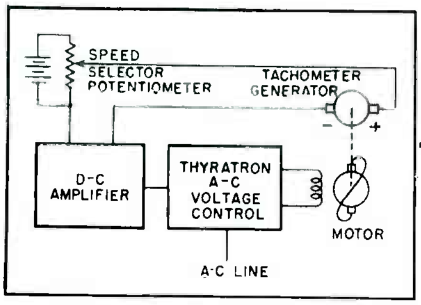

FIG. 1—Difference in voltages from tachometer generator and speed-selector potentiometer results in error signal. This signal, after being amplified, actuates thyratron control circuit

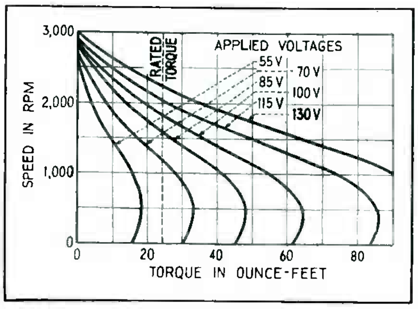

FIG. 2—Speed-torque curves for a 4-pole, ½-h-p, 115-volt repulsion motor. Because the speed characteristic of this type of motor is sensitive to changes in voltage, it is particularly suitable for control systems of the kind described here

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SPEED CONTROL of small motors operating from a-c supply is expensive, particularly in most machine tool applications where it is required that speed be well maintained under load for various preset values. Two controls capable of excellent performance are motor-generator systems of various types, and thyratron-rectifier systems for supplying variable armature voltage to d-c motors. The cost of either of these controls, however, in many cases is ten or more times the cost of the motor, so that they must be ruled out for many applications where their characteristics would otherwise be most desirable.

A simpler control giving a reasonably flat speed-torque characteristic can be obtained by employing thyratrons to regulate the alternating voltage applied to an a-c commutator motor so as to maintain the preset speed under load. Such a system is essentially an adjustable electronic governor. Full voltage is applied to the motor until its speed approaches the preset value. Then the voltage is automatically reduced to a value just sufficient to maintain the desired speed. If the load increases, the voltage is increased correspondingly so that only a very small drop in speed takes place.

Servo Control System

The elements of a complete system of this kind are shown in Fig. 1. The speed selector consists of a constant d-c source and a voltage divider, which provides a voltage proportional to the desired speed. This voltage is bucked against a d-c voltage proportional to the actual motor speed obtained from a tachometer generator. The varying difference in voltage is amplified and applied to the input of the thyratron control, causing corresponding variations in the a-c voltage applied to the motor. Basically, the system is a simple type of servomechanism or closed-cycle control system because the control is actuated by the error, or the difference between the input and the output. The gain of the amplifier can be made sufficient so that only a small difference between the speed selector voltage and the tachometer voltage will cause full line voltage to be applied to the motor with consequent rapid acceleration. As the motor approaches the desired speed, the applied a-c voltage is reduced until equilibrium is reached at a constant speed. When this condition occurs, the tachometer voltage will be very closely equal to the speed selector voltage. Moreover, the speed calibration of the selector in volts per hundred rpm will be very nearly the same as that of the tachometer generator up to the maximum speed that can be provided by the motor.

If the load is increased, more voltage must be applied to the motor to maintain the preset speed. To increase the motor voltage, more d-c control voltage must be applied to the thyratrons. This change in voltage divided by the gain of the amplifier, equals the voltage that must be provided by the tachometer generator. Thus, a small but definite drop in speed must take place when the load is increased. This requirement of a finite error voltage is, of course, characteristic of systems of this kind. The actual variation of speed with torque for a given speed setting depends on the speed-torque characteristics of the motor at various voltages, as well as on the thyratron control characteristics and amplifier gain.

Use of A-C Commutator Motors

The characteristics of a-c commutator motors are particularly suitable for a control of this type. Not only is the speed characteristic sensitive to voltage in the desired manner, but high torque, also, can be provided at low speeds. These facts are illustrated in Fig. 2, which gives a family of speed-torque curves for a 4-pole, 1/2-hp, 115-volt repulsion motor at various constant applied voltages. It will be seen that a speed of 500 rpm can be maintained from no load to well beyond rated torque by varying the applied voltage. At no load at this speed, the electronic control should supply of the order of 30 volts to the motor. At a torque of 18 ounce-feet the voltage should be raised to 55, and at 33 ounce-feet to 70 volts. If the control could automatically supply exactly these required voltages as the load varied, the speed-torque curve of the motor and control would be a horizontal line, but, as pointed out, some drop of speed is necessary to provide the control voltage required by the thyratrons to raise the motor voltage.

Thyratron-Shunted Transformer

In addition to a motor that will respond properly to variations in

* Paper presented at National Electronics Conference in Chicago, 1947.

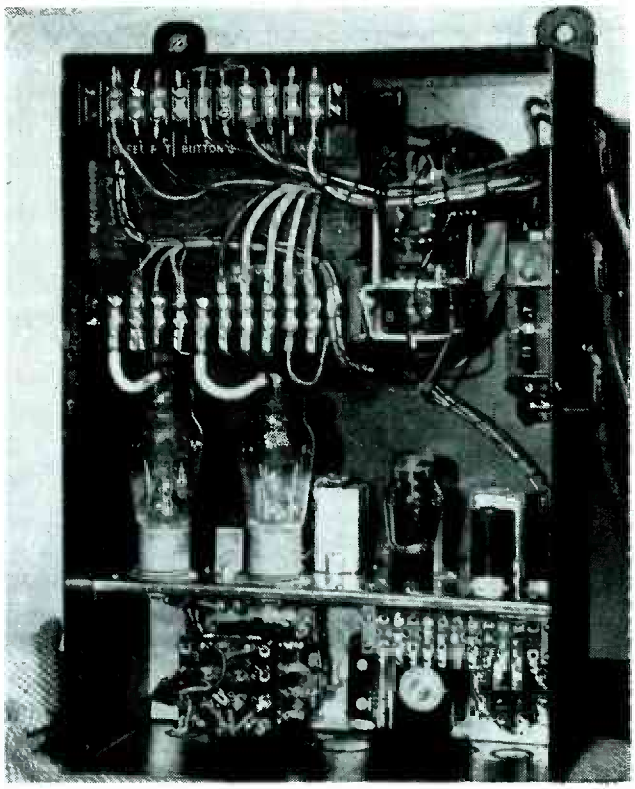
for Small A-C Motors

Using small thyratrons costing only a few dollars per kva of power controlled, this system maintains speed of variably loaded motor within 6 percent of preset values that fall within upper 2/3 of motor speed range. Shunted-transformer circuit minimizes thyratron voltage rating requirements

voltage over the desired range of speed and torque, the system requires, as its other basic element, a device that can control the a-c voltage supplied to the motor in response to small variations in the d-c voltage supplied by the speed-selector potentiometer and by the tachometer generator. A saturable reactor with a suitable amplifier to supply the control current at once suggests itself. But since the speed of response of the saturable reactor is comparable to that of the motor, the use of such a combination would tend to result in an unstable system. The arrangement finally adopted is one which has been used to some extent for voltage regulation and lighting control. It consists of a transformer shunted by a thyratron or pair of thyratrons and placed in series with the load and line as shown in Fig. 3.

When the thyratrons are not firing, the current through the motor is limited to the magnetizing current of the transformer, which is made small enough so that the motor will not start. When the thyratrons fire for part of each half cycle, short-circuiting the secondary, current flows through the motor during the firing time. This current is limited only by the low resistance of the transformer. Essentially, the motor is connected directly to the line during the firing time and disconnected during the remainder of the cycle.

A phase-shifted a-c bias is employed with the d-c control voltage in the conventional arrangement so that as the control voltage is increased, the thyratrons just commence to fire near the end of each half cycle. With larger control voltages, the instant of firing moves progressively nearer the beginning of the cycle. Increasing the d-c control voltage, therefore, causes the rms value of the motor voltage to increase smoothly until full line voltage is applied. Although this system distorts the waveform at reduced voltage, the distortion becomes negligible as maximum output voltage is approached. The system has the great advantage that its response is very rapid, within one cycle or one-half cycle, so that a stable, closed-cycle system can be easily provided for motor speed control.



Shunted transformer, thyratrons, d-c amplifier, reversing relay and speed-selector potentiometer are contained in this chassis

Economical Use of Thyratrons

Another important advantage of this type of thyratron control circuit is that the step-up ratio of the transformer can be used to take advantage of the full peak forward voltage rating of the thyratrons, making it possible for relatively inexpensive tubes to control large amounts of power. If the peak value of the transformer secondary voltages is made equal to the peak-

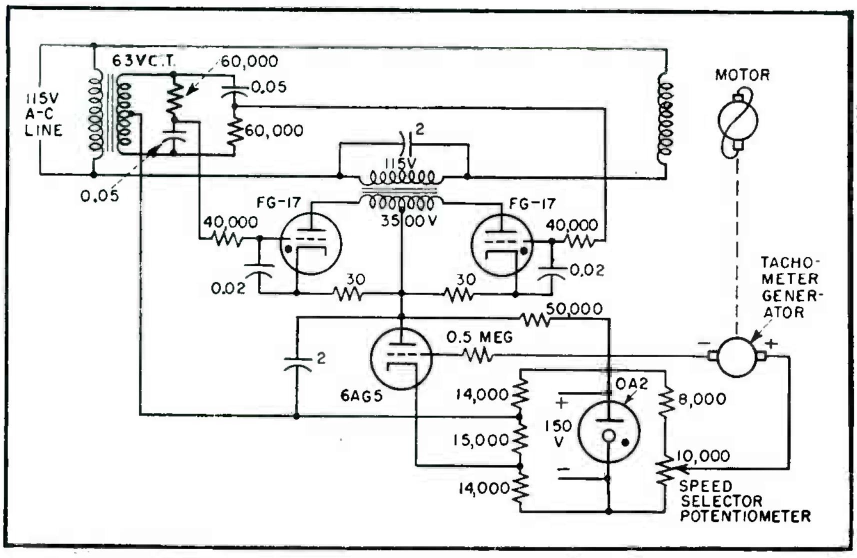


FIG. 3—Motor current flows during periods when transformer is short-circuited by firing of thyratrons. Length of firing periods, and therefore speed of motor, is controlled by changes in thyratron bias voltage

forward-voltage rating of the tubes, it can be shown that the number of volt-amperes which can be controlled by a thyratron equals $\pi/4$ multiplied by the product of the peak-forward-voltage rating and the average current rating. Ratings of a few industrial tubes are shown in Table I.

The tube cost per kva can thus be brought down to a few dollars, even in low-power equipment, although the transformer must have a rating equal to the volt-ampere rating of the load and becomes the most expensive single component of the control. The well-known arrangement of a pair of inversely-connected thyratrons has control characteristics similar to those of the present arrangement and avoids the use of a transformer, but the tube rating must be high enough to carry the full load current. The transformer increases the capacity of even the lower-voltage thyratrons by a factor of 3 or 4 at 230 volts and by twice this amount for 115-volt operation. In comparison with the inversely connected thyratron pair, the transformer system saves the higher initial and replacement cost of the additional thyratron capacity, saves the corresponding additional heater power, and in many cases, benefits from the shorter warmup time of the smaller tubes. In comparison with a system using thyratrons as rectifiers to supply armature power, which also requires a transformer, the tube cost saving is clear gain.

Circuit Details

The circuit shown in Fig. 3 employs a full-wave thyratron. Small cathode resistors in conjunction with time delay networks in the grid circuits insure satisfactory division of the load. Without this precaution, one tube may take a progressively larger share of the load as full firing is approached until the other tube ceases firing altogether and the circuit operates on a half-wave basis. The cathode bias requires the use of separate filament windings for the two tubes. Xenon-filled tubes which were tried divided the load satisfactorily in a full-wave circuit without this complication, possibly because the gas pressure, and consequently the firing point is not progressively shifted as one tube heats more than another under load. The a-c bias voltage for the thyratrons must be in opposite phase for the thyratrons firing on half cycles of opposite polarity. The two R-C circuits required are connected across a single, center-tapped, transformer winding. The rest of the circuit consists of a d-c amplifier, having a gain of about 18, and the associated power supply, which also provides the constant d-c voltage for the speed-selector potentiometer. The output of the tachometer generator is 2 volts per 100 rpm, so that 40 volts is required across the speed-selector potentiometer for speeds up to 2,000 rpm.

Table 1—Thyratron Characteristics

	Average Current Amperes	Peak Forward Voltage	A-C Control Volt-Amperes
3C23	1.5	1,250	1,473
C3J	2.5	750	1,473
FG-17	0.5	2,500	982
5545	6.4	1,500	7,550
NL-714	1.0	1,250	982
FG-172	6.4	2,000	10,050

Range of Speed Control

Performance curves for a ½-hp, 4-pole repulsion motor operating with the control are given in Fig. 4. At speeds below rated speed effective control is readily obtained from no load to well beyond rated torque. At higher speeds control is available only up to the point where full voltage is applied to the motor, beyond which the speed curve follows the constant 115-volt characteristic shown. The upper curve taken for a no-load speed setting of 2,500 rpm, illustrates this characteristic. For this setting regulation occurs only up to very light loads. At greater loads the thyratrons are supplying maximum voltage and can no longer exert control.

The motor should be so designed that it can supply the required torque at maximum speed with somewhat less than the maximum voltage available from the control, which is about 10 percent less than the line voltage. For the curves shown, the motor had a standard 115-volt winding and the voltage was boosted 10 percent before being applied to the control, but the motor could equally well have been wound for lower-voltage operation. If a wider speed range is required than for the 4-pole motor shown, a 2-pole repulsion motor can be employed to cover twice the speed range, or a series motor to reach still higher maximum speeds. Satisfactory control has been obtained over a speed range of more than 100 to 1. In fact, the speed control can be turned down until the motor makes only 2 or 3 rpm, and uniform rotation will continue if no appreciable load is applied.

Figure 4 shows that the rise in speed from full load to no load is about 100 rpm at the rated motor speed of 1,725 rpm. As the setting of the speed selector is decreased, the speed rise diminishes, approaching a final value of 35 to 40 rpm. This decreased speed rise occurs because less voltage change is required at the motor at lower speeds to compensate for a given change in torque. Also, a smaller change in the tachometer voltage and less change in speed are required to produce the necessary change in the thyratron control voltage.

Speed Regulation

Speed regulation curves for the 4-pole motor are given in Fig. 5, expressed both as percentage and as rpm rise in speed from full load to no load. The percentage regulation varies between 4 and 6 percent between 600 and 1,800 rpm, as the reduction in the required control voltage almost balances the drop in operating speed. At speeds below 600 rpm, the percentage rise increases rapidly, the rpm rise between full load and no load remaining constant at the 35 rpm value. Thus, in addition to permitting speed adjustment over a wide range, the control provides reasonably flat speed regulation.

Torque Ratings

A third important factor is the maximum torque available at various speeds throughout the control range. It would be highly satisfactory if the torque rating of an adjustable-speed motor could be maintained constant at speeds below base speed. A d-c shunt motor is sometimes assumed to have a constant torque rating for a wide speed range when armature voltage control is used, because the same armature current produces the same torque and the same I^2R losses. But the greatly reduced efficiency of the cooling fan requires considerable reduction of the allowable continuous-duty torque. Moore[1] gives data on a 1-hp motor operating on pure d-c voltage which at the same torque had twice the temperature rise at 100 rpm as at 1,750 rpm, although the total losses were twice as great at the higher speed, largely because of increased friction and windage.

The repulsion motor is most efficient and commutation is best near synchronous speed. Greater current, involving higher I^2R losses, is required to develop the same torque at lower speeds. One would expect, therefore, that the reduction in torque rating between base speed and low speed would be appreciably greater for the repulsion motor than for the d-c shunt motor. In addition, the fact that the motor voltage waveform is distorted by the a-c control at low speeds would be expected to result in increased losses. This increase in losses was not found to be serious. Consequently, the reduction of rating is determined largely by the motor characteristics.

A favorable factor which compensates to a great extent for this difference at low speeds is that no derating with the a-c system is required at base speed. The increase in losses from the distorted waveform, which is small at low speeds, becomes entirely negligible as base speed is approached and the output voltage of the control becomes more nearly sinusoidal. Therefore, the motor with the present control can be used at its full rating near base speed, whereas, as shown also by Moore, the shunt motor with thyratron control must be derated about one-third, even at base speed, because of the form factor of the rectified armature voltage. The combination of the low-speed derating with this base speed derating of the d-c system is believed approximately equal to the low-speed derating of the repulsion motor, so that the two systems should require comparable oversize motors. A series motor requires approximately the same current to deliver a given amount of torque throughout the speed range. Hence, it is possible that one of the special motors of this type, designed to reduce commutation difficulties, will prove more efficient than the repulsion motor at low speeds. Where a maximum speed of the order of 10,000 to 12,000 rpm is desired, a standard universal motor is almost ideal for use with the control and can deliver considerable power for its size over a wide speed range.

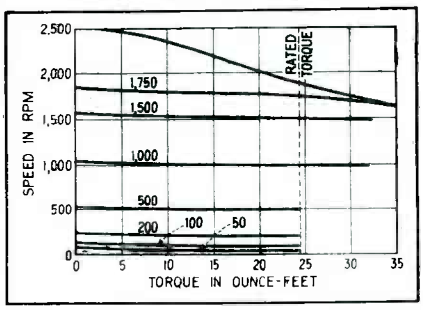


FIG. 4—Speed-torque characteristics for a ½-h-p, 4-pole, 115-volt repulsion motor operating with the control system described. Droop of the 2,500-rpm curve results from inability of control circuit to deliver to motor a voltage greater than that of line

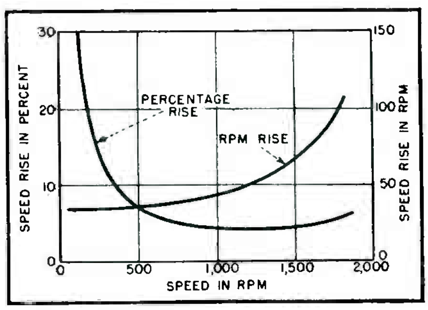


FIG. 5—Speed regulation curves for the 4-pole motor. Speed rise as motor loading changes from full load to no load is given in rpm and percent

The simplicity of the system is illustrated by the size of an experimental control unit for a 1/2-hp, 115-volt electrically reversible repulsion motor. All components, including the transformer, reversing contractor, and overload breaker are enclosed in a case 6 by 12 by 18 inches. Two 3C23 tubes can supply between 25 and 30 amperes to the motor without exceeding their continuous-duty rating. This permits fast starting and instant reversal without any provision for current limiting. Because small tubes are used, the warmup time is only 15 seconds.

The writer wishes to acknowledge courtesies generously extended by the Leland Electric Company, including the supplying of special motors, test equipment, and operating data.

REFERENCE

(1) Raymond W. Moore, Performance of D-C Motors Running on Thyratron Rectifiers, *Elec. Mfg.*, p 124, March 1946.

High-Speed Resistor Tester

Pigtail resistors are checked against a standard with a percentage limit bridge at a speed of 1,800 per hour. An electronic null detector and special fixtures reduce hand operations to a minimum

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Convenient layout of controls and switches permits minimum movement by the operator

In manufacture of electronic equipment, the percentage limit bridge with its usual accessories often fails to meet all resistor-testing requirements. In the design to be described, the instrument is arranged for maximum utility and speed of operation. The physical design of the equipment has been influenced primarily by job analysis and motion study.

The equipment consists of two assemblies so that maximum table space is made available to accommodate other testing operations. All major sources of heat are isolated from the operator, and from the calibrated components, by being mounted in the rear assembly. The front assembly shown in Fig. 1 contains the complete bridge circuit and the null-indicating instrument. This confines all points of operation to a small space and allows minimum motion of both hands and eyes. The sequence of motions by the operator are natural, rhythmical, and as nonfatiguing as possible.

Sequence of Operations

An operator, when inspecting pigtail type resistors, takes them from stock a handful at a time. The individual resistor is delivered to the test clips while being held by its leads, one in each hand. After the resistor is inserted in the test clips, the operator's hands are removed from the test circuit while the limit measurements are being made by continuing the motion of the forearms downward. When the release motion is completed, the limit-switching operation follows automatically since the motion of the right arm is terminated by striking (with the bottom of the hand) a large Bakelite platform which is mechanically coupled to the limit switch.

The operator's cues to observe the indicator are the operations of releasing and switching. If the switching operation causes the indicator needle to cross zero (mid-scale) the resistor is known to be within the limits indicated by the settings of the limit controls. The resistor is then removed by a reversal of the insertion operations.

Although the limit-switching operation might be regarded as a motion that should be eliminated, it becomes useful in this arrangement as an inducement for the operator to remove his hands from R_x. At the same time the switching operation has been reduced to a negligible loss.

Gross time study of the operation of this equipment, inspecting one-watt carbon resistors with axial leads, shows an operating speed of about 1,800 pieces per hour for a male operator.

Null Indicator

In the design of the electronic d-c null indicator shown schematically in Fig. 2, some sacrifice has been made in voltage sensitivity. But, since the input resistance to this instrument is 10 megohms, the current sensitivity is better than 0.001 microampere per least scale division. The voltage sensitivity is

Panel controls and contact jigs of the bridge unit and accessory electronic unit

still great enough for 0.1 percent discrimination with as little as 5 volts applied to the bridge. The electronic null indicator allows the limit bridge to be applied proficiently to resistances ranging between 5 ohms and 50 megohms, a ten-million-to-one ratio.

The circuit of the null indicator consists of a series-balanced d-c voltage amplifier direct coupled to a parrallel-balanced current amplifier. The input of the voltage amplifier is actuated from the null terminals of the bridge through a light a-c filter.

The circuit quantities shown provide ample sensitivities, and zero drift is low enough not to require filament voltage regulation to stabilize contact potentials. At the same time the variable-mu grids obtain a semilogarithmic deflection pattern (see Fig. 3) which is considered most desirable in some applications.

Tube matching is the most critical provision for these circuits. If tube selections are favorable, the zero drift may be less than two degrees deflection (equivalent to about 10 mv) with line voltage variations of 10 percent. The first stage deserves the most favorable choice of tubes and it is also desirable that the input tube be a hard one to minimize the effects of input resistance variation. This latter requirement is not too critical, however, since the final zero adjustment may be corrected for any particular setup, after which the remaining errors will be entirely negligible.

Power Supply

The power supply is inadequate for operating the bridge through the very low end of the resistance range but it takes care of all battery requirements for values above 100 ohms, which include the wide majority of applications. It adjusts itself automatically to the ideal requirements throughout its applicable range.

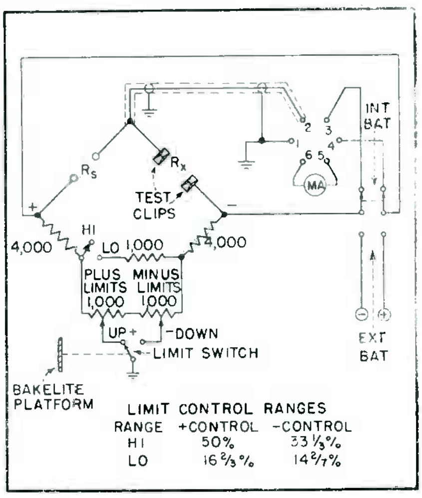


FIG. 1—Schematic of bridge assembly. The panel meter has a 0.5-ma zero-center range and the resistors are accurate to ±0.1 percent

There is no pretense of using the VR-75 for regulating purposes. Rather, this tube serves as an automatic voltage limiter which will not shunt the output circuit as maximum load current is approached. The maximum output voltage obtained was chosen as approximately the maximum which cannot be sensed by an operator's fingers. No greater voltage is ever required because of the high current sensitivity of the null indicator.

Maximum output power, obtained at the deionization potential of the VR-75, is about 1.75 watts. Since the multiplier consumes almost ¾ watt, there remains only one watt to be divided about evenly between the standard and the unknown. This feature provides ample protection against damaging overloads. The maximum current available to the test circuit is 25 ma. Whenever low resistance setups require more current than this, battery power will be more applicable.

The test clips are machined from ⅜-inch square stock. When made from hardened steel or finished in hard chrome plate they have been found to accommodate millions of insertions without noticeable wear. The two members of each contact assembly are bound together with a single screw against a compression spring. This arrangement provides for adequate adjustment of contact pressure, and convenience in dismantling for cleaning.

Reference

(1) Maurice Artzt, Survey of D-C Amplifiers, ELECTRONICS, p 112, Aug. 1945.

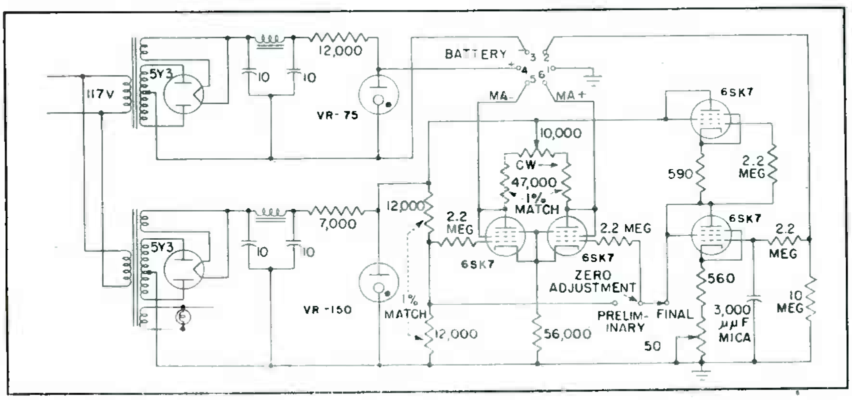


FIG. 2—Circuits of the voltage supply and null indicator amplifiers that form the accessory unit. This may be mounted away from the table area

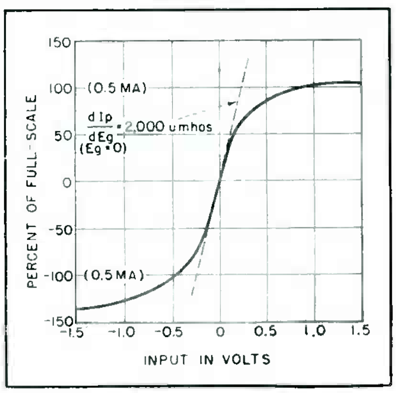
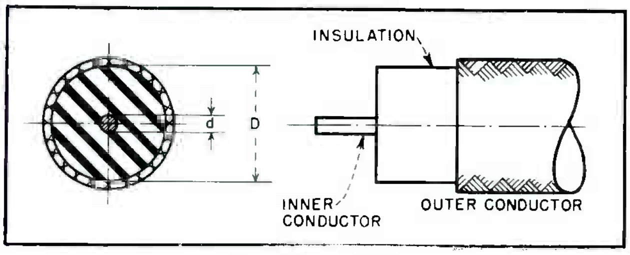
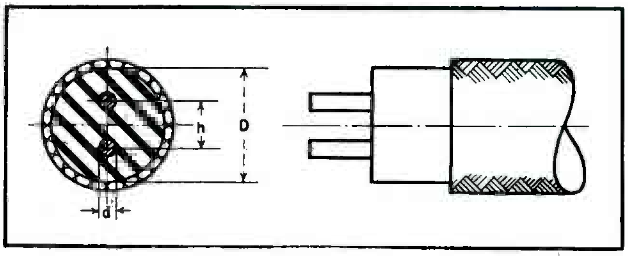


FIG. 3—Deflection curve of null indicator using remote cutoff tubes



Single coaxial line



Balanced shielded line

High-Frequency Cable

Practical design equations and two nomographs facilitate calculation of characteristic impedance, inductance, time delay, attenuation, and power rating for solid-dielectric coaxial and two-conductor balanced lines operating in h-f and vhf bands. A typical polyethylene cable design problem is worked out

THE TREND toward use of higher and higher frequencies during the last war necessitated a completely new approach to the design of high-frequency cables. Since some of the design data has until recently been classified, it was felt that a detailed review of high-frequency cable design would find wide application in the industry.

At high frequencies (in the megacycle range) the transmission line must be terminated in a load whose impedance is equal to the characteristic impedance of the line, in order to prevent reflections and standing waves that cause excessive power loss. For high-frequency operation, therefore, the characteristic impedance of the cable becomes one of its most important properties.

Characteristic impedance in ohms, usually denoted Z_0, is determined by

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \qquad (1)$$

where R is resistance in ohms per unit length, L is inductance in henrys per unit length, C is capacitance in farads per unit length, and G is conductance in mhos per unit length. This reduces to

$$Z_0 = \sqrt{L/C} \qquad (2)$$

since R is very small compared to ωL and G is very small compared to ωC.

Coaxial Lines

The most common type of high-frequency cable is the coaxial cable in which the outer conductor completely surrounds the centrally disposed inner conductor. At high frequencies the internal inductance is negligible due to the skin effect which confines the current to the outer surface of the inner conductor and the inner surface of the outer conductor. The inductance of a coaxial cable then becomes

$$L = 0.140 \log_{10} (D/d) \qquad (3)$$

and the capacitance is

$$C = 7.36\, k/\log_{10} (D/d) \qquad (4)$$

where L is in microhenrys per foot, C is in micromicrofarads per foot, D is the outside diameter of the insulation, d is the diameter of the inner conductor, and k is the dielectric constant of the insulating material.

Substituting Eq. 3 and 4 in Eq. 2 gives the useful design equation for characteristic impedance in terms of the diameters of the conductors and the dielectric constant of the insulating material.

$$Z_0 = \frac{138}{\sqrt{k}} \log_{10} (D/d) \qquad (5)$$

The nomograph in Fig. 1 gives a rapid solution of Eq. 5.

In the foregoing equations, d represents the outside diameter of a solid inner conductor. For the usual concentrically stranded seven-strand conductor, 93 percent of the maximum conductor diameter is used as the effective diameter.

From Eq. 4 and 5 another equation is obtained which is useful in determining the characteristic impedance of a cable from actual measurements of the capacitance C in $\mu\mu$f per foot and the dielectric constant k

$$Z_0 = 1{,}016\, \sqrt{k}/C \qquad (6)$$

Velocity of Propagation

Radio waves travel at a speed of 300 million meters per second in

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Design

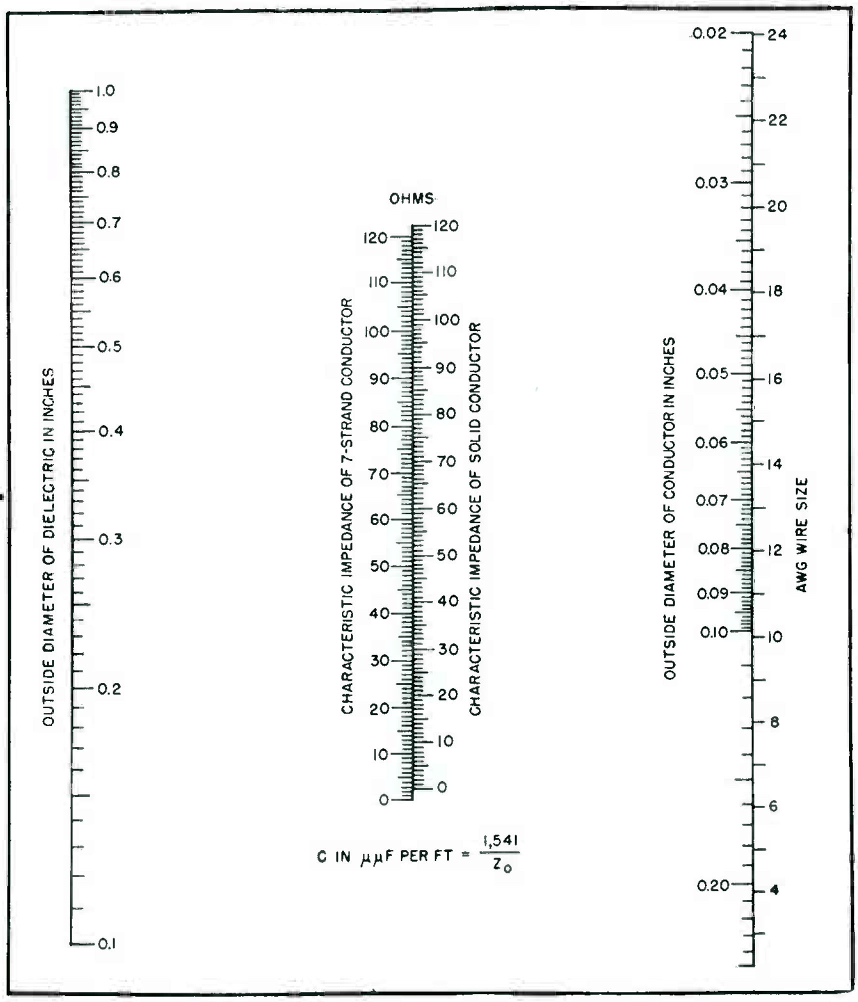

FIG. 1—Nomograph giving characteristic impedance of polyethylene-dielectric single coaxial line. For solid inner conductor, read answer on righthand portion of center scale; for stranded inner conductor, use maximum outer diameter on conductor scale at right and read answer on lefthand portion of center scale

free space. The velocity of a wave propagated along a solid dielectric cable is related to the dielectric constant and the velocity in free space by the relation

$$\frac{v}{c} = \frac{1}{\sqrt{k}} \qquad (7)$$

where c is the velocity of propagation in free space and v is the velocity of propagation in the cable. For polyethylene insulated cables the statistical average of the ratio v/c is 0.663. The velocity of propagation and the dielectric constant can be calculated by finding the resonant frequency of a known length of cable open-circuited at the far end.

The time in microseconds per foot for a wave to travel through a cable can be determined from Eq. 3, 4, and 7

$$T = \sqrt{LC} = \frac{1.016 \times 10^{-3}}{v/c} \qquad (8)$$

Balanced Lines

Whenever it is desirable to transmit power from a balanced source, neither side of which is grounded, the balanced line is used instead of the coaxial line.

Two-conductor shielded lines are designed for a specified characteristic impedance in accordance with the following relation

$$Z_0 = \frac{276}{\sqrt{k}} \log_{10}\left(2v\,\frac{1-Q^2}{1+Q^2}\right) - \frac{120}{\sqrt{k}}\left(\frac{1+4v^2}{16v^4}\right)(1-4Q^2) \qquad (9)$$

where $Q = h/D$ and $v = h/d$, and h is the center-to-center spacing of the conductors. This line has one primary disadvantage in that it is only flexible at right angles to the plane through the two parallel wires. Any attempt to bend it in another direction will damage the conductors or the dielectric. This difficulty has been overcome by separately insulating each conductor to a diameter equal to the desired center-to-center conductor spacing. The insulated conductors are then twisted and another extrusion of dielectric is applied to obtain the final circular cross-section. This not only improves the flexibility of the line but also improves the balance characteristic by providing a closer tolerance on the conductor spacing. Moreover, since the conductors change their positions relative to the shield there is less tendency to unbalance than in the parallel-conductor arrangement where it is possible for one conductor to be closer to the shield for the entire length of the line.

The design of the unshielded twin-conductor parallel transmission line which is used for dipole transmitting and receiving antennas is based upon a certain amount of actual experience. Satisfactory results have been obtained with the relation

$$Z_0 = 120\left(\frac{v}{c}\right)\cosh^{-1} h/d \qquad (10)$$

where h is the center-to-center spacing of the conductors, d is the effective conductor diameter, and v/c is as defined in Eq. 7. The value of v/c was determined from measurements of actual lines as 68, 70, and 81 percent for 75, 100, and 300-ohm lines respectively at 100 mc.

When an extremely high degree of electrical balance is required, two coaxial lines are enclosed in a common braid. The characteristics of each coaxial are determined by precise measurements before the lines are assembled under the common braid and jacket. The characteristic impedance of twin coaxial lines is the sum of the impedances of the individual coaxial units.

Low-Capacitance Lines

For certain applications, capacitance lower than normally possible with solid-dielectric materials is required. Coaxial lines insulated with polyethylene are usually made with impedances ranging from 30 to 150 ohms. The capacitance of a 150-ohm line, obtained from Eq. 6, is 15.6 $\mu\mu$f per foot. The ratio of dielectric diameters, obtained from Eq. 5, is nearly 43 to 1. If No. 22 AWG solid conductor is used for this cable, the dielectric diameter would be 1.08 inches.

If the effective dielectric constant is reduced by replacing part of the dielectric material with air, it is possible to obtain capacitances below 10 $\mu\mu$f per foot. This is accomplished by wrapping a thread of polyethylene or other low-loss material around the inner conductor with a long lay and extruding a tube of polyethylene over the spiral. The polyethylene thread supports the tube and also centers the conductor. A capacitance of 10 $\mu\mu$f per foot can be obtained with a diameter ratio of 11 to 1.

Delay Lines

The time delay of solid dielectric lines is often used as a timing or calibrating device in radio applications, especially radar and television. However, when a greater delay than that possible with the usual coaxial line is required, it is necessary to employ especially constructed lines referred to as delay lines.

The delay line is exactly similar in appearance and construction to the usual coaxial line except that the inner conductor consists of an insulating core around which a spiral of insulated wire is wrapped. The inductance of a single-layer coil is then

$$L = 3.06 \times 10^{-2}\, \pi^2 n^2 a^2 \qquad (11)$$

where n is the number of turns per inch and a is the diameter of coil between wire centers, in inches. The inductance of the line is thus increased while the capacitance remains essentially the same.

Time delay T in microseconds per foot, which is the reciprocal of the velocity of propagation, can be computed from L and C

$$T = \sqrt{LC} = \frac{4.76 \times 10^{-4}\, \pi\, n\, a\, \sqrt{k}}{\sqrt{\log_{10} (D/d)}} \qquad (12)$$

Since the inductance of the line has been increased, it follows that the characteristic impedance has also been increased. From Eq. 2 the characteristic impedance becomes

$$Z_0 = \sqrt{\frac{L}{C}} = \frac{64.5\, \pi\, n\, a}{\sqrt{k}} \sqrt{\log_{10} (D/d)} \qquad (13)$$

It is possible with this construction to obtain impedances greater than 1,000 ohms without increasing the size of the line beyond practical limits.

A high-impedance line is often required in video-frequency transmission when it is desired to drive a terminated line from a high-impedance source.

Attenuation and Power Rating

Attenuation determines the length of line that can be employed and its power-handling capacity. The total attenuation of a line is due to the losses in the inner and outer conductors and the loss in the dielectric. The attenuation in db per 100 feet due to the copper loss is expressed by the relation:

$$A_c = 4.35\, R_t / Z_0 \qquad (14)$$

where R_t is the total high-frequency resistance of the inner and outer conductors in ohms per 100 feet. For solid copper conductors

$$R_t = 0.1 \left(\frac{1}{d} + \frac{1}{D} \right) \sqrt{F} \qquad (15)$$

where d is outer diameter of inner conductor in inches, D is inner diameter of outer conductor or dielectric in inches, and F is frequency in mc.

For other than solid copper inner and outer conductors, such as stranded inner conductors and braided outer conductors, other factors must be introduced to compensate for the effects of spiralling, proximity, and contact resistance. Equation 15 then becomes

$$R_t = 0.1 \left(\frac{R_1}{d} + \frac{R_2}{D} \right) \sqrt{F} \qquad (16)$$

and the total copper loss in db per 100 feet becomes

$$A_c = \frac{0.435}{Z_0} \left(\frac{R_1}{d} + \frac{R_2}{D} \right) \sqrt{F} \qquad (17)$$

where R_1 and R_2 are multiplying factors that are determined by the construction of the conductors and are also variable with frequency. It is necessary to combine experience with experimental data to estimate their magnitude in connection with actual design of various types of cables.

The attenuation in db per 100 feet due to the dielectric is dependent upon the frequency, dielectric constant, and power factor of the material

$$A_d = 2.78\, \sqrt{k}\, pF \qquad (18)$$

where p is power factor of dielectric, k is dielectric constant of dielectric, and F is frequency in mc. The total attenuation in db per 100 feet is then the sum of Eq. 17 and 18.

$$A = \frac{0.435}{Z_0} \left(\frac{R_1}{d} + \frac{R_2}{D} \right) \sqrt{F} + 2.78\, \sqrt{k}\, pF \qquad (19)$$

The power rating of a cable is a function of the maximum temperature which the insulation can safely withstand. The power-handling capability of the cable is limited by the rate at which the cable can dissipate the heat due to the copper and dielectric losses and the rate at which the heat is generated internally. The first depends upon the diameter of the cable, the color, texture, and materials of the jacket, paint, or armor, and the ambient temperature. The second depends on the dimension and construction of the conductors, the dielectric material, and the frequency, among other factors.

The amount of heat which flows radially from the components, conductors, dielectric, and braid will depend upon the temperature gradient, the thermal resistances of the dielectric and jacket, and the thermal resistance of the jacket surface to air (jacket emissivity). The relation for power input[1] is

$$P = \frac{T_o - T_a}{t_a\,(2A_c + A_d) + 2\,A_t\,(t_j + t_s)} \quad (20)$$

where P is maximum average power input, T_o is maximum temperature in degrees F that the dielectric can withstand, T_a is ambient temperature in degrees F, t_a is thermal resistance of dielectric, t_j is thermal resistance of jacket, t_s is thermal resistance of jacket surface to air, A_c is attenuation due to inner conductor, in nepers per inch, A_d is attenuation due to dielectric in nepers per inch, and A_t is total attenuation of the cable in nepers per inch.

For accuracy, values used for attenuation should be corrected to include the effects of temperature rise and any mismatch that may occur.

In view of the safety factor that is required in power rating, the following equation[2] for input power P has been found quite useful and easy to handle

$$P = \frac{K_1\,(K_2 + 6\,D_s)}{A} \quad (21)$$

where K_1 is 435 for black vinylite jackets and 326 for grey vinylite or armored cables, K_2 is 3 for 50-ohm cables and 2.5 for 75-ohm cables, A is attenuation in db per 100 feet, and D_s is outer diameter of cable in inches. This relation is based on a maximum temperature of 80C at the surface of the inner conductor and an ambient temperature of 20C.

If the ambient temperature is higher than 20C, the power rating of the cable is reduced; conversely, if the ambient is lower, the rating is increased. The results of Eq. 21 can be corrected by the nomograph shown in Fig. 2.

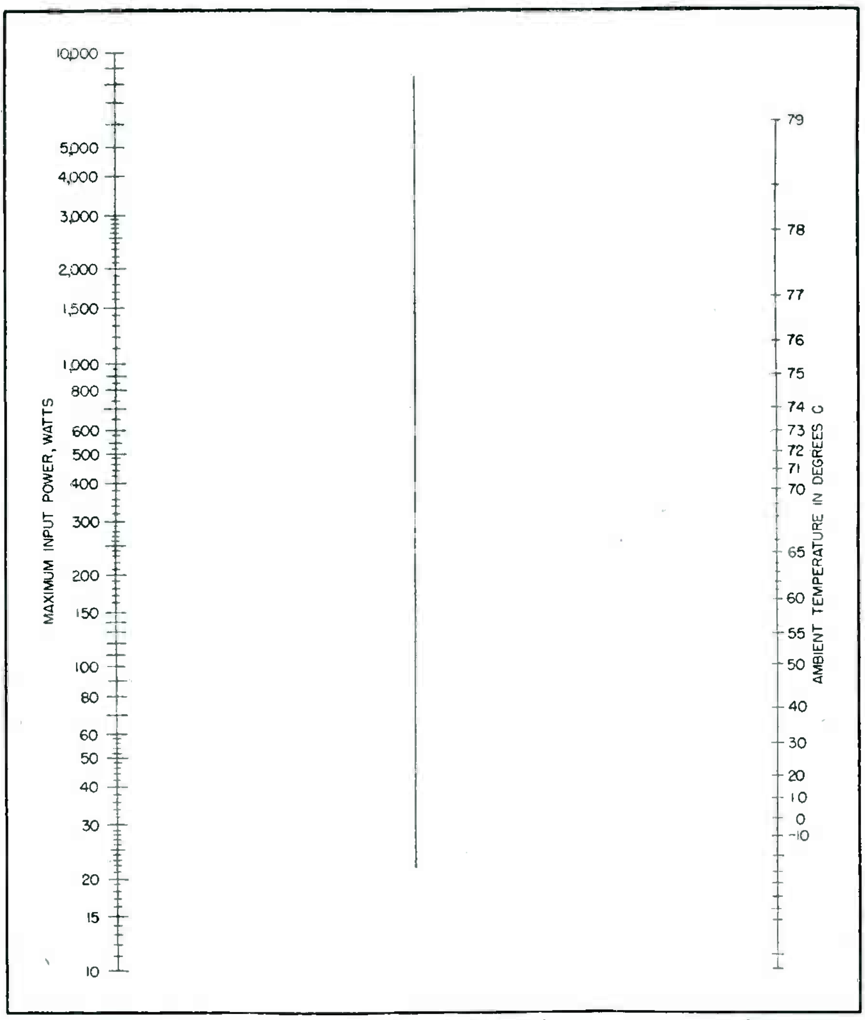

FIG. 2—Nomograph giving power rating at any ambient temperature when rating for one temperature is known. Values are based on maximum inner conductor temperature of 80C. Place straightedge on known values of power and temperature, mark intersection with center vertical scale, rotate straightedge about this intersection to new temperature value, and read new power rating on lefthand scale

Typical Design Problem

Required: A 70-ohm coaxial cable to transmit 7.5 kw of 100-mc power at an ambient temperature of 30C. The dielectric material selected is polyethylene with a dielectric constant k of 2.26, and the available jacket material is black vinylite.

Since the characteristic impedance is specified as 70 ohms, the ratio of D/d is fixed and equal to 5.75, as can be determined from Eq. 5 as follows:

$$70 = \frac{138\,\log_{10}\,(D/d)}{1.5}$$

Arbitrarily, a No. 5 AWG solid inner conductor is selected. Here d is 0.182 inch, so that dielectric diameter D becomes 1.05 inch. Using a typical thickness value of 0.225 inch for the braid and 0.05 inch (50 mils) for the jacket, the overall outside diameter D_s becomes 1.6 inch. From these values the attenuation and power rating can be calculated by using Eq. 19 and 21, assuming values of 1 for R_1 and 2 for R_2 based upon experience with cables having No. 30 AWG braid at 100 mc, and using a value of 3×10^{-4} for dielectric power factor p

$$A = \frac{0.435}{70}\left(\frac{1}{0.182} + \frac{2}{1.05}\right)(10) + 2.78\,(1.5)\,3 \times 10^{-4}\,(100) = 0.584 \text{ db per 100 feet}$$

From Eq. 21 the power rating at 20C is determined as

$$P = \frac{435\,(2.5 + 9.6)}{0.584} = 9{,}013 \text{ watts}$$

The power rating at 30C, obtained from the nomograph in Fig. 4, is then 7,500 watts.

REFERENCES

(1) L. C. Swicker, Recommended Values of Thermal Constants for Use in Estimating the Thermal Characteristics and Power Rating of Various Cables, Navy Report—Case 24893.

(2) Devised by F. A. Muller of Federal Telecommunications Laboratories, R-17.

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and W. H. FAULKNER Jr.
*Cruft Laboratory, Harvard University
Cambridge, Mass.*

Compact tuned amplifier designed for use with bolometer or crystal microwave detectors uses high-Q toroid coils to obtain narrow pass band and high gain. Sensitivity approaches thermal noise and gain is adequate for use with a suitable voltmeter

Bolometer Amplifier

A STANDARD arrangement for detecting microwave signals makes use of a bolometer or crystal detector whose output is fed through an amplifier and thence to a voltmeter. Crystals permit the use of an unmodulated source of microwave energy; then modulation usually is inserted at the amplifier input before amplification. In case a modulated source is used, the crystal or bolometer output can be coupled to an audio amplifier. The amplifier described was specifically designed for use with modulated signals.

The principal requirements for such an amplifier are: linear response over the full range of amplitudes to be handled; adequate gain; minimum noise level.

The first of these requirements is easily fulfilled over a voltage range of 80 db with standard design practice and adequate plate voltage. Likewise, the proper number of stages of amplification will furnish sufficient gain to drive any voltmeter. The fundamental limitation rests in the noise level.

In designing the present amplifier several precautions were taken to minimize the noise level. Band-pass amplifiers have long been used for this purpose; usually an RC network serves to peak the amplifier response. As may be seen on the circuit diagram in Fig. 1, the response of the amplifier described is determined by a tuned load in each plate circuit. Toroids with Polyiron cores are used as inductors. Several advantages accrue from this design.

Toroid Plate Inductors

In the first place, the toroids have a high Q of 60 which yields a very narrow pass band with the simplest circuit. The frequency response of the amplifier is shown in Fig. 2. The large effective plate load also permits full utilization of the tube gain. Toroids are insensitive to outside fields; hence no particular precautions need be taken in mounting them. The circuit with constants as shown in the diagram yields a voltage gain of 107 db with a pass band as shown of less than 20 cycles at 1.09 kc.

The circuit given uses a center-tap connection to the tube plate. An increase in gain of some 5 db per stage is obtained by connecting the plate to the top of the toroid. The pass band then appears to be very slightly increased. Since the amplification is adequate, the center tap was used in this instance.

A further reduction of bandwidth may be obtained by inserting more tuned circuits. However, this approach imposes severe frequency stability requirements on the modulator of the source without a commensurate improvement in the noise level. The rms noise voltage from a resistance R at an absolute

Table I—Amplifier Performance Data

Type of Input	Noise Level in db (0 db 1 volt)
Short Circuit	−160 db
Bolometer (10 ma Littelfuse) carrying 10 ma	−155 db
Crystal (1N21B)	−145 db
Gain	107 db
Maximum Output	100 v

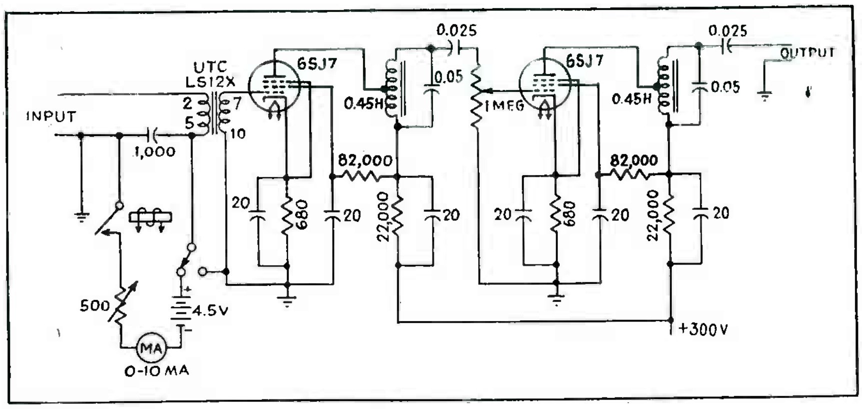

FIG. 1—Tuned plate load circuits use toroid inductors having Polyiron cores. The relay at the left disconnects the bolometer battery circuit when the tube filaments are turned off

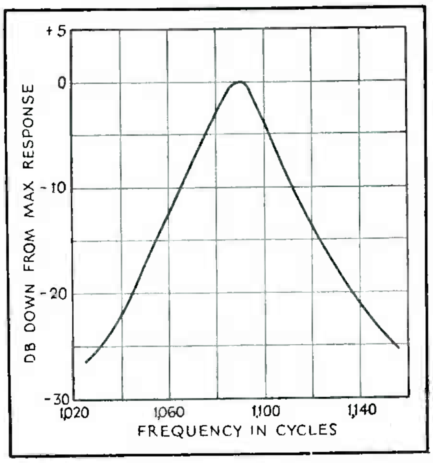

FIG. 2 — Amplifier frequency-response curve shows a bandwidth of less than twenty cycles at a point 3 db down from maximum response. This high selectivity results from the use of the high-Q toroids

temperature T is given by $V = 7.41\times10^{-12}(TR\Delta f)^{\frac{1}{2}}$ where Δf is the frequency band. The square-root term in the formula shows that a reduction in band from, say, two percent to one percent is relatively unprofitable. On the other hand it is essential that the band exclude 60 cycles and its principal harmonics.

Having eliminated noise sources outside the chosen frequency band, it remains to reduce contributions at the modulation frequency. Since bolometers require a d-c source, the input circuit is complicated by the presence of a battery and milliammeter. As shown in Fig. 1, a relay is also provided to open the battery circuit when the tube filaments are switched off. It was found that a 1,000-μf capacitor in parallel with these components reduces the noise level. Leads in the input circuit are kept short, shielded, and close to the chassis. This last precaution minimizes ground loops in the low-impedance input circuit.

The only resistor in the input circuit is in the cathode of the first stage. Its value is not critical but it must be wire-wound. Carbon resistors carrying current become noisy after a period of service.

Elimination of Microphonics

Another difficulty inherent in a high-gain tuned system is that of microphonic resonances. A particularly effective tube shield against microphonic resonances is used in this amplifier. Instead of screwing a shield can over the shock-mounted tube, the shield forms an integral part of the metal tube. This construction is accomplished by filling in the space between the tube envelope and shield can with Wood's metal. The resulting heavy unit is extremely insensitive to microphonics. The low melting point of the metal filler makes tube changes relatively easy.

The particular unit described is designed for use with a Ballantine voltmeter. In this service the performance data are given in Table I.

The resistance of the bolometer is roughly 200 ohms. Taking the operating temperature as 400 K and substituting in the equation, one obtains a value of noise approximately equal to 10^{-8} volt. Evidently the theoretical limit of performance has been approached. Comparison with a thermistor bridge and calibrated attenuator indicates that the minimum detectable microwave power at 3000 mc is of the order of 10^{-9} watt for the bolometer. The crystal is substantially more sensitive, of course.

Measurements were made of the amplifier output as a function of microwave input to a bolometer. For this purpose, an attenuator was used which consisted of a waveguide operated beyond its cutoff frequency and calibrated in terms of a Ballantine voltmeter. From the measurements obtained, amplifier output was found to vary linearly with bolometer input.

Various noise levels were measured with a 0 to 1-ma recording milliammeter. This measurement was made by coupling the a-c output of a Ballantine meter to the recorder through a copper-oxide bridge rectifier. With the amplifier input short-circuited and carrying no current, the noise level at the input was found to be about 0.6×10^{-8} volt. This voltage remained practically unchanged when a direct current of 10 ma flowed through the short-circuited input. When a bolometer carrying no current was connected to the amplifier input, the noise increased to about 1.0×10^{-8} volt. Noise of about 1.4×10^{-8} volt was measured when the bolometer carried 10 ma.

Considerable improvement in the signal-to-noise ratio is obtainable with adequate rapidity of response for most applications through the use of several microfarads of shunt capacitance.

The presence of a signal increases the apparent noise, hence the voltage levels given above were measured with the aid of an attenuator in the output circuit. A signal of 10^{-7} volt is, however, well above the noise on the meter, or on the recorder using no shunt capacitor.

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PROPAGATION of

Part II

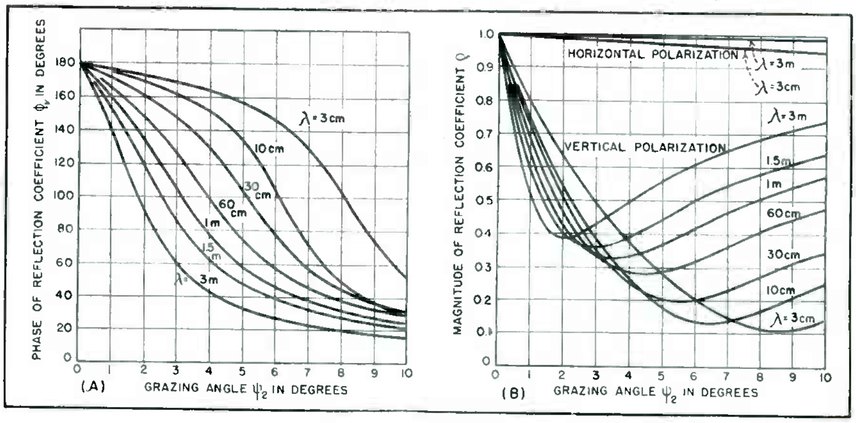

FIG. 7—Phase (A) and magnitude (B) of reflection coefficient as a function of grazing angle for a smooth sea. The phase curves are for vertical polarization

WE shall now consider the characteristics of the reflection coefficient, $\Gamma = \rho e^{-j\phi}$, as expressed by Fresnel's equations for specular reflection of a plane wave from a plane surface. If ε is the dielectric constant of the earth σ is its conductivity in mhos per meter and λ is in meters, and if $|\varepsilon - j60\lambda\sigma| \ll 1$, then Γ is given approximately by

$$\Gamma_v = \rho_v e^{-j\phi_v} \simeq \frac{\sqrt{\epsilon - j60\lambda\sigma}\,\sin\psi_2 - 1}{\sqrt{\epsilon - j60\lambda\sigma}\,\sin\psi_2 + 1} \quad (27)$$

$$\Gamma_h = \rho_h e^{-j\phi_h} \simeq \frac{\sin\psi_2 - \sqrt{\epsilon - j60\lambda\sigma}}{\sin\psi_2 + \sqrt{\epsilon - j60\lambda\sigma}} \quad (28)$$

where v and h denote vertical and horizontal polarization, respectively. It is well known that for soil ε and σ vary widely in a rather unpredictable manner, and we shall not attempt to discuss these variations here; but for sea water the variations are smaller and the values are more definitely known. Fig. 7 shows ρ and ϕ as given by Eq. 27 and 28, for sea water, using the best data available. The striking feature of these figures is the slight dependence of ρ and ϕ on wavelength and grazing angle for horizontal polarization, as contrasted with the marked dependence for vertical polarization. For the latter, ρ_v experiences a minimum at the complement of Brewster's polarizing angle familiar in optics, and ϕ_v undergoes its most rapid change. The phase lag ϕ_h is not shown, as it increases over 180° by less than 1°. It is important to notice that at grazing incidence ($\psi_2 = 0$) the two polarizations behave alike; all the incident radiation is reflected and is retarded in phase by π; thus $\Gamma = -1$ and the field is zero at the surface. This is true as long as ε and σ remain finite, but if σ is assumed to be infinite $\Gamma = +1$ for all ψ_2. Thus the assumption that $\Gamma = +1$ is not justified for the microwave region.

For relatively long wavelengths—say 1 meter or longer—the assumption of a smooth earth surface is reasonably valid, as attested by the large amount of practical data from meter-wave radar. As the wavelength becomes shorter, however, roughness of the surface becomes more important than ε and σ in determining the amount of specular reflection obtained; the tendency is, of course, toward diffuse scattering, which does not produce a well-defined interference pattern. No accurate method for determining the effects of roughness is known, but an estimate can be obtained from a criterion suggested by Lord Rayleigh. If h is the height of a surface irregularity, the surface tends to give specular reflection if $h \sin\psi_2 < \lambda/8$, and tends to give diffuse reflection if the inequality sign is reversed. Although not pretending to numerical accuracy, this criterion predicts the correct trend, showing that surface irregularities increase in importance as wavelength is decreased or grazing angle is increased.

The maximum and minimum values of field strength in the interference pattern are a measure of ρ. If the antenna pattern is so broad that it can be neglected, and if the lobe spacing is so small that ρ does not change appreciably between adjacent maxima and minima, Eq. 22 (Part I) gives

$$\rho = \frac{1}{D}\frac{F_{max} - F_{min}}{F_{max} + F_{min}} \quad (29)$$

Measurements of relative field strength in the maxima and minima thus afford an experimental means of determing ρ. Such measurements have been made by several methods. Figure 8 shows data obtained by flying a receiver at constant altitude through the interference pattern from a transmitter at the sea shore. Lack of accurate means of measuring the state of sea roughness precludes any but qualitative statements, but the scatter of points is believed to be attributable to reflections from time-varying rough wave patches, which tend to "fill up" the minima, increasing F_{min} and causing the indicated value of ρ to decrease. This is particularly true for horizontal polarization, because in the minima the direct and reflected waves are 180° out of phase and are very nearly equal in magnitude, and even a small "stray" reflection takes con-

VERY SHORT WAVES

This concluding installment treats the effect of surface reflections, two-way propagation typical of radar applications, and the variations caused by atmospheric refraction

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trol and determines F_{min}. Similar results were obtained concurrently on 3 cm.

Corresponding measurements over land show that *most* terrain produces diffuse scattering of 10- and 3-cm waves, and no well-defined interference pattern exists. Important exceptions are airport surfaces, flat desert country, and the like, which are often sufficiently smooth to give efficient specular reflection. Radar experience on meter waves indicates that a dependable interference pattern can be obtained if sufficient care is exercised in the choice of the site.

Propagation in Radar Problems

Extension of the above results to radar requires introduction of the effective scattering cross-section of the target, σ. It is defined *for free-space conditions* as the area intercepting that amount of incident energy which, if scattered isotropically, would give an echo equal to that from the target. That is,

$$\sigma = 4\pi R^2 \left| S_r/S_i \right| \qquad (30)$$

where S_i and S_r are the incident and reflected values of the Poynting vector. The value of S_i is given by Eq. 2 (Part I), $S_r = \sigma S_i/(4\pi R^2)$, and the received power $P_r = S_r A f_r^2 (\theta, \phi) = S_r G\lambda^2 f_r^2 (\theta, \phi)/4\pi$. Combining, we have the radar transmission equation *for free space*

$$P_r = P_t \frac{G^2 \lambda^2}{(4\pi)^3} \frac{f^4(\theta,\phi)}{R^4} \sigma \qquad (31)$$

where identical transmitting and receiving antennas are assumed. Comparison of this expression with the parallel expression for one-way transmission, Eq. 7, (Part I) shows that P_r depends in the same way on all corresponding variables except for range and antenna pattern function.

The free-space *radar* detection range may be found directly from Eq. 31, setting $f(\theta, \phi) = 1$, and $P_r = P_{min}$

$$R_0 = \sqrt[4]{\frac{P_t}{P_{min}} \frac{\sigma}{4\pi}} \sqrt{\frac{G\lambda}{4\pi}} \qquad (32)$$

Another numerical example is of interest. Assume that a 10-cm radar system transmits a peak power of 100 kw, the minimum useful received power is 10^{-12} watts, the antenna is identical with that given in the example (Part I), and the target cross-section is 20π sq. meters. Equation 32 indicates a free-space range of about 60 km, or 37 miles. (Had this radar system been used as a one-way communications system its free-space range would have been almost one million miles.)

The modification of the free-space radar equation to include the effects of the earth and atmosphere may be made easily for a *point* target in a manner analogous to that employed for one-way transmission. The antenna pattern function is replaced by F, giving

$$P_r = P_t \frac{G^2 \lambda^2}{(4\pi)^3} \frac{F^4 \sigma}{R^4} \qquad (33)$$

Unfortunately this treatment is

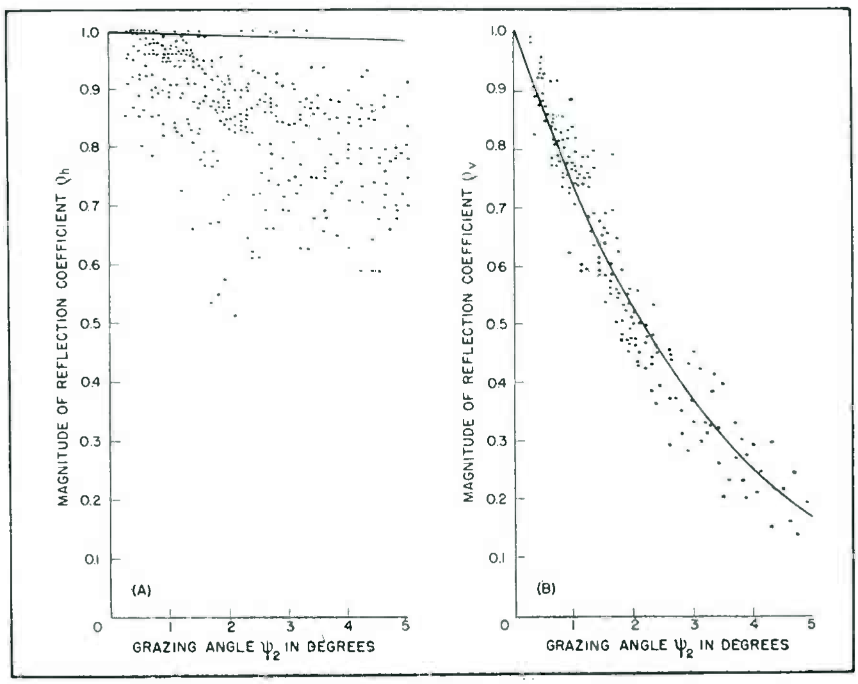

FIG. 8—Measured values of reflection coefficient over sea water at 10 cm, with horizontal (A) and vertical (B) polarization. Lines show theoretical values for smooth sea

in reality not as simple as it appears at first glance, because σ is only a convenient mathematical fiction for any but the simplest of targets. The simplest target is a perfectly conducting sphere, for which σ is essentially the geometrical cross section, πr^2, for r/λ greater than about 4. Most targets consist of a large number of scattering surfaces, the reflections from which interfere and cause the echo to fluctuate in amplitude over wide limits with small changes in target aspect. This effect becomes more pronounced as the ratio of object size to wavelength increases. The microwave scattering pattern from an aircraft, for instance, contains a very large number of fine lobes in the solid angle 4π; consequently the echo fluctuates very rapidly and the radar is likely not to "see" the target every time it scans the region of the target if the scan rate is rapid. (This echo fluctuation is *in addition to* that arising from the passage of the aircraft into and out of the lobes of the interference pattern.) As a result it is necessary to establish arbitrary definitions of σ appropriate to the type of target, radar, method of display of data, the minimum allowable percentage of "hits," and many other parameters. Once these conventions are established numerical values for σ can be obtained which allow estimation of performance by Eq. 32. Subject to these limitations, radar coverage diagrams may be prepared from the equation $R = R_0F$ just as for one-way transmission, and the region enclosed by the diagram is that inside which the target is detectable with the degree of certainty agreed upon. Useful values of σ for wavelengths of 10 or 3-cm range from under 100 sq ft for small aircraft to roughly 700 sq ft for heavy bombers.

An additional complication enters if a target with appreciable height such as a ship is very near the earth's surface, because of the variation of the incident field with position on the target. Assuming a plane earth with $\Gamma = -1$, this variation is given by Eq. 12 (Part I). If the target were "lumped" at a height z_2, then Eq. 33 would give

$$P_r = P_t \frac{G^2\lambda^2\sigma}{4\pi^3R^4} \sin^4\left(\frac{2\pi z_1 z_2}{\lambda R}\right)$$

and for sufficiently small values of the argument of the sine function

$$P_r = P_t \frac{4\pi G^2\sigma}{\lambda^2 R^8} (z_1 z_2)^4$$

It is found experimentally with microwave radar at low altitudes that if appropriate care is exercised in treating the rapid fluctuations of echo strength, a ship echo varies on the average as $1/R^4$ out to some reasonably well defined range, beyond which it varies roughly as $1/R^8$, and in many practical cases falls below the detection limit while varying according to this law. Such behavior would be expected from a point target at a fixed height above a plane earth, from a vertical flat sheet, and from certain other simple models. The actual values of σ are not constant, but vary with radar height, target size and aspect, wavelength, range, and other factors; but by judicious division of the range of the variables approximate values of σ for ships have been determined, and may be used to obtain estimates of radar performance on ship targets.

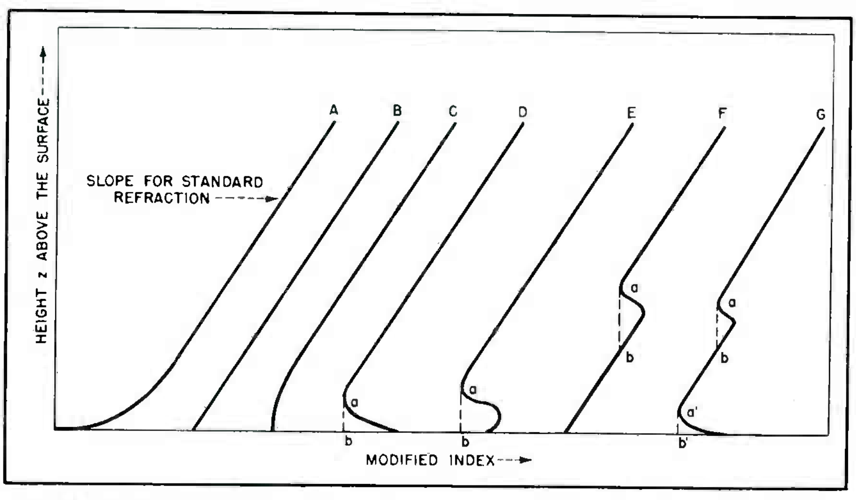

FIG. 9—Idealized modified index profiles: *A*, substandard surface layer; *B*, standard refraction; *C*, superstandard surface layer; *D*, same as *C* with surface duct; *E*, elevated superstandard surface layer with surface duct; *F*, same as *E* with elevated duct; *G*, surface and elevated superstandard layers with ducts. In each case, the duct extends from *a* to *b*, and *a'* to *b'*

Atmospheric Refraction

Thus far the effects of the atmosphere have been neglected. It is well known that the gradual decrease of the atmospheric index of refraction with increasing altitude and the accompanying increase of phase velocity cause a slight distortion of the wave front and a tendency for the waves to follow the earth's curvature. If the index decreases essentially linearly with height the effect is as if the propagation occurred over an earth with no atmosphere but with an effective earth's radius greater than the true radius.* If the effective radius a_e is known the methods described above can be applied by substituting a_e for the true radius a. The generally accepted value of a_e/a is 4/3, giving $a_e = 5{,}280$ statute miles. The refraction in this case is called *standard* refraction and gives rise to *standard* propagation.

Considerable work has been done in an attempt to discover geographical and seasonal variations of the effective earth's radius. It is now clear that such investigations are not particularly significant, however, because when marked variations of the refractive index gradient occur the concept of an effective earth's radius loses its validity, and other methods are necessary to give a meaningful description of refraction phenomena.

Large variations in refractive index gradient are best expressed in terms of a parameter called the *modified* index of refraction, N, defined by

$$N = h\,(1 + z/a) \simeq n + z/a \qquad (34)$$

where n is the atmospheric index of refraction at the height z (n de-

* Schelleng, Burrows and Ferrell, "Ultra Short Wave Propagation," *Proc IRE* vol 21, p 427, 1933.

parts from unity by only about 3×10^{-4}). The modification consists of adding the term z/a, thereby introducing the curvature of the earth into the refraction problem. The modified index is useful because it permits treatment of the complicated problem of a spherical earth with atmospheric index of refraction n as the simpler problem of a plane earth and equivalent index of refraction N. It is also important because it is a clearly defined boundary between the meteorological side of the problem, which takes the meteorologist as far as determining n as a function of height, and the electromagnetic side, which begins with n (or N) and concerns the effect of a given variation of N with height upon field strength. Neither phase of the problem can be given in detail here, but a few of the most important features and some interesting practical results may be outlined.

The absolute value of n is not important, but the vertical gradient of n or N

$$\frac{dN}{dz} = \frac{dn}{dz} + \frac{1}{a}$$

determines the characteristics of the propagation. In the absence of atmospheric stratification dn/dz is essentially independent of z, and

$$\frac{a_e}{a} = \frac{1}{a\frac{dN}{dz}} = \frac{1}{1 + a\frac{dn}{dz}}$$

When dn/dz varies with z, marked transmission abnormalities are likely to occur and give rise to *nonstandard propagation*. (The term *anomalous* propagation is also frequently employed, but it has been so abused that it is avoided here.) Some basic forms of N as a function of z, called *modified index profiles*, are shown in Fig. 9. In each case the region in the vicinity of the atmospheric "layer" in which the slope departs from the constant value for the remainder of the profile is responsible for transmission vagaries.

The regions marked $a-b$ show marked affinity for very short radio waves; if the wavelength is sufficiently short, energy may be guided for great distances with very low spatial attenuation, and is often said to be "trapped."

The "trapping" layers, $a-b$ in Fig. 9, are also called "ducts" because of their wave-guiding properties; in fact they may be likened to a parallel-plane wave guide with a leaky top. The analogy to such a wave guide is useful because: (1) it renders plausible the *increase* of trapping effects as wavelength *decreases;* (2) it suggests that complicated field strength distributions may be formed by superposition of a number of transmission "modes"; and (3) it illustrates the importance of the position of the energy source in determining the degree of excitation of the modes. The analogy is unsatisfactory in a quantitative investigation, and a correct analysis requires extension of the theory for the diffraction region to include the effects of irregularities of the modified index profile. It yields expressions for the field strength similar in form to Eq. 24, (Part I) but differing in detail to express the trapping effect and distortion of field strength by the duct. For example, the broken lines in Figs. 5 and 6 (Part I) apply to a modified index profile of type D in Fig. 9 that has been approximated by two straight lines, the top section having the slope corresponding to standard refraction and the bottom section having the negative of this slope. The height h of the joint between the two lines (called the height or the depth of the duct) is $h = \frac{g}{2}\left(\frac{a_e \lambda^2}{\pi^2}\right)^{1/3}$ where g is 1.93 and 2.68 in the curves shown. (These values apply only to the lowest order transmission mode, which predominates sufficiently far below the tangent ray.)

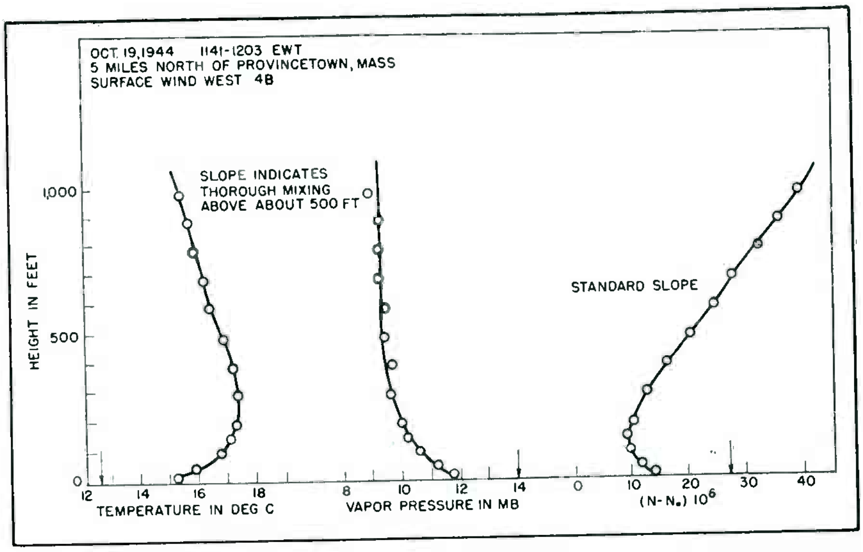

FIG. 10—Atmospheric sounding, showing variations in temperature vapor pressure and index of refraction with height, taken in an aircraft. Arrows on baseline indicate water surface values, determined by water temperature

Figure 5 (Part I) shows that the duct causes the field strength to decrease very much less rapidly with range in the diffraction region than it does with standard refraction, and Fig. 6 (Part I) shows that within and near the duct the height-gain function is distorted. It suggests a reduction of field strength above the duct. When the height-gain and range-attenuation functions are combined, however, the field is seen to be enormously stronger, both above and in the duct, than with standard refraction.

A numerical example will illustrate the gain in signal strength at low heights. Suppose a duct 64 ft deep occurs over a 10-cm transmission circuit 41.5 miles long with terminal heights of 100 and 15 ft. From Eq. 25 and 26 (Part I), $X = 5$, $Z_1 = 3$ and $Z_2 = 0.45$. The 64-ft duct corresponds to the middle curve in Fig. 5 and 6 (Part I). Then

$$20 \log_{10} F = 20 \log_{10} |V(5)| + 20 \log_{10} |U(3)| + 20 \log_{10} |U(0.45)| = -3 - 1 - 6 = -10 \text{ db}$$

For standard refraction, however, the first two terms would have been -69 and $+15$, and the total would have been -60 db; that is, the duct has increased the signal level by 50 db.

By contrast with the situation in a simple wave guide, each transmission mode, although guided by the duct, "leaks" out of the top of the duct; the greater the degree of trapping the smaller is the rate of leakage. Increasing the duct height (more correctly, the quantity g) increases the degree of trapping, causing the "bulge" in Fig. 6 (Part I) to become more pronounced and the rate of attenuation with range to decrease. (It also encourages the presence of higher-order transmission modes, not considered here.) If the transmitter is in the duct or not far from it, the general effect is to produce a long "finger" in the coverage diagram coinciding roughly in position with the duct, often extending for great distances. Two common cases in which the duct rests on the surface are shown by D and E in Fig. 9.

The terms employed above are only crudely descriptive of the complete mathematical formulation of the problem, which is too involved to give here. (The same mathematical problem occurs in connection with potential barriers in quantum theory.) Most writers base elementary explanations of trapping phenomena upon the methods of geometrical optics, using Fermat's principle and tracing ray paths through the inhomogeneous layers. Such ray methods have the advantage of pictorial simplicity, but they represent an oversimplification of the true problem and they may easily lead to erroneous conclusions if they are interpreted without full knowledge of their limitations. These methods have been avoided and the more difficult but correct wave theory is used in this brief discussion. A complete discussion of the problem requires application of both ray and wave solutions in the regions for which each is valid.

It should be emphasized that only energy leaving the transmitter at *very small* angles of elevation is affected by ducts. The field at angles above roughly 1° is not affected appreciably.

When the duct is considerably above the transmitter, as in F of Fig. 9, energy may also be propagated beyond the horizon. The rigorous theory for this case has not yet been carried to a numerically useful state, however, and approximate methods are necessary. One of the best known of these methods describes the propagation in terms of a *plane* wave reflected from a *plane* layer in which n varies with height. If the layer is not too thick (in terms of wavelength), strong reflections may occur at *very small* grazing angles. In this case the longer wavelengths experience the greatest effect, by contrast with the trapping discussed previously.

Early investigators sought explanations of refraction effects in terms of "reflections from air-mass boundaries," which in current terminology would be called refraction by (or reflections from) the elevated irregularities in the modified index profile. (These irregularities are by no means limited to boundaries between different air masses in the meteorological sense, however.) It seems clear now that the early results included the combined effects of profiles of types D, E, and F of Fig. 9.

The effect of the layer represented by the bottom of profile A of Fig. 9, in which dN/dz is greater than the standard slope, is to decrease the field strength below the standard level near the surface, hence it is called a *substandard* layer; this is the opposite of the effect of superstandard layers in which dN/dz is less than the standard slope and fields in and near the duct are above the standard level.

The meteorological phase of the refraction problem is vastly complicated; it requires the answers to many questions that are new in meteorology and defy analysis in terms of existing knowledge. Consequently it was necessary during the war to start from scratch in the new field of radio-meteorology, developing experiment and theory simultaneously with the application to the radio problem. Study of the dynamics of the lower atmosphere was begun experimentally by meteorological soundings employing methods capable of revealing great detail in atmospheric structure. Meteorological analysis based upon the soundings and upon other weather information has brought to light the fundamental principles of the processes involved, but working out their application is a problem for the future.

Figure 10 shows atmospheric soundings, made in an aircraft over the ocean with specially developed instruments when warm, dry air was blowing over the water from the land on a hot summer afternoon, forming a surface duct capable of producing strong trapping on wavelengths of roughly 10 cm or less. Several thousand soundings of this general nature have been made in various localities by several groups of investigators.

The atmospheric index of refraction n depends upon pressure, temperature and humidity but is *independent of wavelength* down to about 1 cm (where atmospheric absorption becomes important.) The index gradient, dn/dz, involves both the gradients of the atmospheric quantities and their absolute values, with the result that a very wide range of effects on the modified index profile is possible. We may summarize the most important of these effects very briefly as follows:

(a) In an atmosphere that is completely mixed vertically dN/dz is nearly constant, and is approximately 0.04 per ft; but complete mixing is rare and 0.036 is the value commonly defined as that giving standard refraction. (Type B of Fig. 9.)

(b) An increase of temperature with height (temperature inversion) tends to make $dN/dz < 0.036$ per ft, and tends to give profiles of Types C through G of Fig. 9.

(c) A decrease of water vapor pressure or concentration (specific humidity or mixing ratio) with height tends to make $dN/dz < 0.036$ per ft, and tends to give profiles of Types C through G in Fig. 9. Relative humidity is an essentially useless quantity in this work because it is not a conservative property of the atmosphere.

(d) An increase of humidity with height tends to make $dN/dz > 0.036$ per ft, and tends to give profiles of Type A of Fig. 9.

When (b) and (c) combine dN/dz may easily become negative and strong ducts may be formed; this is particularly prevalent along a coast, where warm dry air from the land may flow out over cold sea water. If, on the other hand, the air is warmer than the water but is extremely moist, the reverse situation (d) is likely to occur, giving substandard surface layers.

Any of the profiles of Fig. 9 may also occur over land as a result of numerous meteorological processes. The most pronounced effects over land occur as part of the diurnal cycle of daytime solar heating of the earth's surface and nocturnal cooling by radiation. During the middle of the day the air is mixed by convection from solar heating, but at night radiational cooling of the surface chills the air from below, and if the sky is clear and winds are light a temperature inversion is likely to form. Humidity gradients may also occur, and depending upon their sign and magnitude, either ducts or substandard layers may result. The result is that overland transmission as a rule becomes variable at night, often producing a wide range of signal strengths as a result of the continually varying nature of the atmospheric stratification.

A general feature of both overwater and overland transmission between terminals near or below the horizon is that when ducts occur at or near the surface the *average* signal level tends to rise, often to the vicinity of the free-space level, but it tends to decrease under the influence of substandard layers. Superposed on this shift in average level is scintillation or fading which may be small or may encompass a range of as much as 40 or 50 db. The maximum levels reached in most cases reported so far are from 10 to 15 db above the free-space level. The mechanism of the fading is not clearly understood, but in the light of existing information it is reasonable to believe that it results from superposition of a number of transmission modes, the relative amplitudes and phases of which are continually varying as a result of time variations in the microstructure of the atmosphere.

Figure 11 shows typical behavior of 10 and 3 cm one-way transmission on a nonoptical overwater transmission path. Each signal type was found to occur when the indicated modified index profile predominated on the path, which in this case was 41 miles long, between

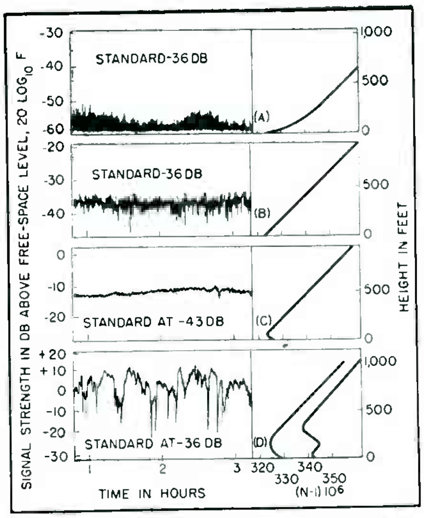

FIG. 11—Variations in signal strength associated with modified index profiles identified in FIG. 3. The standard signal strength is indicated in each diagram

Provincetown and Gloucester, Massachusetts. High average signal with deep "roller" type fading was unfailingly characteristic of ducts roughly 100 feet or more in depth, but when the ducts were shallow, about 50 feet or less, the average signal was lower, and fading was slight. In the second case only the lowest order transmission mode is important (on 10 cm), and freedom from interference by higher order modes is presumably responsible for the increased steadiness of the signal. These shallow ducts are believed to prevail over most of the open oceans, and may be of considerable importance in microwave radar and communications at low altitudes.

Measurements by low-power radar from a height of 50 feet at Provincetown made simultaneously with the one-way measurements and on the same wavelengths showed wide variations in maximum detection range on ships and coastal surface targets. With standard modified index profiles detection was limited to targets within horizon range (15 miles or so), while substandard surface layers reduced this coverage somewhat. Shallow ducts increased the detection range by roughly 20 or 30 percent, but deep ducts permitted ranges very far beyond the horizon. Echoes were received at one time from Nova Scotia, 280 miles distant, and ranges between 100 and 200 miles were common.

A most interesting and significant feature of this particular path was that during the *summer* standard profiles and signal levels occurred only about 2 or 3 percent of the total time. During the rest of the time either deep ducts and high fading signal or substandard conditions prevailed in this particular location, often for two or three days at a time; but trapping conditions accounted for the major fraction of the period. Diurnal effects, predominant in overland transmission, were barely noticeable. As cold weather approached standard refraction occurred an increasing fraction of the time, and the departures from standard signal level and radar ranges decreased. Other measurements during the winter indicate that fairly small variations are to be expected then (in this region). This seasonal trend is to be expected because of the corresponding seasonal variation in the air-water temperature and humidity contrasts which determine the modified index profile.

This is only a small sample of a large amount of information accumulated from all parts of the world from which reports on radar operations are available. Ranges up to 400 miles on coastal targets have been reported in the Mediterranean Sea, and comparable ranges have been obtained off the northwest coast of Africa, in the vicinity of Australasia, in the South Atlantic, and in numerous other places. Perhaps the most startling report comes from a 1.5-meter radar at Bombay, which obtained echoes intermittently over a period of several weeks from the coasts of Arabia, about 1,700 miles away.

This brief outline of some of the problems of propagation can do no more than to suggest the kind of information needed for successful design and operation of equipment in the microwave range. Other equally important problems not discussed here are those of radar echoes from meteorological phenomena and attenuation by the atmospheric gases and by such hydrometeors as rain, hail, snow, and fog. These subjects form a new field that has hardly begun to be explored, and offer fascinating opportunities for further research.

Design of Loudspeaker Dividing Networks

Four-parameter chart gives directly the required values of L and C for a parallel-connected constant-resistance dividing network, at any desired crossover frequency and line impedance, when separate low and high-frequency loudspeakers are employed

By EARL R. SCHULER
Washington, D. C.

With divided-range loudspeaker systems, an electrical dividing network must be used to separate the low and high frequencies into two bands so that each may be reproduced by the proper loudspeaker unit. To approximate the ideal network transmission characteristics of Fig. 1, the parallel-type constant-resistance dividing network of Fig. 2 is favored for its simplicity since both inductors (and both capacitors) have the same values.[1,2] The chart in Fig. 3 gives these values of L and C directly for various values of crossover frequency f and line impedance R_o.

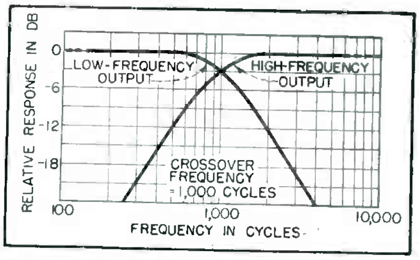

FIG. 1—Ideal transmission characteristics of a 1,000-cycle dividing network

Although the values of L and C may be computed easily from the simple formulas given in Fig. 2, the chart will be found very useful for preliminary design problems. The chart may be used beyond the ranges shown by employing one of the following sets of multiplying factors for the scales:

R_o	f	L	C
1	10	0.1	0.1
10	1	10	0.1
10	10	1	0.01

To prevent the generation of harmonics and intermodulation products by the network, the inductance of the coils must be independent of the signal level. Since air-core inductors are inherently free of this difficulty they are usually preferred over iron-core types. They must be rather large, however, and must be wound with heavy wire in order to obtain a reasonably high Q. A value of 20 at the crossover frequency is satisfactory. Information on the design of air-core inductors may be found in the literature[3,4].

Example 1: A dividing network is required for use in a 15-ohm line, the crossover frequency to be 1,000 cycles. From the point of intersection of the diagonal 15-ohm and 1,000-cycle lines on the chart, read out to the left and upper edges of the chart to the values 3.37 mh and 7.50 μf for L and C. Coils may be wound especially for this value, and standard-size capacitors may be connected in parallel to make up the required capacitance within 5 to 10 percent.

It is permissible to redesign the network for a slightly different crossover frequency to permit use of standard capacitors. New values taken off the chart, starting from the intersection of the 15-ohm and 8-μf lines, are 938 cycles and 3.60 mh.

Example 2: A dividing network is required for use in a 600-ohm line, the crossover frequency to be 500 cycles. This installation will require the use of separate autotransformers to match the low- and high-frequency units to the 600-ohm outputs of the network. Since 600 ohms does not appear on the chart, preliminary values must be determined from the intersection of the 60-ohm and 500-cycle lines; these are found to be 27 mh and 3.75 μf. Since the value for R_o must be

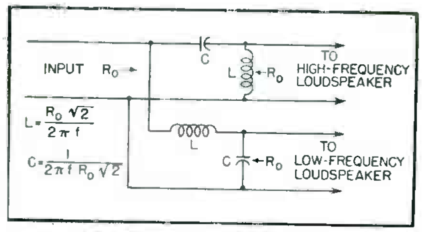

FIG. 2—Circuit of parallel-type constant-resistance dividing network, with design equations (L is in henrys, C is in farads, f is crossover frequency in cycles, and R_o is impedance in ohms of input and each output branch of the network)

multiplied by 10 and there is no change to be made in the frequency (f multiplied by 1), the conditions for determining the final values are met by applying the multiplying factors on line 2 of the table. This gives final values of 600 ohms, 500 cycles, 270 mh, and 0.375 μf for the network.

References

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(2) "Motion Picture Sound Engineering", chapter XX, D. Van Nostrand Co., New York, 1938.
(3) H. A. Wheeler, Simple Inductance Formulas for Radio Coils, *Proc. IRE*, p 1938, Oct. 1928.
(4) E. S. Purington, Simplified Inductance Chart, Electronics, p 61, Sept. 1942.

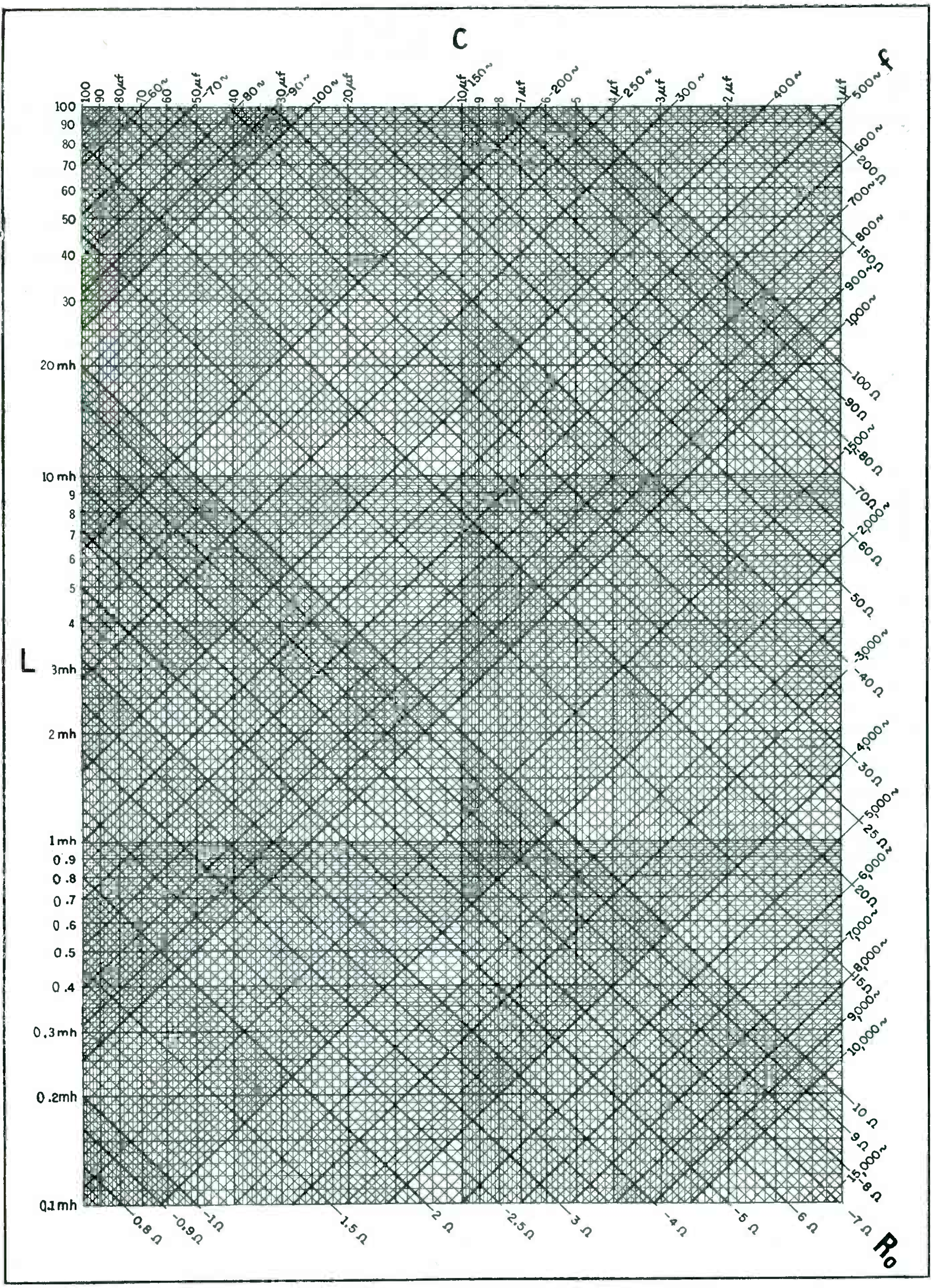


FIG. 3—Chart giving values of *L* and *C* for desired crossover frequency and line impedance in a parallel constant-resistance network

TESTING Long-Persistence Screens

Equipment for determining the light output of cathode-ray tube phosphors makes possible accurate evaluation of screen materials during development and product sampling to assure adherence to tolerances. Special features of test set are described

By JOSEPH C. TELLIER and JOSEPH F. FISHER

Project Engineers
Research Division
Philco Corporation
Philadelphia, Pa.

INTRODUCTION of long-persistence cathode-ray tube screens for radar indicators necessitated standardization of characteristics of the screens among all tube manufacturers. Toward this end a group at the Radiation Laboratory of the Massachusetts Institute of Technology under the direction of W. B. Nottingham developed basic specifications, test equipment, and procedures for testing.

Equipment developed by the Philco Research Division was in accordance with the standards and utilized basic circuits developed by the Radiation Laboratory, but was extended in scope to provide greater versatility. Two complete units were constructed and are now in use as an adjunct to further screen phosphor development.

Functions of Equipment

Broadly, the functions performed by the equipment can be divided into three general categories. All static voltage and current characteristics of a wide variety of cathode-ray tubes can be measured. Steady measurements of light output from tube screens under various test conditions can be made. However the primary function of the equipment is to measure the build-up and persistence of light output from long-persistence screens exemplified by the P7 type.

Physically the equipment consists of 13 standard relay-rack chassis in two six-foot racks, and a light-tight wooden console in which the cathode-ray tube is mounted for test. The several units comprising the equipment, together with the general nature of their functions, are represented in Fig. 1.

CONSOLE—This unit provides for mounting any of a variety of cathode-ray tubes at a standard distance of 30 centimeters from a 931 photomultiplier tube. It also contains provision for making absolute calibration of light intensity, and means for rapidly de-energizing the screen between tests.

Light-tight console accommodates all shapes of cathode-ray tubes

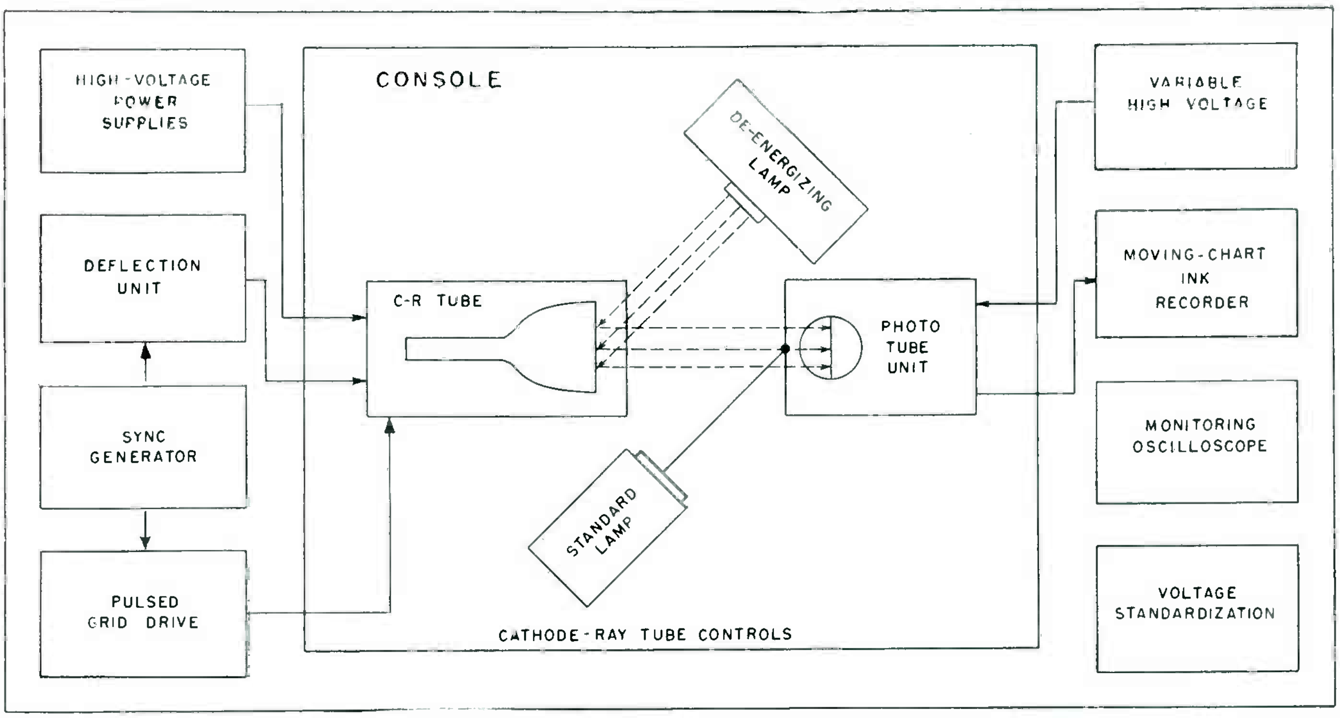


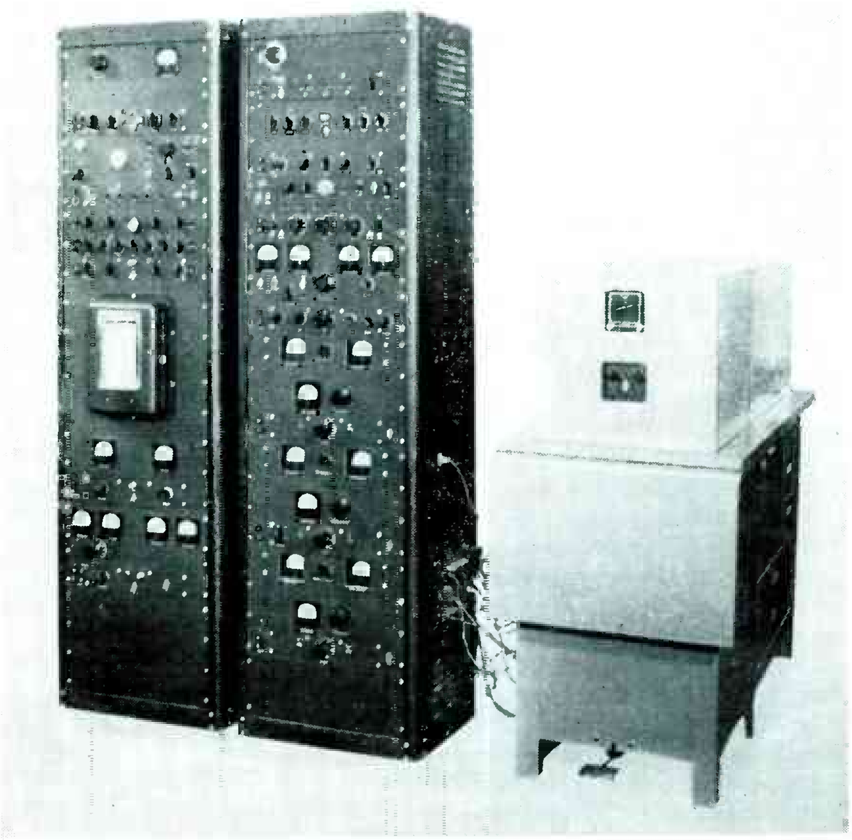
FIG. 1—Block diagram shows interrelation of units of cathode-ray tube test equipment

CRT CONTROLS—Filament voltage, cathode bias, and other potentials are controllable from a convenient central point.

SYNC GENERATOR—Synchronizing pulses for the deflection unit are provided in this compartment.

DEFLECTION UNIT—Horizontal and vertical deflection voltages producing a 200-line, noninterlaced raster at a 60-cycle frame rate are provided for either electrostatically or magnetically deflected tubes.

PULSED GRID DRIVE UNIT—Duration of the raster, repetition rate, and number of rasters applied in total are determined by an electromechanical network incorporated in this chassis.



Associated equipment provides adjustable voltages, raster, and recorders

MOVING CHART INK RECORDER—A record of light output as a function of time is made on the chart of an ink recorder. From this record is obtained all numerical data relating to light output from the crt screen.

VOLTAGE STANDARDIZATION UNIT—Critical voltages from the entire system are brought to this unit and checked against a standard-voltage cell, in a comparison circuit utilizing a 6E5 indicator tube.

PHOTOMULTIPLIER TUBE POWER SUPPLY—This is a variable, regulated high-voltage supply used to adjust the amplification of the 931 tube.

POWER SUPPLIES—These are two conventional low-voltage regulated power supplies.

H-V POWER SUPPLIES—Three supplies provide anode voltages to the crt under test and incorporate a unique, extremely effective regulating system. Multirange current metering is also provided.

MONITORING OSCILLOSCOPE—This unit permits observation of waveshapes throughout the system and facilitates adjustment of the

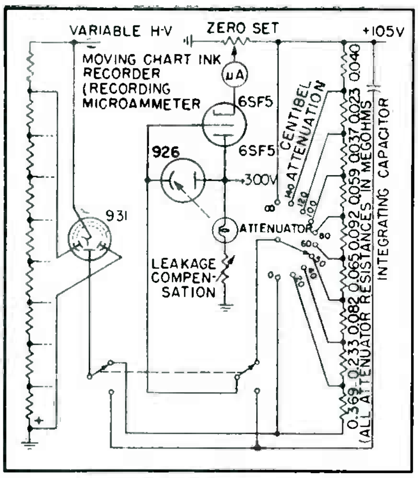


FIG. 2—Basic prototube-unit circuit

synchronization of various units.

The P7 screen, which is a typical long-persistence type, comprises a double layer, the outer layer being a zinc cadmium sulphide and the inner a zinc sulphide silver activated fluorphor. Under electron bombardment, the inner layer fluoresces brightly and excites the outer layer. The latter phosphoresces under this excitation, continuing to glow long after the fluorescent excitation has disappeared. If the excitation is applied periodically, for brief intervals, the light output from the outer screen will take on increments until a saturation condition is reached. This condition represents maximum light output.

To obtain a unique unit of measurement, the centibel was adopted, and defined. This unit is one one-hundredth of a bel, so that the number of centibels corresponding to a given light power ratio is given by $cb = 100 \log_{10} (P_1/P_2)$ where P_1 and P_2 are the two values of light power whose ratio is to be expressed. In addition, the zero level was chosen as 2×10^{-6} foot lamberts, corresponding to the generally accepted zero sound level of one milliwatt.

If, then, the voltages and beam current of a particular cathode-ray tube are set to specified values, the raster size is adjusted to a given area, and the raster is applied to the screen for brief, constant periods, spaced by known time intervals, the light output will vary as a function of time in the following general fashion. Each instant of raster application will produce a bright fluorescent flash from the inner screen, followed by a slowly decaying phosphorescent glow. The glow after each flash will be at a higher level than that after the preceding flash, with the increments gradually becoming smaller.

The light level after a fixed number of flashes is a direct measure of the buildup characteristic of the screen. This measurement is the data actually taken in practice to determine this characteristic.

Test Parameters

Certain values of test parameters were found to give optimum results, and standards of test procedure were consequently based on these. The type 5FP7 tube, as an important example, is tested under the following conditions.

The anode potential is accurately set to 4,000 volts, and the beam current, during raster application, to 60 microamperes. The raster area is 50 square centimeters, and is applied for one sixtieth of a second, at one-second intervals. All of these factors are maintained precisely, some manually in conjunction with self-contained measuring instruments, and some automatically by the equipment itself. The resulting light output as a function of time is plotted on the recorder. From this plot, the light output after the first, fifth, and tenth flashes is measured, the ratio of the fifth to the first and the tenth to the first is calculated, and the corresponding number of centibels derived. These ratios of light output are defined as $cb_{(5:1)}$ and $cb_{(10:1)}$ respectively, and are taken as factors indicative of the build-up and persistence of the screen. On the basis of these factors, tubes can be directly compared, or tolerances can be established on $cb_{(5:1)}$ and $cb_{(10:1)}$ within which production tubes must lie.

Two auxiliary tests are commonly made in conjunction with the build-up measurements. The first of these is the fluorescent measurement and involves applying a steady raster, all other test conditions being the same, and measuring the total light output emanating from the screen. The second of these is a measurement of integrated flash. For this purpose a single raster is applied for one sixtieth of a second, and the phototube output circuit is converted to an integrating network. This technique provides an accurate method of measuring the effect of the initial flash from the inner screen, and is important because the latter is a source of annoyance to the eye of the operator, and must not be allowed to become excessive.

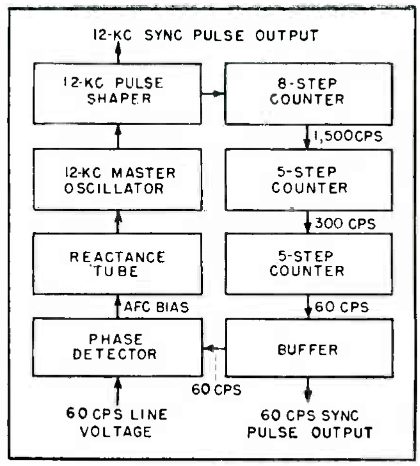


FIG. 3—Elements of sync generator

Mounting the tube to be tested presented the first equipment design problem. Several pieces of associated equipment had to be positioned near the tube, light output had to be measured under darkroom conditions, and yet access for changing tubes rapidly had to be provided. The solution to these mechanical problems was to use the console.

In the console, the tube under test is mounted in the righthand section, which is accessible by lifting the hinged lid. In position, the tube faces the lefthand section in which is the phototube chassis and de-energizing lamp. The entire lefthand section can be dropped flush with the table top, leaving the tube face exposed for preliminary adjustments. This section is raised by means of a foot pedal. Various compartments and drawers provide

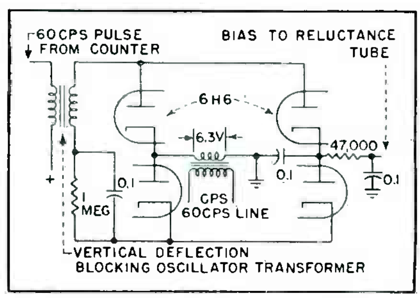


FIG. 4—Circuit of phase detector

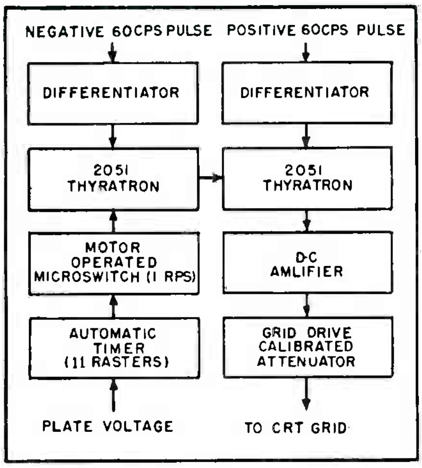


FIG. 5—Pulsed grid drive unit

space for adaptors and other equipment.

In the righthand section is a sliding carriage so arranged that the faces of tubes of any length can be positioned at the standard distance of 30 cm from the phototube. Positioning is accomplished quickly by the use of front and rear sighting wires. A variety of clamping sections, providing for several neck diameters, can be bolted to the base of the sliding carriage. On the rear wall are sockets providing all needed electrical connections.

Phototube Unit

The long, rectangular closed chassis in the lefthand section is the phototube unit, and is the heart of the optical portion of the system. The central point in this chassis is the 931 photomultiplier tube, which provides the basis for making absolute measurements of light output from the screen under test. The tube is mounted on a sliding subchassis, in order that the light-sensitive surface may be set at exactly the correct distance from the sighting wires used to position the cathode-ray tube face. Other auxiliary components of this chassis are the light-leakage compensation phototube, the inner standard lamp, the attenuator, and the cathode-follower output stage, shown in Fig. 2.

By means of the ganged switch in this unit, the plate load impedance of the 931 tube may be made either the centibel-calibrated attenuator or the integrating capacitor. The output voltage developed across either load is directly coupled to the grid of the 6SF5, and the recorder microammeter is connected into the cathode. Initial current in the recorder is adjusted to zero by setting a variable resistor such that the 6SF5 is just cut off, with the grid at +105 volts. There is always a small current flow in the 931 plate, because of dark current in the latter, light leakage into the console, and the crt filament glow. In order to cancel this current, a 926 leakage-compensation phototube is connected in opposite polarity, and the magnitude of the cancelling current is controlled by means of a small lamp. The brilliance of the latter is adjusted by the compensation resistor.

To avoid frequent use of the external standard lamp, an inner secondary standard lamp is provided. The brilliance of this lamp is controlled by a precision attenuator, which is calibrated occasionally by means of the external standard lamp.

To the base plate of the phototube unit is mounted a swivel arm on the end of which is placed the external standard lamp. In position, the standard lamp is directly in front of the 931 phototube, and exactly 22.6 cm from it. When the current in the lamp is of such a value as to develop a drop of 1.018 volts (standard cell voltage) across a resistor of 16.75 ohms, exactly +500 cb of light is produced.

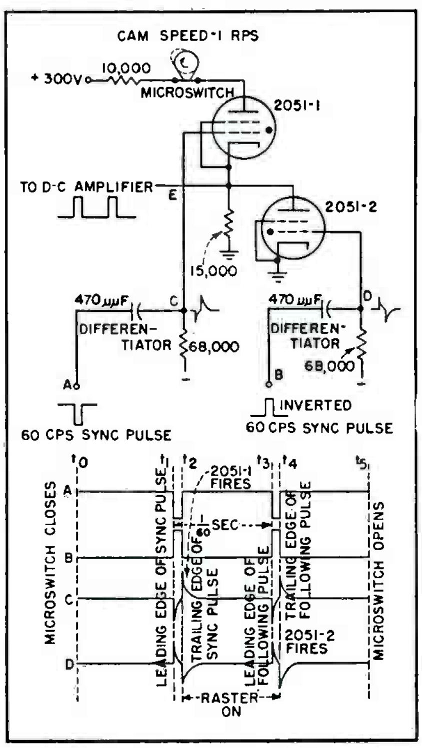


FIG. 6—Thyratrons control raster

In making tube tests, it is necessary to start with a condition of no light output. A P7 screen, however, will glow for at least one half hour after excitation. It has been found, fortunately, that red light at a frequency of about 6,000 angstroms will deactivate a screen in 45 seconds. Light at this frequency will release the electrons momentarily established in trapped energy levels, without raising them to higher energy levels. Hence they fall to the desired neutral level, and the tube face is darkened. A red theater flood light is used for this purpose.

The crt control chassis needs little description. Here, in a central convenient point, are means for controlling and metering filament voltage, cathode bias, and focus-coil current. In addition, the master power switch is located in this chassis. In particular, cathode bias is controlled by a precision step attenuator, operating from an accurately established 300-volt supply.

Deflection Unit

In order to obtain comparable light output readings, a consistent pattern must be applied to the crt screen; this is accomplished by standardizing on a 200-line, noninterlaced raster. In order to maintain such a raster, it is first necessary to derive certain synchronizing pulses, in this case a 12-kc and a 60-cps pulse. The sync generator unit is outlined in Figure 3. Output at approximately 12 kc is first obtained from a master oscillator. This sinusoidal voltage is then applied to an overdriven two-stage amplifier whose output is essentially a 12-kc square wave. The latter signal is next applied to a conventional 8-step diode counter and blocking oscillator, the resulting signal being a 1,500-cps pulse. The procedure is repeated in two 5-step counters, the final output being a pulse at approximately 60 cps. This pulse is then compared with the 60-cps line voltage by means of a phase detector, and the resulting bias applied to a reactance tube which holds the master oscillator frequency at exactly 12 kc. The

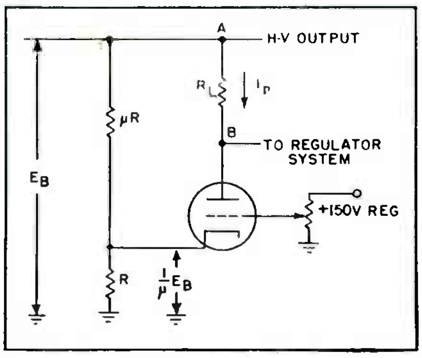


FIG. 7—Improved voltage regulator

basic phase detector is shown in Fig. 4.

The deflection circuits utilized to produce the 200-line raster are conventional and need not be elaborated upon. Some complexity of switching is caused by the necessity for providing horizontal and vertical deflection for both magnetically and electrostatically deflected tubes, but individual circuits, neglecting switching, are those commonly found in the literature.

Raster Timer

With the raster-producing voltages available, it is next necessary to apply the raster periodically for brief intervals. This keying is accomplished through the medium of the pulsed grid drive unit—a most important unit upon which the sequence of all operations performed automatically depends. The basic elements of this circuit are shown in block diagram in Fig. 5.

A Microflex automatic timer is so connected as to close a 300-volt circuit for slightly more than eleven seconds after a switch inaugurating the raster pulsing is thrown. A Telechron clock motor drives a cam at the rate of one revolution per second, which in turn is arranged to close a Microswitch for slightly more than one sixtieth of a second, once each revolution. Plate voltage is thus applied through the timer and Microswitch to the thyratrons once a second for an eleven-second interval.

By means of the thyratrons, the grid of the crt under test is raised from below cutoff to a value determined by the calibrated attenuator. During this period, a raster corresponding to a previously determined beam current is thus applied to the screen.

Operation of the thyratrons can be discussed with reference to Fig. 6 where a typical sequence of Microswitch closing and pulse occurrence is illustrated. At time t_0 the Microswitch closes. At time t_1, the leading edges of two pulses, coincident but of opposite polarity, are applied at terminals *A* and *B*. The differentiated pulse at *C* is negative, however, and nothing happens. At a slightly later instant t_2 a positive pulse appears at *C* corresponding to the differentiated trailing edge of the pulse at *A*. Thyratron 2051-1 is fired, and a positive voltage appears at *E*. This voltage is transmitted through the d-c amplifier and the attenuator to the crt grid, and a raster appears on the screen. At time t_2, the pulse at *D* is negative, because of differentiation, and thyratron 2051-2 remains nonconducting.

At time t_3, essentially one-sixtieth of a second later, a positive pulse appears at *D*, firing thyratron 2051-2 and reducing the voltage at *E* to a sufficiently low value to cut off the crt. Shortly afterward, at t_5, the Microswitch opens, turning off both thyratrons. This cycling continues for eleven seconds, after which the automatic timer removes the plate voltage permanently and the run is completed.

As was noted (Fig. 2) the phototube current developed by the raster is applied through a cathode follower to the sensitive element of an ink recorder. This element has a full-scale sensitivity of 250 microamperes. The recorder chart moves at a rate of approximately 5 inches in 11 seconds.

To provide for testing as many crt types as possible, three high-voltage supplies at nominal outputs of 7, 3.5, and 2 kv are supplied. These supplies contain an unusual feature in the regulating system which makes the latter very effective. Referring to Fig. 7, it will be seen that the grid of the triode is connected to an adjustable bias point, while in the cathode, a voltage equal to the output voltage divided by μ is applied. Under these conditions it is possible to show that I_p is independent of E_b. Therefore, the voltage drop across R_L is constant, and if voltage variations occur at *A*, the same magnitude of variation occurs at *B*, but at a lower center value. This behavior is in contrast with a resistive divider wherein the voltage variations are reduced in magnitude by exactly the reduction in center value. Thus the gain of the regulating network is greatly increased by the use of this additional tube.

To establish exactly all critical voltages in the system, a method of comparison with the voltage output from a standard cell is used. These voltages are obtained from current flow through precision resistors. Knowing the resistance value, the required current flow to produce a given voltage is calculated. Next, the resistance required to produce a voltage of 1.018 volts with this current is determined and obtained. This latter voltage is then compared with a standard cell, and the current adjusted until both are equal.

For the purpose of comparing standard cell and test voltages, a circuit utilizing a magic-eye tube is used, as shown in Fig. 8. The standard cell and test voltages are switched alternately to the grid of a d-c amplifier, whose output is connected to the grid of the 6E5. When no change is observed in the eye angle, the voltages are equal.

The final unit is the monitor, which is a conventional oscilloscope mounted with the rest of the equipment for convenience in establishing correct operating conditions.

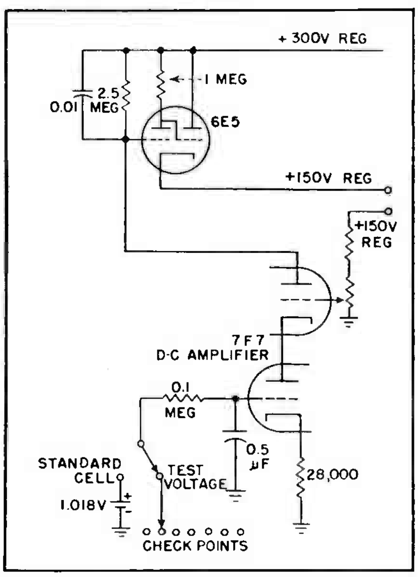
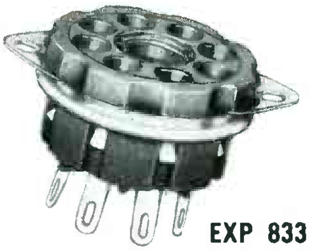


FIG. 8—Voltage and current calibrator

Shortest Electrical Path to the Ground



EXP 8330
Octal

CINCH·ERIE "Plexicon"

TUBE SOCKETS*

with built-in

CERAMIC CONDENSERS

EXP 8350
Lock-in

ERIE CERAMICON
BY-PASS CONDENSERS

. . . provides the most effective method of by-passing . . . with condenser close to tube element . . . plus shortest path to ground.

. . . capacity up to 1,000 MMF—any tube element may be coupled or by-passed as desired.

Mounting specifications:

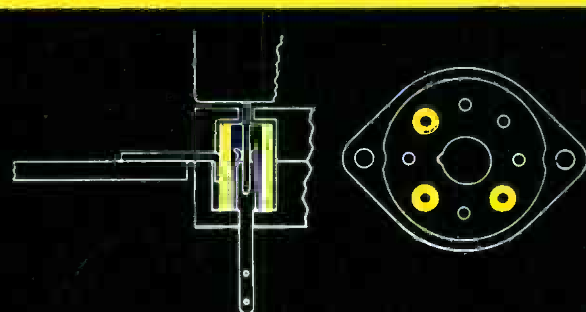
Octal and Lock-in type, 1⅛" diameter chassis hole, 1-5/16" Mounting center
Miniature, 7-pin (T5½), ⅝" diameter chassis hole, ⅞" Mounting center
Noval (T-6½) type socket, ¾" diameter chassis hole, 1⅛" Mounting center

"Plexicon" Tube Sockets are a joint development of Erie Resistor Corporation and Cinch Manufacturing Corporation

AVAILABLE AT LEADING ELECTRONIC JOBBERS—everywhere

EXP 8481
Noval

EXP 8365 Miniature
7 pin



The above two schematic diagrams show the basic design principles of Cinch-Erie Plexicon Tube Sockets.

In the plan view, the socket is shown with condensers for by-passing three tube pins. The silvered ceramic condensers are shown in yellow.

Note in the side view that the condenser completely surrounds the tube pin, and that specially designed tube prong terminals are used.

CINCH MANUFACTURING CORPORATION

2335 WEST VAN BUREN STREET, CHICAGO 12, ILLINOIS

Subsidiary of United-Carr Fastener Corporation, Cambridge 42, Massachusetts

*Cinch Sockets are Standard

Piston Attenuator Chart

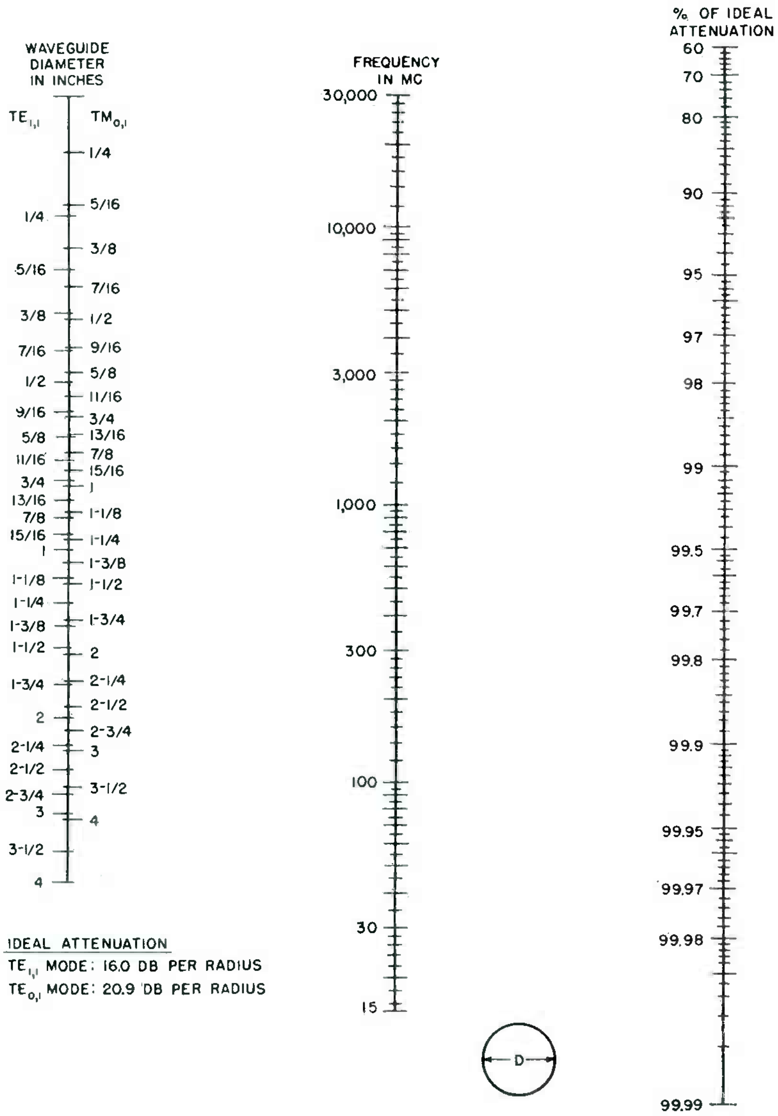
Deviation from ideal attenuation at any frequency in vhf, uhf, and shf bands is given directly on nomograph for piston diameters from 0.25 to 4 inches

By RAYMOND E. LAFFERTY

Chief Engineer, WSLB
St. Lawrence Broadcasting Corp.
Ogdensburg, New York

PISTON ATTENUATORS are used as variable attenuators in the very high, ultrahigh, and superhigh frequency bands. The attenuation per unit length is linear when calibrated in db and may be computed from theory[1,2,3] when the physical dimensions and mode of operation are known.

Although there is some variation of attenuation with frequency in all piston attenuators, this error can be minimized by proper selection of frequency range and pipe diameter. The accompanying nomograph gives directly the extent of this attenuation error, as a convenient guide for the design of new attenuators. The $TE_{1,1}$ scale is for the mutual inductance type of attenuator with coplanar coils, and the $TM_{0,1}$ scale is for the mutual capacitance type.



To use this chart, locate the pipe diameter on the scale for the proper mode, place a straightedge on this value and on the frequency value (center scale), and read the percent of ideal attenuation where the straightedge intersects the righthand scale. Multiplying the ideal attenuation (see bottom of chart) by this percentage factor gives the true attenuation in db per radius for the given frequency.

Example: A signal generator uses a $TE_{1,1}$ half-inch diameter piston attenuator. The frequency range is from 1,000 to 3,000 mc. What is the attenuation over this range? At 1,000 mc the attenuation is 16 times 0.9974, or 15.96 db per radius. At 3,000 mc it is 16 times 0.976, or 15.62 db per radius. This is a variation of approximately 0.33 db for each radius of travel (0.25 inch) of the piston. If the piston travels 1.5 inches from the 0-db starting point the difference in attenuation between the frequency limits will be approximately 2 db.

REFERENCES

(1) D. E. Harnett and N. P. Case, The Design and Testing of Multi-range Receivers, *Proc. IRE*, p 578, June 1935.
(2) E. G. Linder, Attenuation of Electromagnetic Fields in Pipes Smaller Than Critical Size, *Proc. IRE*, p 554, Dec. 1942.
(3) F. E. Terman, "Radio Engineers' Handbook," p 981, McGraw-Hill Book Co., New York, N. Y., 1943.

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TUBES AT WORK

Including INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Line-Operated pH Meter

By H. S. ANKER
Department of Biochemistry
University of Chicago
Chicago, Illinois

SEVERAL pH METERS of the type to be described have been constructed and have operated satisfactorily over a number of years.

The circuit employed is based on the Roberts[1] feedback amplifier. Its main feature involves the use of two identical amplifiers in a compensating arrangement with the heaters of V_1 and V_2 connected in series. The output is measured between both amplifiers. This method makes a regulated power supply unnecessary. A 20-volt change in line voltage gives about 0.05 pH unit variation of the output.

As the instrument is to be used with a high-resistance glass electrode, input tube V_1 should be selected to insure a grid current of less than 2×10^{-12} ampere when the filament voltage is 3.2 volts, the screen 25 volts and the control grid -1.5 volts. The tube is cleaned with absolute alcohol and coated with polystyrene lacquer to prevent surface leakage. Tubes V_1, V_2, and the grid resistor are built into a separate box for shielding and protection from light. Connections to the glass electrode are made by a polystyrene insulated connector.

Calibration

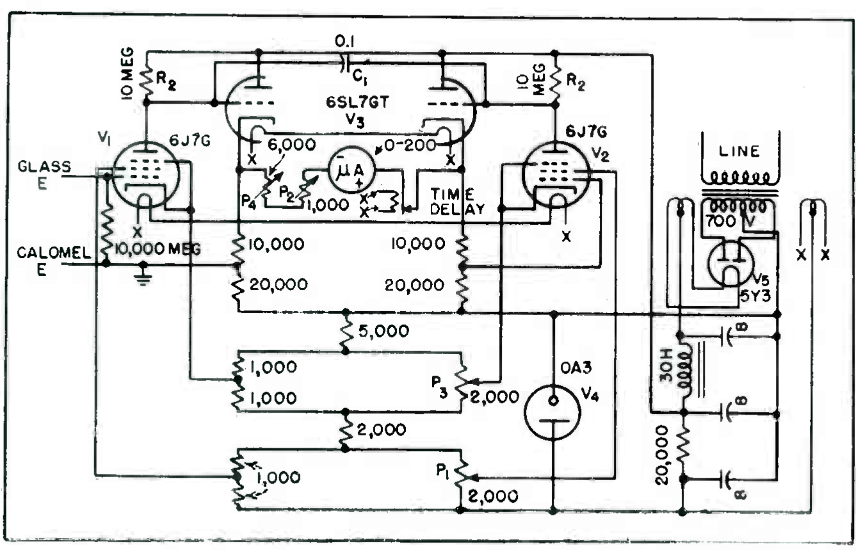
After construction, the instrument is aged for 24 hours. The meter is provided with a scale of 0–14 pH units, and the cabinet is well grounded. Controls P_1 and P_2 are set to their midpoints, the meter is set to a reading of 7 by P_3, and, by means of two known precision chemical buffers, the meter sensitivity is adjusted by P_4 so that the difference in meter reading corresponds to the two buffers. Control P_3 is then varied until the meter gives the proper reading for one of the buffers. Potentiometers P_3 and P_4 are mounted inside the cabinet, since after this initial adjustment they need not be changed. Control P_2 provides a temperature compensation scale.

For calibration, the electrodes are disconnected, P_1 adjusted to give a reading of 8 and the points at which readings of 8.36 and 7.30 are obtained by changing P_2 are marked 0 and 40 respectively on the scale of P_2. The interval between the marks is divided into 40 equal parts.

The time delay relay on the diagram could be replaced by an ordinary switch. Beckmann glass and saturated calomel electrodes were used with the instrument. For routine use, after a warming up period of about 10 minutes, the meter is standardized against a known buffer with P_1.

With only few modifications, a recent instrument was equipped with miniature tubes using a 6AU6 for V_1, V_2; V_3, 12AU7; V_4, OB2 and V_5, 6X4. A selected 6AU6 tube will show a sufficiently low grid current with the heater operated at 3.2 volts, the screen at 50 volts, and control grid at -2.0 to -2.5 volts.

(1) S. Roberts, *Rev. Sci. Inst.* **10**, p 181, 1939.

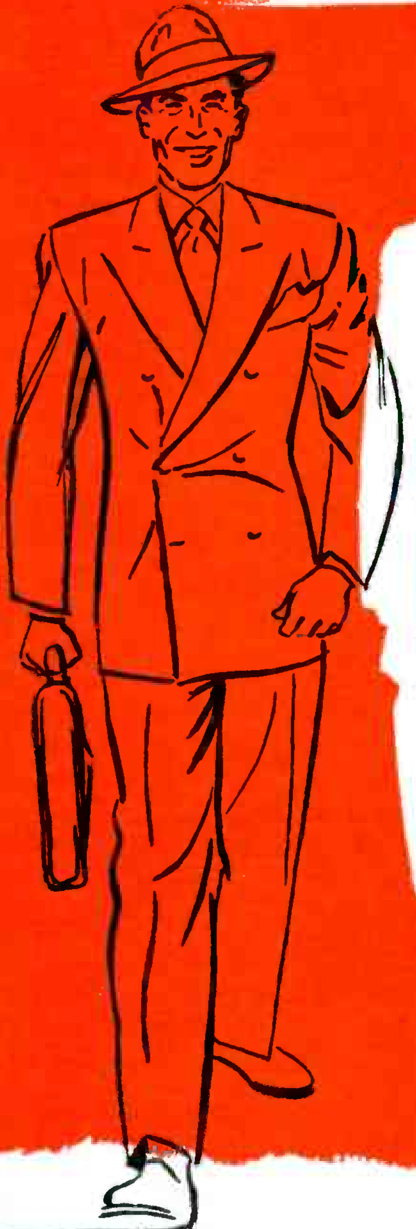


Complete Circuit of the pH meter. The voltage regulator tube is arranged in the cabinet as a pilot light

Selenium Rectifiers for Television Receivers

By GEORGE EANNARINO
Engineer
Federal Telephone and Radio Corp.
New York, N. Y.

USE OF SELENIUM RECTIFIERS in voltage multiplier circuits eliminates the power transformer, rectifier tube, and filter choke, and enables the use of separate supplies for each functional circuit. For example, the multiple power supply shown in



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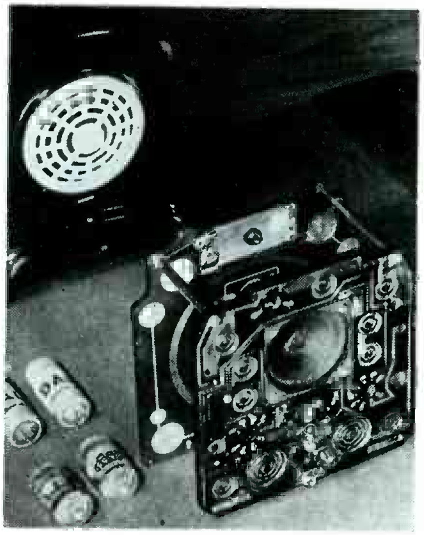

THE FRONT COVER

MACHINE-MADE RADIO produced in England by John Sargrove, Ltd. employs two twin-tetrodes in a regenerative circuit for the broadcast band, is the forerunner of more ambitious superheterodyne models already in an advanced stage of development.

Two plastic panels having preformed depressions and holes are fed into automatic electronically-controlled machines (one of which is pictured here), where they are successively sand-blasted and sprayed with zinc. Moving through the machine on a conveyor belt, the panels are then face-milled, so that zinc remains only in depressions to form wiring, inductances and capacitors. Resistors are added by spraying on graphite as the panels continue through the machine, and as they near the end of the line tube and filter-capacitor sockets and some small hardware is automatically installed.

When the panels emerge from the machines little remains to be done by hand labor but bolt them together, install the loud speaker, plug in the two filter capacitors and two tubes, test, and place the chassis in the cabinet. Some of the electronic gear and relays are shown in the illustration below.

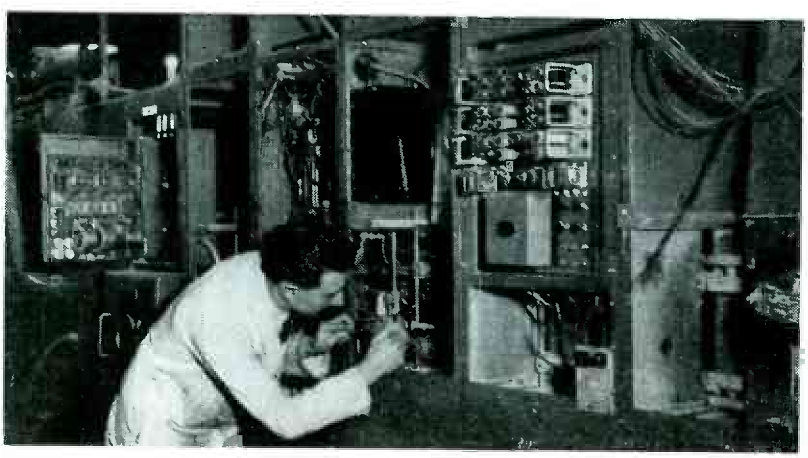

Fig. 1 provides separate outputs of 280 volts at 75 ma, 390 volts at 100 ma, 135 volts at 200 ma, and 100 volts at 50 ma, without using a common voltage divider. The unit weighs 3 pounds, at least 7 pounds less than a conventional power supply providing the same service.

A conventional power supply for a television set provides one power source for all circuits by placing about 440 volts across a bleeder and voltage divider having taps to obtain desired voltages for each stage. The power lost in the divider can be saved through the use of a selenium rectifier supply.

For example, the r-f and i-f supply requires approximately 135 volts at 200 ma. To obtain this power, in the transformer supply, it is necessary to drop the 440 to

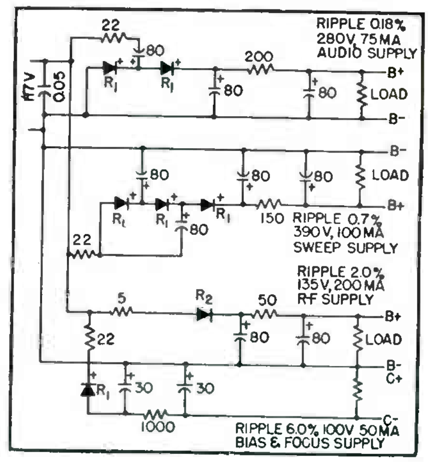

FIG. 1—Circuit of multiple power supply for a television receiver. Rectifiers marked R_1 are Federal type 403D2625; R_2 are type 404D2729

135 volts or 310 volts. At 200 ma, this represents a power dissipation of 62 watts.

In a similar manner 12 watts are lost to provide the audio supply. Furthermore, the rectifier tube filaments dissipate 30 watts (based on the use of two 5Z3's) which are not required when selenium rectifiers are used. Thus a saving of approximately 100 watts can be realized.

The operating temperature is reduced appreciably, enabling the use of a smaller chassis and increasing the life of the receiver components. This, combined with the reduction in concentrated weight represented

(continued on p 150)

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10 standard crystal types—between 1.2 and 50,000 KC

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20J	1.2 to 10 kc
21N	16 to 100 kc
21E	90 to 300 kc
22D	200 to 500 kc
22C	300 to 1,000 kc
24A	2,000 to 10,000 kc
22A	3,950 to 10,000 kc
24B	4,000 to 15,000 kc
22B	5,000 to 15,000 kc
23A	15,000 to 50,000 kc

The new Western Electric standardized line of quartz crystals will eliminate many of your circuit design problems. This new line consists of ten crystal types—listed in the table at the right—for operation within specific *frequency* ranges. Each of these ten crystal types consists of a number of separately coded crystal units which are designed to operate, with nominal tolerances, within specific *temperature* limits.

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THE ELECTRON ART

Edited by FRANK H. ROCKETT

Radio Propagation Research

WIRELESS communication depends on the control and utilization of numerous natural phenomena. One of the leading pioneers in discovering and indicating methods of using these phenomena is Sir Edward Appleton, who has been awarded one of the Nobel prizes in 1947 for his researches.

The most celebrated discovery of Appleton was the reflecting layer that had been independently postulated by Heaviside in Great Britain and Kennelly in the United States. In 1924, with the use of the B.B.C. transmitter at Bournemouth operating on a medium wavelength and a receiver at Oxford made available by a grant from the Department of Scientific and Industrial Research, he proved that the reflecting layer existed at a height of 60 miles above the earth. The technique used to measure the height of the Kennelly-Heaviside layer was to observe the beating produced at the receiver by the direct ground wave and the reflected sky wave as the frequency of the transmitter was varied. The method also paved the way for radar techniques.

Sir Edward Appleton, who has been awarded a Nobel Prize for his researches on radio waves, is now mapping the earthward face of the moon by radar

Later, using wavelengths in the 10 to 50 meter range, he discovered the Appleton layer at 120 miles, now referred to as the E and F layers. Ionospheric forecasting on which long distance transmission depends is based on these discoveries. In 1932-33 Appleton took an expedition to northern Norway to study the effect on radio of the Aurora Borealis. From these observations he discovered that ionospheric reflectivity varies with sunspot activity. Recently he has shown that meteorites reflect radio waves, and, with J. S. Hey, has found that sunspots are powerful emitters of wavelengths in the vicinity of five meters. Appleton has been Secretary of the Department of Scientific and Industrial Research of the British government since 1939. He had served in World War I, and later taught, his first position being under Sir J. J. Thomson. He has been honored by numerous learned and engineering societies and by several nations.

Increasing Efficiency of Fluorescent Lamps

HIGH-FREQUENCY OPERATION of fluorescent lamps increases both the lamp and the overall efficiencies and decreases the ballast requirements.[1] In addition, the lamp current and voltage at h-f are of better waveform than at 60 cps, instant starting circuits are simpler, and stroboscopic effects are minimized.[2]

Efficiency-Frequency

Using an audio oscillator and a power amplifier capable of delivering about 1,000 watts at frequencies from 60 to 10,000 cps, the operating characteristics of a 40-watt fluorescent lamp were measured as functions of frequency. Holding the line at 200 volts and the lamp power at 40 watts, it was found that for all three types of simple ballast (series inductance, resistance, and capacitance) the lumens per lamp watt increased over the value at 60 cps (10 percent for inductance and resistance ballast at 600 cps, and 200 percent for capacitance ballast), and that the lamp power factor approached unity. Although tests were carried to the highest available frequency, practically all the improvement had been obtained when the frequency was increased to 600 cps.

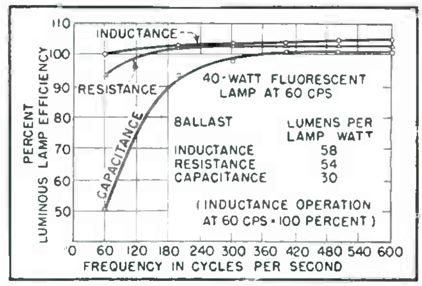
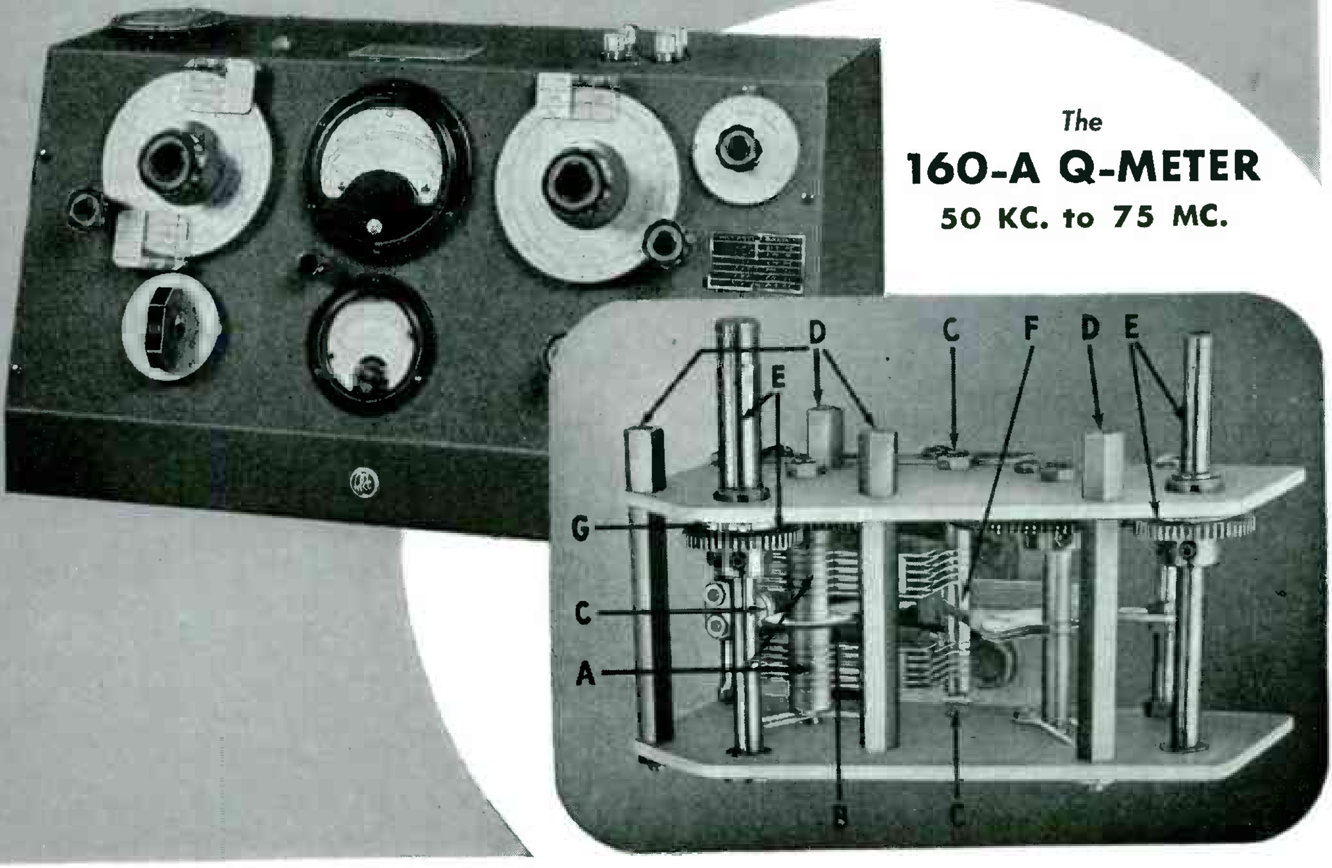


FIG. 1—Luminous efficiency, and consequently overall efficiency, increases with frequency for fluorescent lamps

At 600 cps an inductance ballast weighs 50 percent of its 60-cps weight. At frequencies above about 300 cps, capacitance ballast can be used without the serious stroboscopic effects produced at 60 cps, and with better regulation than possible with other ballasts. Because the lamp voltage decreases with increasing frequency, a resistance ballast may be practicable at 120 volts at 600 cps. Figure 1 shows

For the MEASUREMENT of

Q, INDUCTANCE and CAPACITANCE



The

160-A Q-METER

50 KC. to 75 MC.

Radio frequency circuit design often requires the accurate measurement of Q, inductance, and capacitance values. For this application, the 160-A Q-Meter has become the universal choice of radio and electronic engineers throughout the country.

Each component part and assembly used in the manufacture of this instrument is designed with the utmost care and exactness. Circuit tolerances are held to values attainable only in custom built instruments.

Consider, for example, the Q tuning capacitor assembly of the 160-A Q-Meter, specially manufactured for maximum range, low loss, and minimum residual inductance. The ultimate design of this unit was reached only after months of intensive engineering research to produce the finest in performance, quality, and workmanship.

This is but one of the many desirable features of the 160-A Q-Meter which contribute to its outstanding accuracy and dependability.

Be sure to include the 160-A Q-Meter in your new equipment plans for 1948.

Write for Catalog "E"

BOONTON RADIO *Corporation*
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Shown above is the Q tuning capacitator assembly of the 160-A Q-Meter. Note the following design features of this unit—features which insure reliable, trouble-free operation.

A. Parallel connection of dual rotor and stator assemblies minimizes internal inductance and resistance.
B. Spring silver fingers contact both sides of silver disc to provide low series resistance.
C. Three point pyrex ball stator suspension reduces losses and permits accurate stator alignment.
D. Four point panel mounting designed to produce maximum structural rigidity and capacitance stability.
E. Precision-cut brass spur gears and stainless steel shafts, mounted in oversize bearings, assure long, trouble-free service.
F. Common stator mounting for main and vernier stator plates reduces loss and internal series resistance of vernier capacitor section.
G. Positive shaft stop protects main rotor assembly and gears against mechanical overload.

SPECIFICATIONS

Oscillator Frequency Range: 50 kc. to 75 mc. in 8 ranges.
Oscillator Frequency Accuracy: ±1%, 50 kc.—50 mc.
±3%, 50 mc.—75 mc.

Q Measurement Range: Directly calibrated in Q, 20-250. "Multiply—Q—By" Meter calibrated at intervals from x1 to x2, and also at x2.5, extending Q range to 625.

Q Measurement Accuracy: Approximately 5% for direct reading measurement, for frequencies up to 30 mc. Accuracy less at higher frequencies.

Capacitance Calibration Range: Main capacitor section 30-450 mmf, accuracy 1% or 1 mmf whichever is greater. Vernier capacitor section +3 mmf, zero, −3 mmf, calibrated in 0.1 mmf steps. Accuracy ±0.1 mmf.

DESIGNERS AND MANUFACTURERS OF THE Q METER · QX CHECKER FREQUENCY MODULATED SIGNAL GENERATOR · BEAT FREQUENCY GENERATOR AND OTHER DIRECT READING INSTRUMENTS

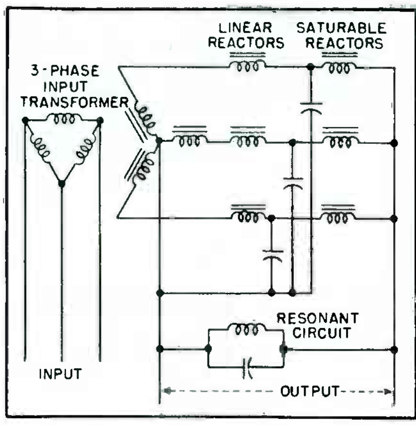


FIG. 2—Harmonic generator produces 540 cps from 60-cps input for h-f excitation of fluorescent lamps

the relative luminous efficiency obtained with the three types of series ballast.

Although rotary converters, such as the 400-cps equipment that has recently become popular, could be used, other methods are preferable. A magnetic harmonic generator can be used to convert three-phase 60-cps power to single-phase 540-cps power.[3] The circuit, Fig. 2, uses three saturable Nicaloi core reactors to quickly discharge three capacitors into a resonant output circuit. The capacitors are charged through separate linear reactors.

The three impulse circuits (similar to those used to excite ignitors[4]) are displaced 120 electrical degrees by the three-phase input. Each phase produces two peaks per cycle which are displaced 180 electrical degrees from each other. Thus, six impulses are produced per input cycle. The output is resonated to the 9th harmonic of the input frequency. A power pulse is thus delivered to the output on every third half cycle, thus obtaining the required phase relation. When the inductive kva in the resonant circuit is about six times the output power, the overall efficiency of the frequency converter is about 70 percent.

(1) J. H. Campbell, High Frequency Operation of Fluorescent Lamps, A paper presented at the National Technical Conference of the Illuminating Engineering Society, New Orleans, La., September, 1947; to be published in *Illuminating Engineering*
(2) J. H. Campbell and B. D. Bedford, Fluorescent Lamp Operation at Frequencies above 60 Cycles, A paper presented at the National Electronics Conference, Chicago, Ill., November 1947
(3) E. F. W. Alexanderson and A. H. Mittag of General Electric developed such a frequency changer
(4) A. H. Mittag and A. Schmidt, Jr., Ignitor Excitation Circuits and Misfire Indicating Circuits, AIEE Summer Convention, Chicago, Ill., 1942. Published in *AIEE Transactions* for 1942, p 575, disc. p 1062

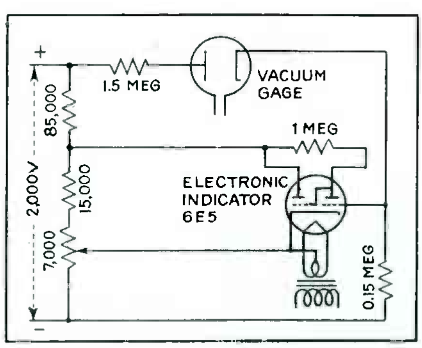
Nonlinear Indicator for Vacuum Gage

R. S. MACKAY
Department of Physics
University of California
Berkeley, California

A DEVICE for indicating when a predetermined vacuum has been attained is often desirable. For example, in connection with work on a gold evaporating chamber to be used by relatively unskilled operators, a fast-acting direct-reading gage was desired that would also be rugged, simple and foolproof.

Vacuum Detector

The detecting device that best suited the needs of this application seemed to be a Philips cold-cathode ion gage.[1] In this gage, which is sealed to the vacuum system, the cathode consists of two parallel plates, and the anode is a loop of wire between the cathode plates. Free electrons present in the gage oscillate in the direction of an externally applied magnetic field. Because the magnetic field prevents the electrons from falling directly into the anode loop, the electrons move in long enough paths to produce appreciable ionization of the residual gas molecules.



Electronic eye closes when vacuum is pumped to preset pressure

The result is that a discharge is established whose current is an increasing function of pressure. In the case of the tube used here, the cathode consisted of two circles of molybdenum 2.0 cm in diameter. separated by 2.0 cm, and the anode was tungsten wire ring 3.0 cm in diameter. Magnetic fields of 400, 800, and 1,600 oersteds were tested, greatest sensitivity being obtained with the field of 400 oersteds.

Gage Indicator

It was desirable that the gage indicator give a sudden decisive change when the preassigned condition was reached. The gradually changing reading of a microammeter is therefore unsuitable. The current passed by the gage can be passed through a resistor, the voltage drop being used to actuate a high-resistance detector. An inexpensive cathode-ray tuning eye proved very satisfactory as such an indicator when used in the accompanying circuit.

When the pressure drops to a predetermined value, the eye closes, giving an obvious indication. By proper choice of series resistors and plate and bias voltages of the indicator, the eye can be made to close abruptly in as small a pressure range as required, consistent with stability. Furthermore, this nonlinearity can be made to fall anywhere in the operating range of the gage by shifting the bias. If high sensitivity is desired, after reducing the 1.5 meg resistor, it might be well to introduce a resistor in series with the grid of the tuning eye to protect the grid on its positive swing (at pressures above the preset one). This resistor will not affect sensitivity because, when the eye is closing, the grid is negative and draws negligible current.

The eye tube is not only mechanically rugged, but also does not suffer when the currents rise due to bursts of air. Thus the gage can be left on at all times. If the gage is turned on when the system is at atmospheric pressure, the eye will be closed because the gage tube is then not conducting. As the pres-

(continued on p 170)

Collins vhf Airborne Equipment

A B C D E F

. . . for navigational use of the omnidirectional range

Aeronautical Radio, Inc., asked the radio communications industry in 1946 for proposals on receivers and instrumentation designed to meet the very difficult specifications demanded by omnidirectional range reception and indication in an airplane. Collins, one of six companies to comply, conducted demonstrations in January, 1947, for ARINC's Radio Equipment Committee and commercial airline engineers, and for the Air Transport Association's Air Navigation Traffic Control Research Group. Collins was one of two companies whose designs were approved.

Up to the time this announcement is written, demonstrations have been made for all domestic and many foreign airlines, and orders have been received for this equipment from American, Chicago & Southern, Northwest, Pan American, United, and Peruvian International. Meanwhile, the omnidirectional radio range system is now being installed on the major United States airways, and it is expected that this system will supplement and ultimately replace the four-quadrant beam range for air navigation.

The Collins equipment includes our 51R 280-channel receiver covering 108-136 mc on a 100 kc channel basis, and the instruments shown above and summarized below. The receiver includes all modern circuit features, and provides extremely high stability and rejection of spurious signals. The engineering model of a companion vhf transmitter is now under test.

Key to illustration above

A. 51R Receiver on Shockmount
B. Control Box
C. Radial Selector
D. Deviation Indicator
E. Radio Magnetic Indicator
F. Accessory Unit (Provides mounting for 2 Radial Converter Indicators, 3 Servo Amp. for R.M.I., and 2 Power Units for 2 51R's. The photograph shows 1 Radial Converter Indicator and 1 Power Unit mounted on the Accessory Unit.)

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COLLINS RADIO COMPANY, Cedar Rapids, Iowa

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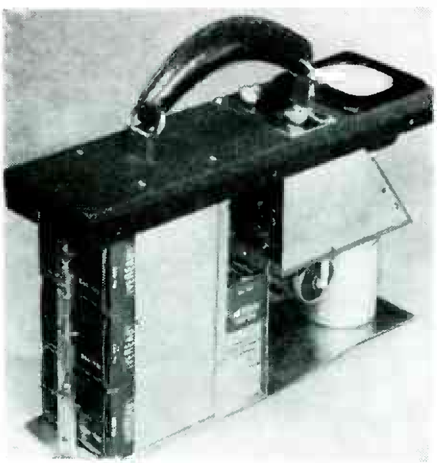
NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications received.

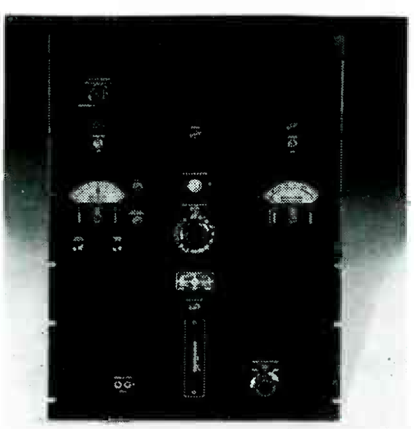
Portable Geiger Counter

VICTOREEN INSTRUMENT CO., 5806 Hough Ave., Cleveland 3, Ohio. Model 263-A battery-powered Geiger counter comprises a thin-wall counter tube that permits measurement of beta as well as gamma radiation. Three scales are provided that correspond to 0.2, 2.0, and 20 milliroentgens when calibrated against gamma radiation from radium.



F-M and Television Monitor

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. Type 1170-A f-m monitor provides center-frequency deviation and percentage-modulation indications for f-m broadcast and television audio-channel transmitters. Input sensitivity of the instrument is better than 1 volt r-f over the range 30 to 220 mc. Center frequency indicator is calibrated in 100-cycle divisions from minus to plus 3,000 cycles. The pulse counter discriminator is linear to better than 0.05 percent at 133 percent modulation. The crystal frequency is within plus or minus 10 parts per million.



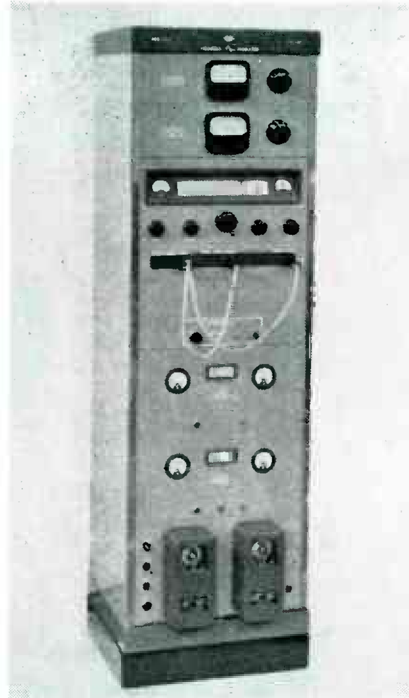
Cartridge Wire Recorder

RADIO CORP. OF AMERICA, Camden, N. J. A lightweight wire recorder features a plug-in cartridge that records up to a half hour of speech or music. An indexing device makes it possible to determine exact

locations of recordings on the wire. A unique takeup device insures movement of the wire at a constant speed.

F-M Networks

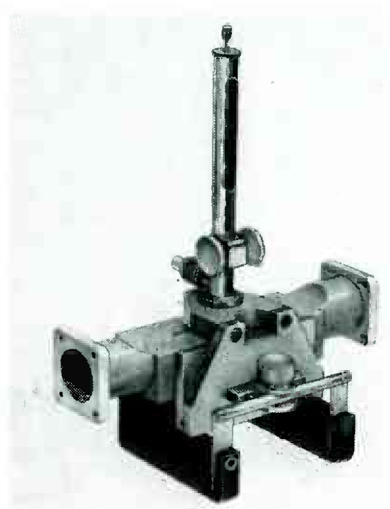
RADIO ENGINEERING LABORATORIES, INC., 35-54 Thirty-Sixth St., Long Island City 1, N. Y. Type TTL equipment model 693B illustrated is a combination of receivers, either



fixed tuned or tunable, a jack field, amplifier, and vu meters used to relay f-m programs from one broadcast area to another. Automatic clocks allow semiattended operation by preselection of programs at given times of day. Telephone lines can also be tied into the system.

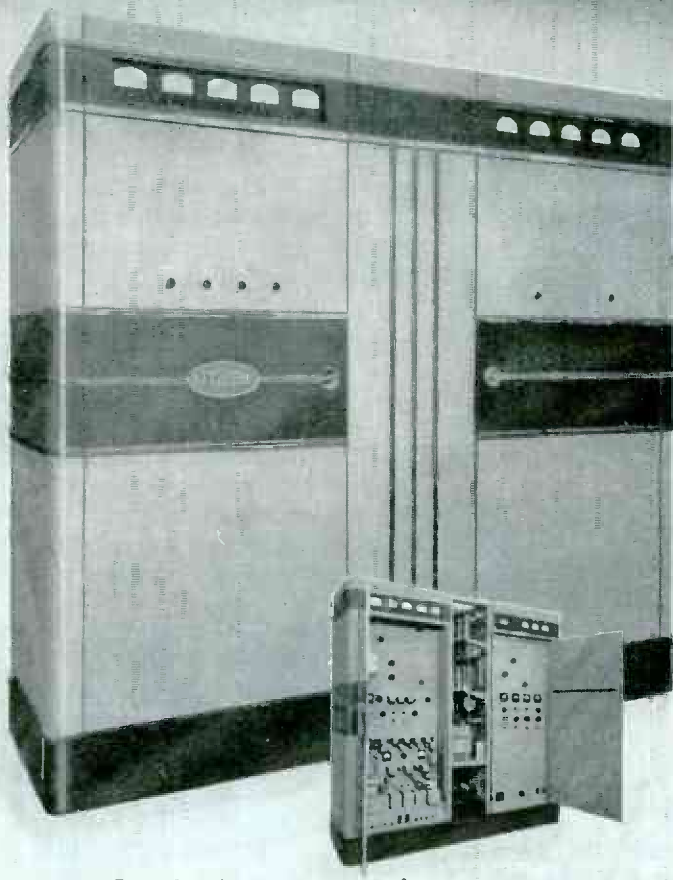
Slotted Section and Probe

POLYTECHNIC RESEARCH AND DEVELOPMENT CO., INC., 66 Court St., Brooklyn 2, N. Y. Slotted-section and probe combinations for microwave testing equipment are available in all commonly used waveguide and coaxial line sizes for the frequency bands between 1,000 and 40,000 megacycles. The probe illus-

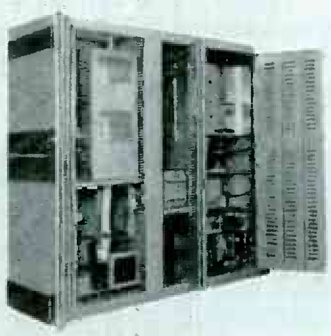


READY NOW

A New 3 KW-FM TRANSMITTER *by* RAYTHEON



Front view shows arrangement of controls for tuning driver and amplifier. Center lift-off panel has been removed to show accessibility of power supply.



Rear view showing accessibility of chassis, terminal boards, etc.

It's a RAYTHEON *Responsibility*

Backed by Raytheon's *complete* manufacturing and service facilities . . . when you specify *Raytheon* not only for FM or AM transmitters but for speech input and station equipment — you are teaming up with Raytheon's huge organization devoted to research and manufacture for the Broadcast Industry.

Look ahead with RAYTHEON

Raytheon's *Integrated Design* Policy lets your station grow with the industry. Start as low as 250 watts . . . step it up with the new 3KW-FM Amplifier and Transmitter . . . use it later as a driver for a 10 KW unit. You're set for the future with no fear of obsolescence.

Write today for complete information and technical details

Ask WLAW-FM *about* RAYTHEON SERVICE

Marked "OK for shipment" at Raytheon, Waltham, on Thursday, equipment for WLAW's new FM transmitter began feeding programs into their antenna at Burlington, Mass., on Saturday. That's evidence of Raytheon super service made possible by dependable, easy-to-install Raytheon quality equipment.

You'll like its LOOKS

It's clean as a whistle, modern, streamlined — a handsome addition to any up-to-the-minute station. It's true, but hard to believe, that the new Raytheon 3KW-FM Transmitter is the lowest cost reliably made equipment of its class that you can buy.

You'll like its PERFORMANCE

It's easy and quick to tune — requires a minimum of special testing equipment . . . delivers a high quality, stable, hi-fidelity signal . . . operates at an inherently lower noise level. Features *Raytheon* direct crystal control and simplified Cascade Phase Shift Modulation.

You'll like its EASE OF MAINTENANCE

Simple, conservatively rated circuits . . . easy accessibility . . . *the use of standard, readily obtained, easily replaced parts* — make this Raytheon 3KW-FM Transmitter the easiest, most economical equipment to service and operate.

RAYTHEON

Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY

COMMERCIAL PRODUCTS DIVISION

WALTHAM 54, MASSACHUSETTS

Industrial and Commercial Electronic Equipment, Broadcast Equipment, Tubes and Accessories

Sales offices: Boston, Chattanooga, Chicago, Dallas, Los Angeles, New York, Seattle, Washington, D. C.

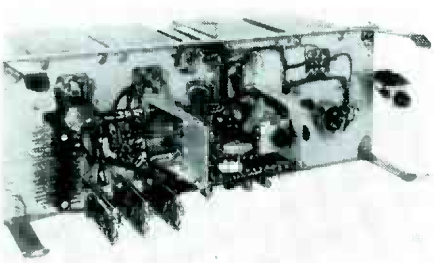
trated covers 1,000 to 12,400 mc. A feature of the units is the ball-bearing movement that eliminates backlash or play.

Sweep Generator

McMurdo Silver Co., Inc., 1240 Main St., Hartford, Conn. Model 909 f-m and television sweep generator covers a center frequency range of 2 through 226 mc in three bands. The frequency modulation sweep is adjustable from 40 kc to over 9 mc and output from 0 to 0.5 volt is available. Synchronization of the oscilloscope used to trace alignment pictures is at power line frequency or by saw tooth synchronizing voltage at twice power frequency. Net price of the new unit is $48.50.

Short-Haul Carrier

Federal Telephone and Radio Corp., Newark, N. J., Type 9-H-1 carrier system provides three channels that will operate on open tele-



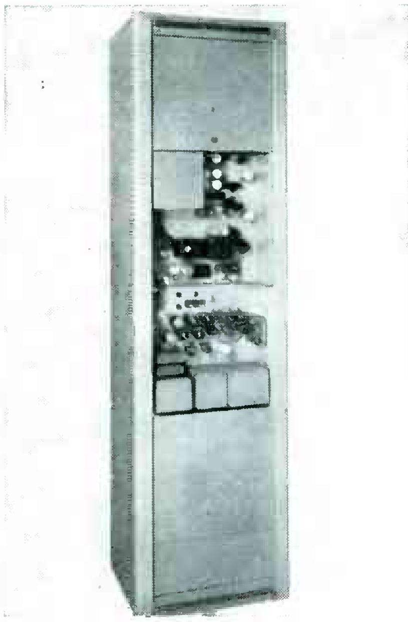
phone wires for distances up to 150 electrical miles. Other types of single-channel and long-distance systems are also in production.

Casting Resin

Mathieson Alkali Works, Inc., 60 East 42nd St., New York 17, N. Y. A casting resin described recently in releases from the National Bureau of Standards is now available in commercial quantities. Its properties include low power factor, low dielectric constant, short polymerization period, small volume shrinkage on polymerization, and low moisture absorbtion.

Monoscope Signal Source

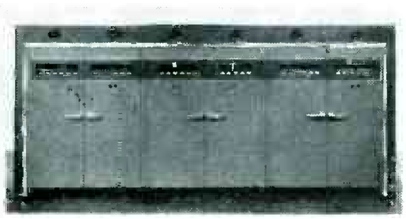
Polarad Electronics Co., 9 Ferry St., New York 7, N. Y. Model



PT102 television monoscope signal source produces a complete composite video signal for testing equipment from camera to receiver. Frequency response at 10 mc is 6 db down; resolution is greater than 600 lines; and there are both positive black and positive white outputs.

5-Kw Television

General Electric Co., Syracuse, N. Y. Type TT-6-A and TT-6-B 5-kw visual and 2.5-kw aural transmitters are available for operation on television channels 1 through 13.



The units are designed for low-level plate modulation. Specification sheets may be obtained from Electronics Park.

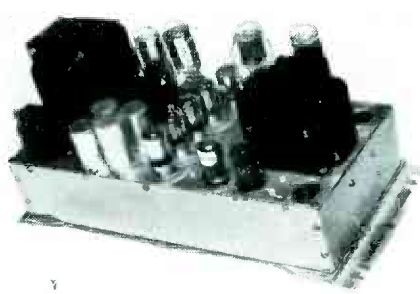
Decade Scaler

Potter Instrument Co., Inc., 136–56 Roosevelt Ave., Flushing, N. Y. Model 2092 decade scaler for radioactivity measurements has an input sensitivity of 0.25 volt. The scaler will resolve two pulses which are 5 microseconds apart and will count continuously with absolute accuracy rates up to 130,000 counts per

second. A high-voltage regulated power supply adjustable from 600 to 1,500 volts is included for operation of Geiger tubes.

Triode Amplifier

Brook Electronics, Inc., 34 DeHart Place, Elizabeth, N. J. Latest addition to a line of high-fidelity amplifiers is model 10-D a 30-watt, rack-mounting unit with 75-db gain. Frequency response from 20 to 20,000 cycles is within 0.2 db.



At 5 watts, the harmonic distortion is 0.6 percent and intermodulation distortion only 0.2 percent. Power supply is selfcontained. Noise is 70 db down. Further details from manufacturer.

F-M Sweep Generator

Radio Corp. of America, Camden, N. J. Type WR-53A sweep generator furnishes all signals needed for

(continued on p 194)

You can depend on these electronic tube alloys for better tube performance

GRADE A NICKEL:

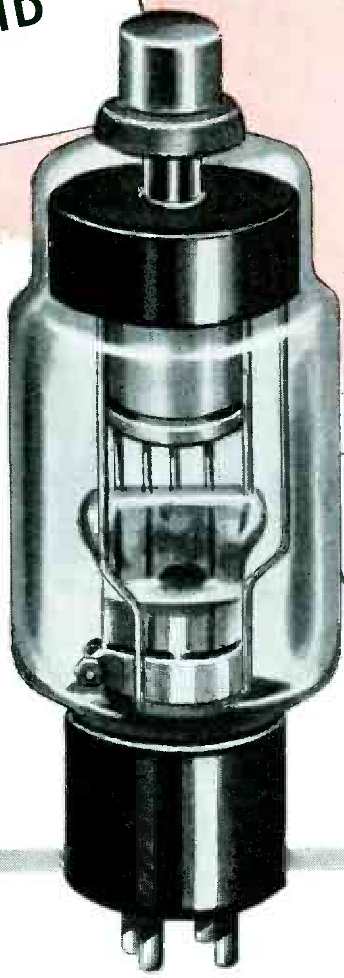
NICKEL WIRE
FOR SUPPORTS
NICKEL RIBBON
FOR ANODES

GRID WIRE:

MANGRID

CARBONIZED NICKEL RIBBON:

RADIOCARB A
POLICARB
DUOCARB



From the beginning of the industry Wilbur B. Driver Co. has been the leading supplier of alloys for Radio and Electronic uses. Constant development of new alloys and adoption of better processes has maintained this leadership.

Wilbur B. Driver alloys are made from the purest raw materials available and are melted in induction furnaces of the most modern type. The aim of the Wilbur B. Driver Co. is to aid in your technical development by continuing to supply alloys to match the demands of progress.

FILAMENT BASE METALS:

SYLVALOY, HILO
MODIFIED HILO
COBANIC, TENSITE
BALLAST

WILBUR B. DRIVER CO.
150 RIVERSIDE AVE., NEWARK 4, NEW JERSEY

TOPHET
FOR TOP HEAT

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

List of television stations; new heating frequencies; research positions open; phone recording legalized; radar ignites flash bulbs

Printed Circuit Techniques

A COMPREHENSIVE 43-page survey of the present status of the art of printing radio and electronic circuits has been issued by the National Bureau of Standards to meet increasing demands from industry for information on mechanized wiring techniques and mass-production printing of components themselves. Authors are Drs. Cledo Brunetti and Roger W. Curtis of NBS.

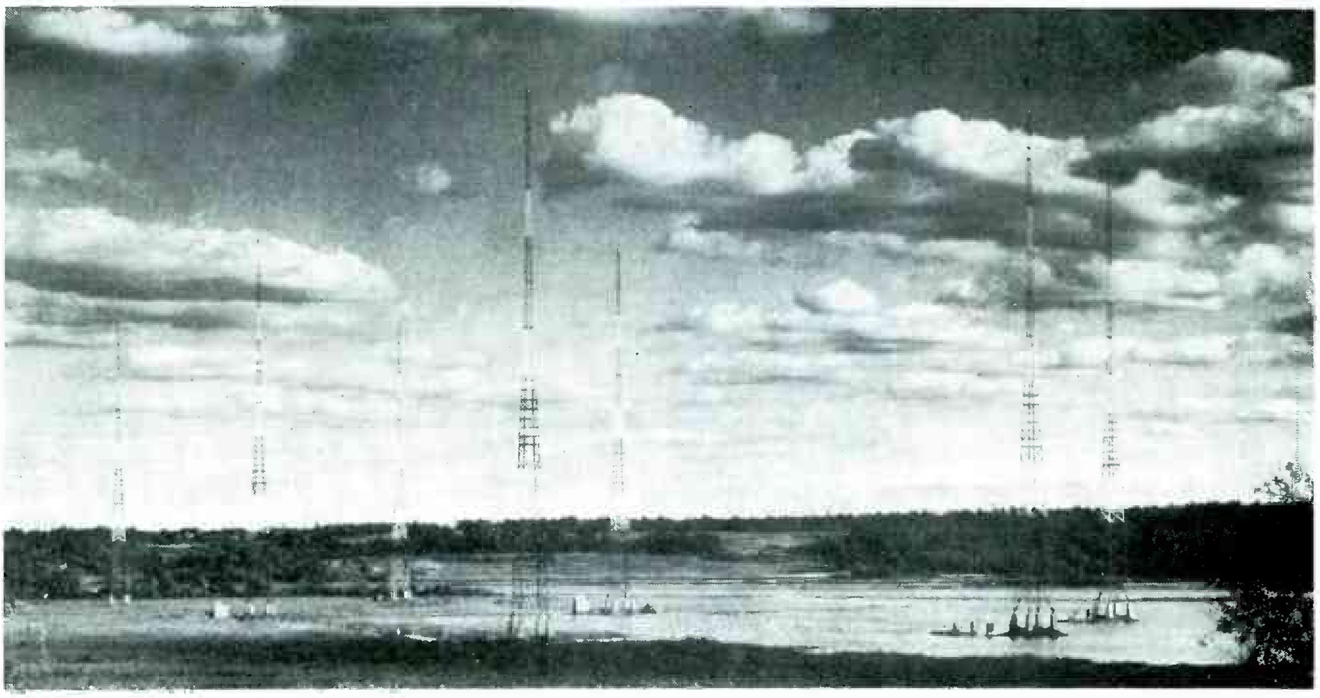
The survey divides the methods of printing into six groups and gives detailed instructions for using each, including compositions of the paints and inks used. The classifications are: (1) painting, wherein conductive and resistive paints are applied separately by brush or stencil, with other components added after drying; (2) spraying, wherein molten metal or paint is sprayed onto an insulating surface to form the wiring, or an abrasive spray is used to remove unwanted metal from a metal-plated plastic, to achieve the same results as an alternative direct die-casting process; (3) chemical deposition, involving mirror-silvering techniques for precipitating a metallic film on an insulating circuit; (4) vacuum processes, for depositing resistive or conductive layers on nonmetallic surfaces in a vacuum; (5) die-stamping, including preforming of conductors and stamped-embossing of conductors from a copper or aluminum sheet laid over a composition or plastic panel; (6) dusting of tungsten and molybdenum powder onto a ceramic body through a stencil and then firing in an oven or flashing with a flame. Performance characteristics of printed components and assemblies are given, many specific applications are cited, the patent situation is discussed, and a bibliography of 60 articles, books, and patents dealing with the subject is included.

This NBS Circular 468, designated as Printed Circuit Techniques, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. at 25 cents per copy.

FCC Adopts Final Rules for Citizens Band Equipment

FOLLOWING publication of proposed technical requirements and equipment approval procedures for the Citizens Radio Service (reported by ELECTRONICS, Jan. 1947, p 238), the FCC on Oct. 23, 1947 adopted certain sections of Part 19 of its rules. These sections, like those considered earlier, pertain only to the equipment; proposed rules for

Towers In The Sky



Seven selfsupporting base-insulated Blaw-Knox towers, some with wet feet, make up this unusual directional array used by station WREX in Duluth, Minnesota to protect several other stations operating on the same frequency in the a-m broadcasting band. Each tower is 225 feet high. Six are used at night, and the seventh is used with two of the nighttime towers as a three-element array providing daytime coverage over the Iron Range

THEY never leave the ground in a Link trainer. All their "flying" is done blind, by instrument and "radio beam," and every movement of the controls is recorded. The recording device is powered by a Telechron synchronous electric motor.

Such an application is not unusual for these versatile motors. They have been used successfully in clocks, and timing and instrumentation devices for 25 years—and more. Every day Telechron *application engineers* are helping manufacturers adapt them to new and important uses.

Dependable, self-starting Telechron motors meet a wide variety of needs in electric devices—from the simplest switch to the most complicated control mechanism. They reach rated speed almost instantly and operate in perfect synchronism with any commercial frequency . . . *can't run faster or slower*. Torque ratings are conservative. Precision building and Telechron's exclusive sealed-in oiling system assure accurate service and long life.

With a Telechron motor you give your product the plus value of Telechron leadership. For over 25 years, Telechron has been the largest producer of synchronous electric motors. Every one is Underwriters Laboratories approved. Telechron *application engineers* will be glad to discuss your needs. Address Motor Advisory Service, Dept. M, Telechron Inc., Ashland, Massachusetts.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

Telechron Motors Are Now Being Used for:

- Stoker, Oil Burner and Temperature Controls
- Industrial Process and Cycling Timers
- Business Machinery
- Medical Devices
- Household Appliance Timers
- Musical Devices

Telechron
REG. U. S. PAT. OFF.
SYNCHRONOUS MOTORS

The first and favorite synchronous electric timing motor licensing actual operation in the Citizens Radio Service are now being formulated.

The rules now adopted are substantially the same as those contained in the preliminary proposals. Chief differences are in section 19.203 which outlines procedures for making type tests of equipment, and which requires the following less stringent conditions for making the tests:

(1) Gradual ambient temperature variations from 0 to 125 F.

(2) Relative ambient humidity from 20 to 90 percent. This test will normally consist of subjecting the equipment for at least three consecutive periods of 24 hours each, to a relative ambient humidity of 20, 60, and 90 percent respectively at a temperature of approximately 80 F.

(3) Movement of transmitter or objects in the immediate vicinity thereof.

(4) Power supply voltage variations normally to be encountered under actual operating conditions.

(5) Additional tests as may be prescribed, if considered necessary or desirable.

Testing new two-way radio developed by Al Gross, president of Gross Electronics Inc., Cleveland, Ohio, for operation in the 460-470-mc band allocated for a citizens radio service. The set weighs only 11 ounces. See Nov. 1947 ELECTRONICS, p 80-89 for report on Citizens Radio Project sponsored by ELECTRONICS

MEETINGS

MARCH 22-24: Chicago Technical Conference, Stevens Hotel; meetings and exhibits; sponsored by 51 societies, including IRE, SMPE, and AIEE.

MARCH 22-25: IRE Convention and Radio Engineering Show, Hotel Commodore and Grand Central Palace, New York City.

APRIL 1-3: AIEE Great Lakes District Meeting, Des Moines, Iowa.

APRIL 7-9: Midwest Power Conference, Sheraton Hotel, Chicago, Illinois.

APRIL 24: Spring Technical Conference of IRE Cincinnati Section, featuring television papers, at Engineering Society Headquarters Building.

APRIL 28-30: AIEE North Eastern District Meeting, New Haven, Conn.

MAY 9-14: 1948 Radio Parts Show, Hotel Stevens, Chicago.

MAY 11-16: Engineering Progress Show, Franklin Institute, Philadelphia, Pa.; exhibits and two evening lectures.

JUNE 21-25: AIEE Summer General Meeting, Mexico City, Mexico.

AUG. 24-27: AIEE Pacific General Meeting, Spokane, Wash.

SEPT. 13-17: Third Instrument Conference and Exhibit, Convention Hall, Philadelphia, Pa.

OCT. 5-7: AIEE Middle Eastern District Meeting, Washington, D. C.

OCT. 11-12: FM Association Second Annual Convention, Sheraton Hotel, Chicago.

Television Station List

THE FOLLOWING FCC tabulation of television broadcast authorizations and applications shows activity as of Dec. 1, 1947 in 54 cities, with 6 stations licensed, 65 holding construction permits (of which 11 are on the air), and 43 applications pending (including 25 in hearing).

NOMENCLATURE

*	Licensed station
CP	Construction permit
CP-O	In operation, under special temporary authority
A	Applicant
A-H	Applicant, in hearing

FREQUENCIES OF CHANNELS

1 44–50 mc	8 180–186 mc
2 54–60 mc	9 186–192 mc
3 60–66 mc	10 192–198 mc
4 66–72 mc	11 198–204 mc
5 76–82 mc	12 204–210 mc
6 82–88 mc	13 210–216 mc
7 174–180 mc	

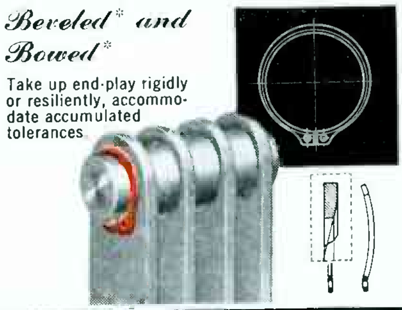
City and Applicant	Call Letters	Channel No.	Power in kw Visual	Power in kw Aural
CALIFORNIA				
Hollywood				
Television Productions, Inc.— CP-O	KTLA	5	30	15
Los Angeles				
American Broadcasting Co., Inc.— CP	KECA-TV	7	4.5	2.7
Earle C. Anthony, Inc.— CP	KFI-TV	9	16.1	17
National Broadcasting Co., Inc.— CP	KNBH	4	15	8
Dorothy S. Thackrey — CP	KLAC-TV	13	16	16
Times-Mirror Co.— CP	KTTV	11	19.15	19.15
Don Lee Broadcasting System — A-H	.....	2	.....	.....
Riverside				
The Broadcasting Corp. of America — CP	KARO	1	1	1
San Diego				
Balboa Broadcasting Co.— A	.....	6	.....	.....
San Francisco				
American Broadcasting Co., Inc.— CP	KGO-TV	7	5.4	2.7
Associated Broadcasters, Inc.— CP	KWIS	5	23.6	12.6
The Chronicle Publishing Co.— CP	KCPR	4	18–24	19–2
Don Lee Broadcasting System — A-H	.....	2	.....	.....
Stockton				
E. F. Peffer — CP	KGDM-TV	8	1.93	1.80
CONNECTICUT				
Hartford				
Connecticut Broadcasting Co.— A-H	.....	10	.....	.....
New Britain Broadcasting Co.— A-H	.....	8	.....	.....
Travelers Broadcasting Service Corp.— A-H	.....	10	.....	.....
Yankee Network, Inc.— A-H	.....	8	.....	.....
New Haven				
Elm City Broadcasting Corp.— CP	WNHC-TV	6	1.82	0.957
Waterbury				
Empire Coil Co., Inc.— A-H	.....	12	.....	.....
Fairfield Broadcasting Co.— A-H	.....	12	.....	.....
Harold Thomas — A-H	.....	12	.....	.....
DELAWARE				
Wilmington				
WDEL, Inc.— CP	WDEL-TV	7	1	0.5
DISTRICT OF COLUMBIA				
Washington				
Bamberger Broadcasting Service, Inc.— CP	WOIC	9	30–25	24.5
Allen B. DuMont Labs., Inc.— CP-O	WTTG	5	6.25	2.5
Evening Star Broadcasting Co.— CP-O	WMAL-TV	7	27.7	13.9
National Broadcasting Co., Inc.— CP-O	WNBW	4	20.5	17

(continued on p 236)

Waldes Truarc Retaining Rings
Now Nationally Distributed, Nationally Stocked

*Standard**
Forms secure shoulder, gives tight pressure fit when installed in a groove.

*Beveled** *and Bowed**
Take up end-play rigidly or resiliently, accommodate accumulated tolerances.



Crescent
Snaps on radially where axial assembly is impossible. No special tools needed.

E-Ring
Provides large strong shoulder for small shafts. Applied radially.

*Self-Locking**
Economical where thrust is moderate—holds fast, yet shaft requires no groove.

Interlocking
2-piece ring takes heavy thrusts, gives positive lock, secure against high RPMs.

*Available for both internal and external application

*Inverted**
For bearings with large corner radii, uniform shoulder for curved abutting surfaces.

There's a Waldes Truarc precision-engineered retaining ring to answer every need. Truarc rings give a never-failing grip because of their mathematically precise construction. No matter how demanding your specifications, it's a simple matter to refine your present designs to save material, machining and assembly costs. And now it's more convenient for you too—there's a distributor near you who stocks the rings you need. See the list below. Send your design problem to Waldes Truarc engineers, who will give it individual attention without obligation.

ONE OF THESE AUTHORIZED DISTRIBUTORS IS CONVENIENT TO YOU:

Akron, O., The Ohio Ball Bearing Co.
Albany, N. Y., Tek Bearing Co., Inc.
Appleton, Wisc., Wisconsin Bearing Co.
Atlanta, Ga., Moffatt Bearings Co.
Baltimore, Md., Moffatt Bearings Co.
Birmingham, Ala., Moffatt Bearings Co.
Bluefield, W. Va., W. Virginia Bearings, Inc.
Boston, Mass., Tek Bearing Co., Inc.
Bridgeport, Conn., Tek Bearing Co., Inc.
Buffalo, N. Y., Syracuse Bearings Co.
Canton, O., The Ohio Ball Bearing Co.
Charleston, W. Va., W. Virginia Bearings, Inc.
Charlotte, N. C., Moffatt Bearings Co.
Chicago, Ill., Berry Bearing Co.
Cincinnati, O., The Ohio Ball Bearing Co.
Cleveland, O., The Ohio Ball Bearing Co.
Columbus, O., The Ohio Ball Bearing Co.
Dayton, O., The Ohio Ball Bearing Co.
Decatur, Ill., Illinois Bearing Co.
Denver, Colo., Bearings Service Supply Co.
Detroit, Mich., Michigan Bearings Co.
Erie, Penn., Pennsylvania Bearings Inc.
Ft. Wayne, Ind., Indiana Bearings Inc.
Hamilton, O., The Ohio Ball Bearing Co.
Hammond, Ind., Berry Bearing Co.
Huntington, W. Va., West Virginia Bearings, Inc.
Indianapolis, Ind., Indiana Bearings Inc.
Ironton, O., The Ohio Ball Bearing Co.
Lafayette, Ind., Indiana Bearings Inc.
Lima, O., The Ohio Ball Bearing Co.
Lorain, O., The Ohio Ball Bearing Co.
Los Angeles, Calif., Edward D. Maltby Co.
Mansfield, O., The Ohio Ball Bearing Co.
Marion, Ill., Bearings Service Co.
Milwaukee, Wisc., Wisconsin Bearing Co.
Minneapolis, Minn., Industrial Supply Co.
Muncie, Ind., Indiana Bearings Inc.
New York, N. Y., Tek Bearing Co., Inc.
Newark, N. J., Tek Bearing Co., Inc.
Niagara Falls, N. Y., Syracuse Bearings Co.
Oakland, Calif., Bearing Specialty Co.
Peoria, Ill., Illinois Bearing Co.
Philadelphia, Penn., Moffatt Bearings Co.
Phoenix, Ariz., Edward D. Maltby Co.
Pittsburgh, Penn., Pennsylvania Bearings Inc.
Portland, Ore., O. W. I. Corporation
Providence, R. I., Tek Bearing Co., Inc.
Richmond, Va., Moffatt Bearings Co.
Rochester, N. Y., Syracuse Bearings Co.
St. Louis, Mo., Neiman Bearings Co.
Salt Lake City, Utah, Bearings Service Supply Co.
San Francisco, Calif., Bearing Specialty Co.
San Diego, Calif., Edward D. Maltby Co.
Seattle, Wash., Bearing Engineering & Supply Co.
Shreveport, La., Bearing & Transmission Co.
South Bend, Ind., Bearings Service Co.
Syracuse, N. Y., Syracuse Bearings Co.
Terre Haute, Ind., Indiana Bearings Inc.
Toledo, O., The Ohio Ball Bearing Co.
Toronto, Ont. Can., Controlite Engr. & Sales Ltd.
Wheeling, W. Va., West Virginia Bearings, Inc.
Youngstown, O., The Ohio Ball Bearing Co.
Zanesville, O., The Ohio Ball Bearing Co.

Factory engineering representatives available in each area

WALDES TRUARC RETAINING RINGS

WALDES KOHINOOR, INC.
LONG ISLAND CITY 1, N. Y.

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U.S. PATS. 2,302,948; 2,026,454; 2,416,852 AND BY OTHER PATS. PENDING.

(continued from p 136)

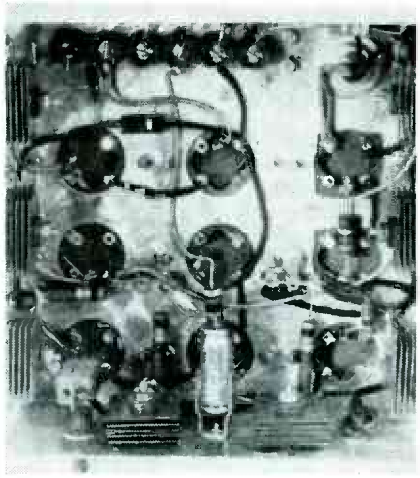


FIG. 2—Under-chassis view of a multiple-voltage power supply built on a 7 by 7-inch chassis and weighing three pounds

by the power transformer and filter choke, eases the production problem and allows the use of a less expensive cabinet. Size of a complete unit is illustrated in Fig. 2.

Stray Fields

The elimination of the power transformer also provides an electronic advantage. Since stray magnetic fields cause interference in the cathode-ray tube, it is often necessary to confine the power supply to a special chassis position away from the tube to minimize this effect. The use of selenium rectifiers places no such limitations on the engineer and they can be installed in any convenient location on the chassis.

Eliminating the transformer forces the designer to ground one side of the power line to the chassis, which introduces problems of safety. However, since all televis-

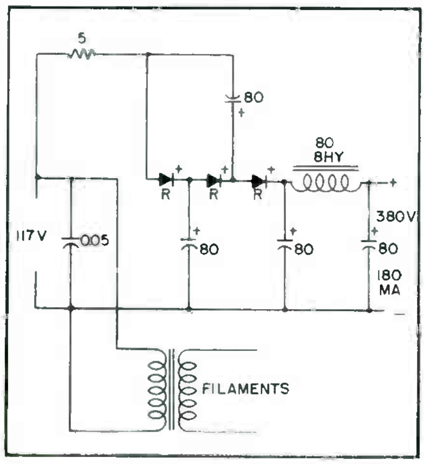


FIG. 3—Voltage tripler circuit for supplying 68 watts at 380 volts

IF YOU ARE LOOKING FOR

wet process insulators...

GENERAL CERAMICS AND STEATITE CORPORATION
STEATITE INSULATORS

—they're coming your way NOW!

It's true! Wet Process Electrical Insulators are in good supply at General Ceramics *now.* No matter what quantity needed, you can depend on General Ceramics for immediate delivery and a steady supply. Quality? They're engineered and manufactured to the same high standards that have for years made General Ceramics steatite insulators and sealed leads the accepted standard in the electronic and electrical industries.

If you need porcelain insulators for any application — high or low voltage — call or write us today. We'll do the rest — *and fast!*

General CERAMICS and STEATITE CORP.

GENERAL OFFICES and PLANT: KEASBEY, NEW JERSEY

MAKERS OF STEATITE, TITANATES, ZIRCON PORCELAIN, ALUMINA, LIGHT-DUTY REFRACTORIES, CHEMICAL STONEWARE

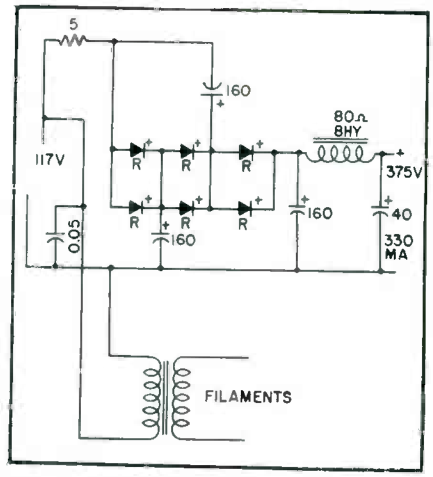


FIG. 4—Parallel-connected selenium rectifiers provide 122 watts at 375 volts

ion receivers use very high voltages, they ordinarily will be provided with a suitable back cover and interlock switch so that the hot chassis introduces no new complications. Some additional insulation of shafts and bolts passing through the cabinet may be needed to meet underwriters requirements.

The use of separate power supplies for each functional unit eliminates the problem of current changes in one circuit affecting all the rest, such as action of avc defocusing the set.

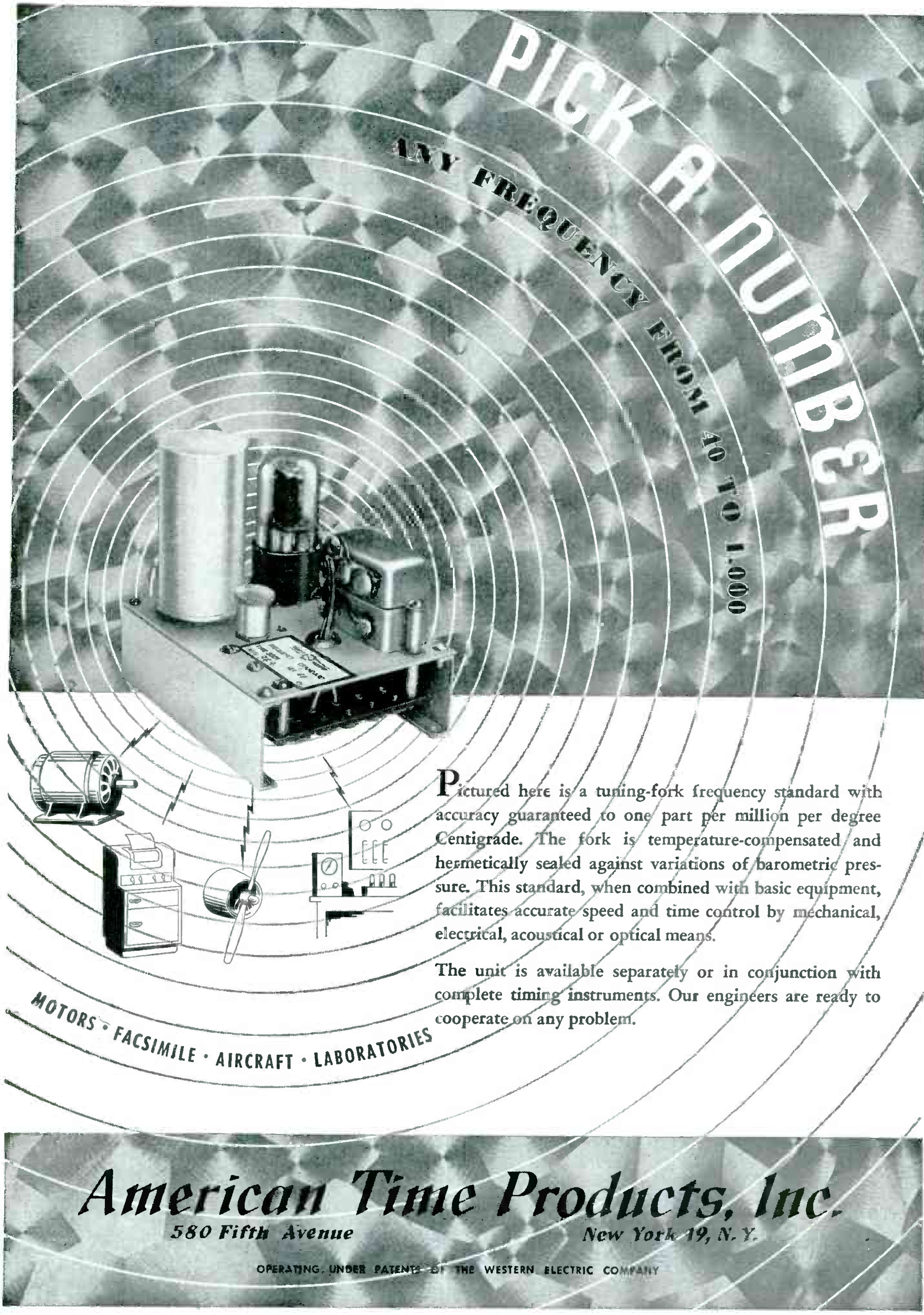
Good voltage regulation is obtained when the capacitances recommended on Fig. 1 are used. If the regulation exceeds requirements for any one or series of circuits, lower values can be used. This may be preferable from an economy viewpoint.

The 5 or 22-ohm resistor in series with each supply functions both as a current limiter and fuse. This resistor should be of the blowout type so that in the event of a short circuit, the resistor will burn out before the rectifier is damaged.

Figures 3 and 4 are schematic diagrams of two other types of selenium rectifier power supplies that may be used in television sets. In both circuits Federal type 404D2795 units are used.

Video for Hotel Rooms

HOTEL-ROOM radio installations, long a standard feature of the accommodations offered by many hostelries, can now be supplement-


PICK A NUMBER
ANY FREQUENCY FROM 40 TO 1,000
Pictured here is a tuning-fork frequency standard with accuracy guaranteed to one part per million per degree Centigrade. The fork is temperature-compensated and hermetically sealed against variations of barometric pressure. This standard, when combined with basic equipment, facilitates accurate speed and time control by mechanical, electrical, acoustical or optical means.
The unit is available separately or in conjunction with complete timing instruments. Our engineers are ready to cooperate on any problem.
MOTORS · FACSIMILE · AIRCRAFT · LABORATORIES
American Time Products, Inc.
580 Fifth Avenue
New York 19, N. Y.
OPERATING UNDER PATENTS OF THE WESTERN ELECTRIC COMPANY

ed by a system of individual television viewing units. A number of systems are now available that enable a hotel guest to select one of three channels at the viewing unit in his room.

The viewing units incorporate the sync, scanning, and audio power-amplifier circuits that are usually found in complete receivers. For each channel, video and audio from a master receiver are carried to all viewing units. Thus, to make three channels available to the guest, three coax networks connect three master receivers with the viewing units.

One three-channel installation of this type, including 44 viewers using 15-inch tubes, has been undertaken in the Hotel Roosevelt by Hotelvision, Inc. Receivers and viewing units for this firm are made by Olympic Radio and Television, Inc., Long Island City, N. Y. For use in the hotel's public gathering places, 20-inch units can be produced.

Industrial Television, Inc., Nutley, N. J., displayed its multiple-viewer system at the National Hotel Exposition November 10. Although more channels can be connected, this system was demonstrated with three master receivers, permitting selection of three channels on viewers having 10, 15, and 20-inch tubes.

A novel consolidation of juke box and television receiver, built by Emerson for use in restaurants and bars, was displayed by American Communications Corp. at the hotel exposition. This unit was so constructed that during the period when television stations are not on the air, the juke-box would operate in the usual fashion. When television programs are available, a switch is thrown, whereupon each nickel inserted in the machine allows three minutes of television to be displayed.

Variable-Capacitance Aircraft Fuel Gage

LIMITATIONS inherent in float-operated fuel gage systems led to the development of a capacitance fuel measurement system which is sensitive to mass rather than volume of fuel, and relatively insensitive to temperature and humidity variations and changes in plane altitude.

Basically, the capacitance fuel gage consists of three elements. The first element is the primary detector which consists of a varying-dielectric capacitor whose capacitance is a function of the quantity of fuel in the tank. Aircraft fuels presently used have a dielectric constant of about two, while air, or fuel vapor, has a dielectric constant of unity. Thus, as the fuel content of the tank varies from empty to full, the capacitance of the primary detector changes by a ratio of about two to one.

The second component of the system is a capacitance-to-current converter, the circuit of which is shown in Fig. 1. Two oscillators are used, each of which has inductive coupling between plate and grid inductors. One oscillator operates at a fixed frequency, while the other oscillates at a frequency that is controlled by the capacitance of the primary detector.

In the variable-frequency oscillator, a conventional *L-C* network forms the resonant plate circuit while the resonant grid circuit consists of a fixed inductor across which the variable-capacitance detector is connected. Thus the resonant frequency of the plate circuit is fixed while that of the grid circuit varies as the fuel quantity changes. Because the grid and plate circuits are coupled, they must oscillate at the same frequency. When the fuel tank is empty, the resonant frequencies of the two tuned circuits are nearly equal, and the power required to maintain oscillation is a minimum. As the fuel content of

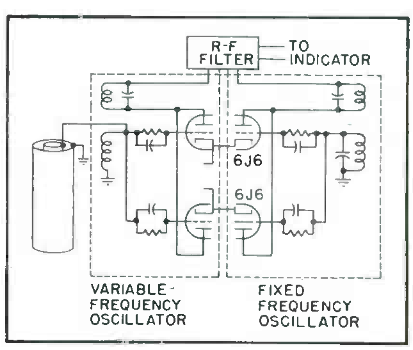
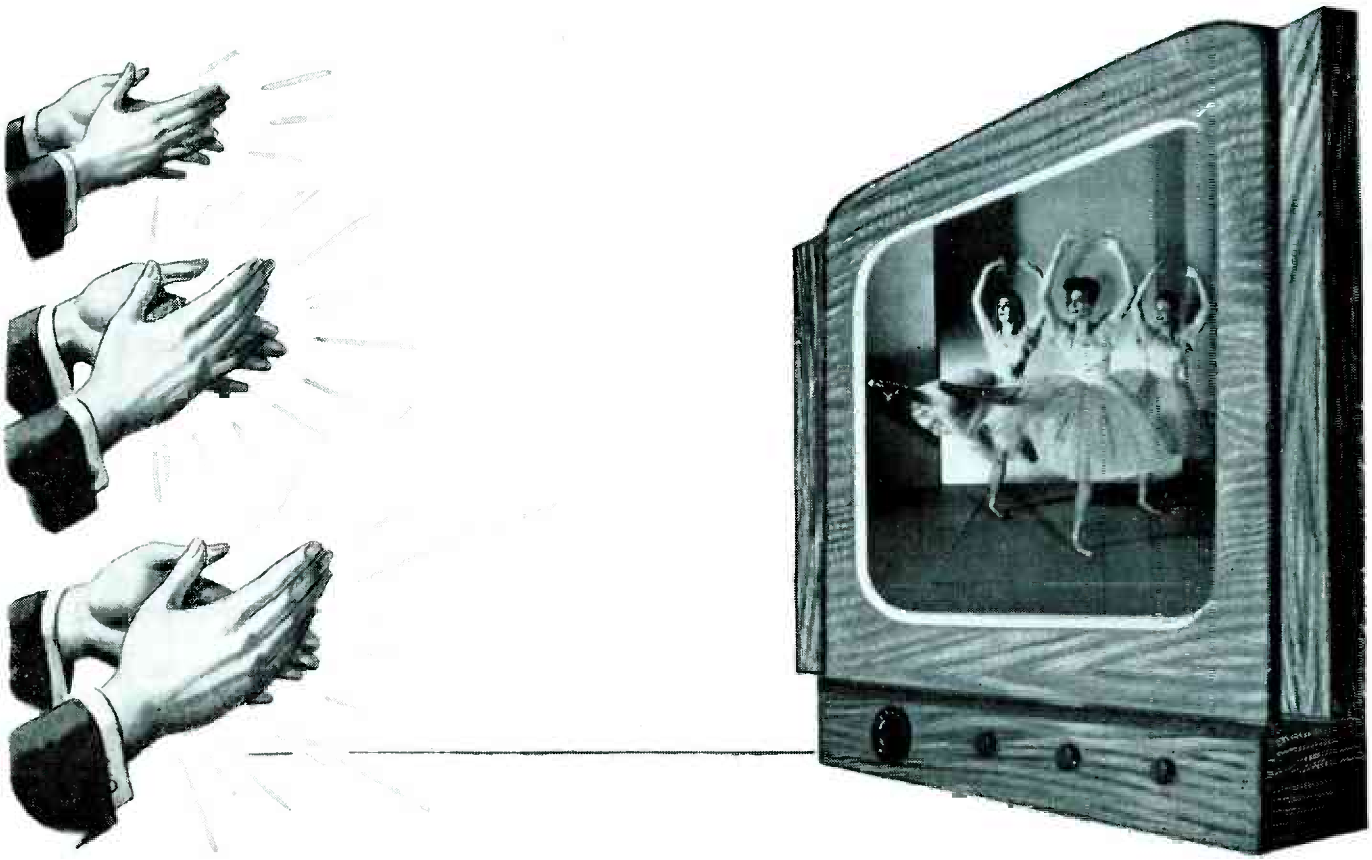


FIG. 1—Dual oscillators convert capacitance changes to current variations to be read on the fuel indicator



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The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV lead-in lines.

The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest development in coaxial cables. 48446

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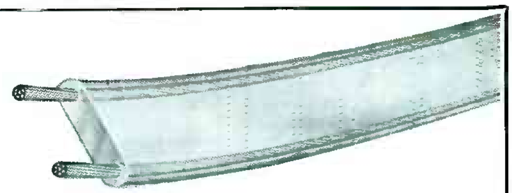

A TYPE ATV LEAD-IN FOR EVERY NEED

Anaconda offers a complete selection of Type ATV lead-in lines for 75, 150 and 300 ohms impedance unshielded and shielded lines of high impedance. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York.

ANACONDA

Anaconda Wire and Cable Co.

the tank increases, the natural frequency of the grid circuit changes from that of the plate circuit and the power required to drive the oscillator increases. If the supply voltage is constant, the direct current drawn by the oscillator is a measure of the power required to maintain oscillation, and is a function of the quantity of fuel available.

Variable direct current from the variable-frequency oscillator and constant direct current from the fixed-frequency oscillator are fed to a moving-magnet, ratio type indicator, the third basic element of the system.

A dual oscillator circuit is used so that changes in tube characteristics occurring as the tubes age, as well as variations in supply voltage, ambient temperature, and relative humidity will have nearly equal effects upon both oscillators. In this way, errors are minimized.

Detector

The primary detector consists of two concentric aluminum cylinders, strong enough to withstand normal handling and operating conditions. Spacing between the cylinders is made greater than ⅛ inch, to minimize the effects of capillary action. By varying the contours of the cylinders, or the spacing between them, the capacitance per inch of length of the primary detector can be varied over a rather wide range. This feature permits the distribution of the indicator scale to be somewhat independent of the shape of the fuel tank, which is a characteristic necessary for totalization.

Suitable damping is incorporated in the primary detector by restricting the rate at which fuel may enter and leave the concentric cylinder capacitor. The holes through which the fuel flows are small enough to prevent sudden changes in fuel level within the capacitor, but are large enough to render unlikely the possibility of clogging by solid particles in the tank. This feature provides satisfactory indicator pointer operation in rough air.

Effects of changes in attitude of the aircraft are further minimized by using three variable-capacitance detector units located at different points in the tank. The units are

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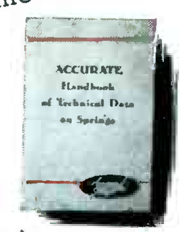

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connected in parallel and the indicator calibration is adjusted so that tank fuel content is read correctly.

Tests have shown that sufficient energy is not available at the primary detectors to cause an explosion in the fuel tank if a short-circuit does occur at this point. The primary detector is connected in the low-energy grid circuit, where the only power available is from the r-f oscillator. If a short-circuit does occur, the oscillations stop, and no energy is available in the fuel tank. Complete details of the system were disclosed by D. B. Pearson of General Electric Co. at a recent meeting of AIEE.

Watch Timer

By R. S. Mackay, Jr.
Department of Physics
University of California
and
R. R. Soule
University of California
Berkeley, California

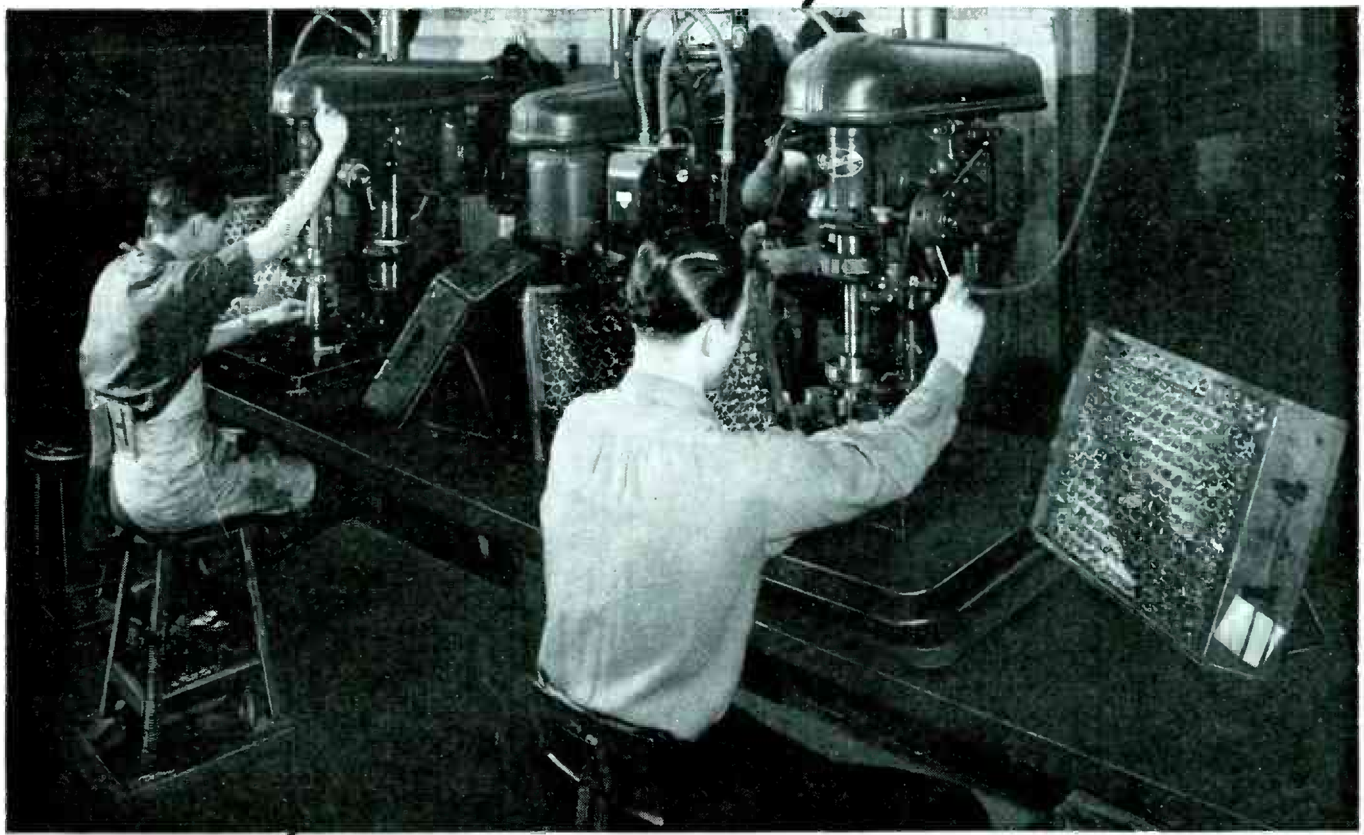
The problem of indicating in a period of a few minutes whether a watch is running fast or slow calls for some means of timing the interval between ticks. Since most watches tick five times per second, corresponding to 5 cps, a precise frequency indicator or comparator for this low frequency is needed.

A standard interval timer in which a capacitor charges during the interval between two successive ticks is not a satisfactory solution because it does not give the average interval between ticks. A bent tooth in the escapement would invalidate the readings.

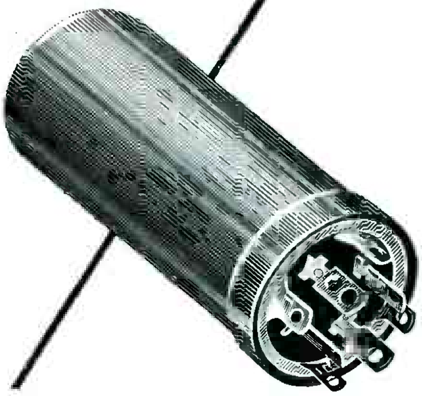
It is possible to construct a resonant circuit tuned to 5 cps, but stability seemed somewhat inadequate for this purpose. A heterodyne arrangement using a higher-frequency high-Q filter seemed cumbersome. A standard counting-rate meter circuit, in which a small constant increment of charge is given a large capacitor upon arrival of each tick impulse and the total charge is measured as an indication of the number of impulses per second, also appeared uncertain in its limitations.

The method actually chosen involves stroboscopic comparison of

Leading Radio Manufacturers Specify Components by Magnavox



Spinning cathode mounting ring and cover assembly in fabricated plate electrolytic capacitors.



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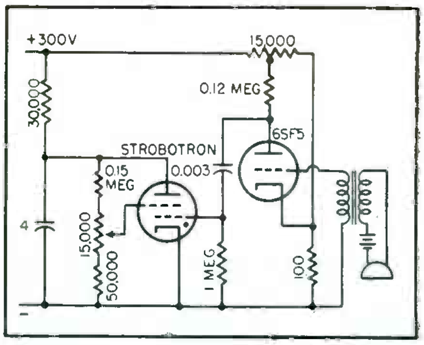

FIG. 1—Circuit for converting tick of watch or other sound into a flash of light for comparing frequency of ticks with standard frequency source

the tick rate with a standard frequency. A synchronous motor rotates a disk at a speed of 5 revolutions per second and is illuminated by a flash of light each time that the watch ticks. If the watch is keeping correct time, the disk appears to stand still; if the watch is running fast, it appears to rotate backward, and forward if slow. Furthermore, the apparent rate of rotation is a linear measure of the amount of adjustment necessary for correct timing.

Strobotron Circuit

The electronic problem involved constructing a stroboscope that would flash each time the sound of a tick was picked up by a microphone. The circuit developed for this purpose is shown in Fig. 1. The strobotron cold-cathode gas-filled tube serves as the light source. A discharge takes place whenever the potential difference between any two of its electrodes becomes high enough. Being neon filled, the discharge (in which the current may for an instant rise to many amperes) is accompanied by a bright red flash.

In the circuit shown, the 6SF5 is normally biased to cutoff. An impulse from the microphone allows current to flow and results in an abrupt drop in the potential of the plate. A negative pulse is thus applied through a capacitor to the inner grid of the strobotron, driving this grid below its normal ground potential. Since the outer grid has been maintained at its original positive potential, the resulting increased potential difference between grids causes a breakdown in which the 4-μf capacitor discharges through the tube. The

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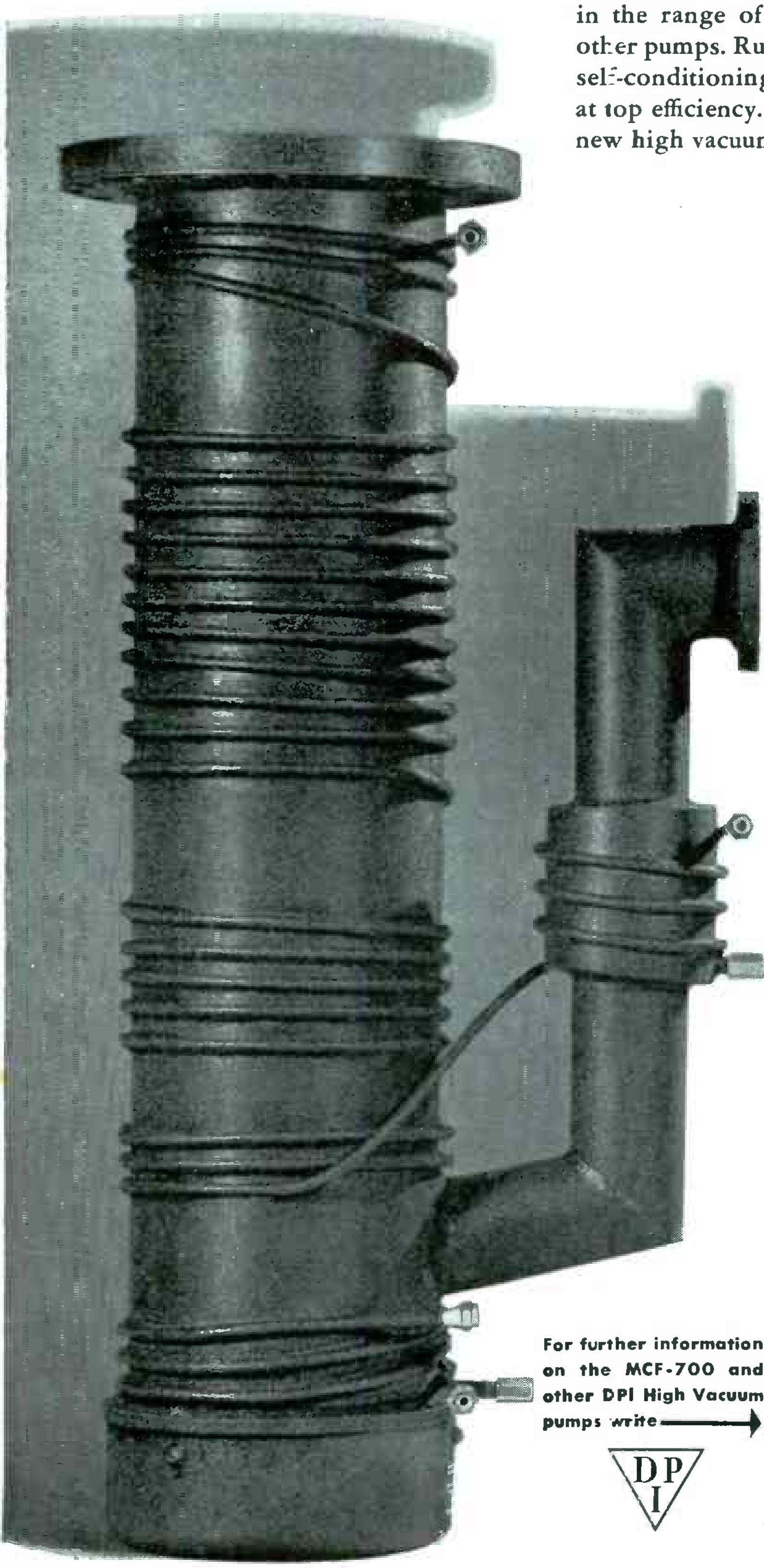
WHEN you need high pumping speeds in pressures down to 10^{-6} mm of mercury, the performance of the new MCF-700 will meet your specifications exactly. This pump delivers from 100 to 500 liters per second in the range of 10^{-6} to 10^{-5} mm,—performance unduplicated by any other pumps. Ruggedly constructed, the MCF-700 operates on a unique, self-conditioning principle which keeps the fractionating jets operating at top efficiency. The tables below outline the essential features of this new high vacuum pump.



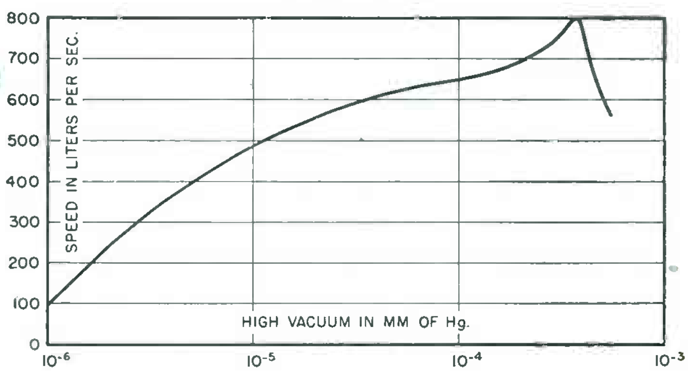
PHYSICAL DATA

High Vacuum Flange	6″ i.d., 9″ o.d. 8″ bolt circle
Forepump Flange	2⅜″ i.d., 3¾″ o.d. 3 5/16″ bolt circle
Height	29″
Length	14″
Width	9″
Construction:	
Casing	Seamless Steel
Jet Assembly	Aluminum and Steel
Cooling	Water
Weight	Approx. 40 lbs.

OPERATION DATA

Amount of Oil	500 grams
Recommended Oil	Octoil or Octoil-S
Forepressure	0.10 mm
Heater Power	800 watts
Heater Current	7.0 amp.
Heater Voltage	115 volts A.C. or D.C.
Speed	700 l/s
Ultimate Vacuum	5×10^{-7} at 25° C.

PERFORMANCE



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discharge of the capacitor lowers the plate and outer grid potentials so the tube can deionize and ready itself for another cycle. The RC constant of this circuit was chosen to minimize spurious flashes due to miscellaneous noises.

If direct mechanical contact is maintained between the watch and the carbon button the unit will work as shown. If it is desired to let the air-carried sound of a small watch activate the microphone, it will be necessary to interpose a stage of capacitance-coupled amplification between the microphone transformer and the 6SF5 tube. A carbon microphone was used because of its high output, but any other type could be made to work as well.

Accuracy of Reading

In use, a mark on the disk attached to the synchronous motor is observed by the light of the strobotron. The watch error for a given observation period can be marked directly on a scale in front of the disk, or a simple chart can be used to indicate the error in terms of the time required for turning through some given marked angle. If, for instance, a watch gains time at the rate of 10 seconds per 24-hour day, the spot will appear to rotate one revolution backward in 28.8 minutes. With a five-minute observation period the rotation would be 62.5 degrees, which is more than enough for an accurate observation.

The accuracy of the device is of course no greater than the stability of the standard comparison frequency which is driving the synchronous motor. In certain localities the 60-cycle line frequency is accurately enough controlled even over short intervals to permit connecting a 24-tooth synchronous motor directly to the line for a rough check, giving a compact unit. Where the regulation is poorer or greater accuracy is desired, the motor must be driven by some form of stabilized oscillator, such as a tuning fork unit or a quartz crystal oscillator with a frequency divider. The motor itself must maintain constant speed during any reasonable voltage changes.

Two-Watch Method

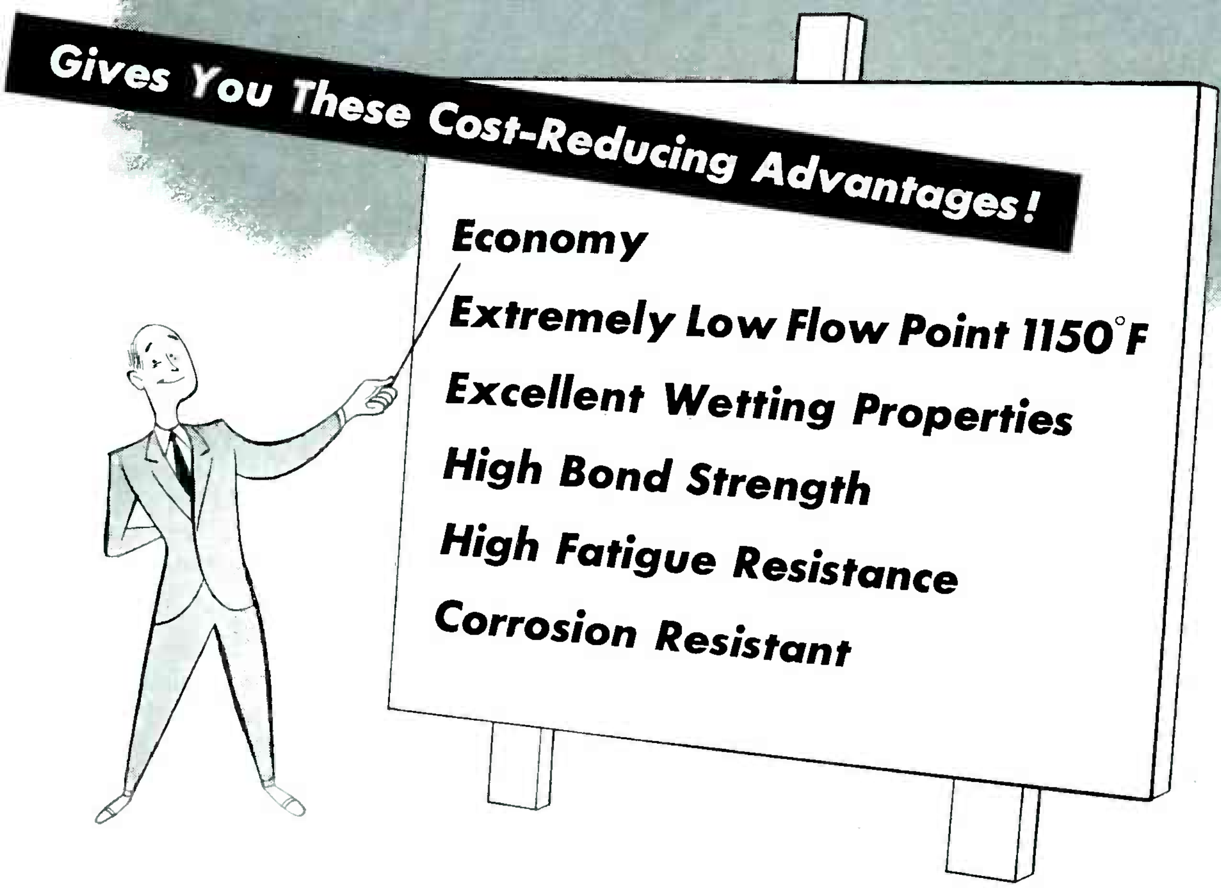
An accurate watch or chronometer, if available, can serve in place

GENERAL PLATE

Lo-Flo

(154)

SILVER SOLDER



General Plate *Lo-Flo* 154 is an ultra low-flowing silver solder that greatly exceeds other silver solders in wetting properties. For that reason and because it contains 45% silver, *Lo-Flo* 154 is more economical than conventional solders that contain 50% silver.

Besides its low flow point of 1150° F, this silver solder gives you high bond strength and corrosion resistance. General Plate *Lo-Flo* 154 will increase production and save you money. It is available in a variety of forms for pre-positioning such as strips, washers, etc. Write for complete information, today.

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of a standard frequency. A double microphone input to the strobotron tube is then used. The synchronous motor speed need be only approximately five revolutions per second. One microphone is placed near the chronometer, while the other is exposed to the watch under test. Two dots appear, one due to each source. If the angle between the dots remains constant with time, correct timing of the watch under test is indicated. If not, the rate of change of this angle is a measure of the degree of maladjustment.

If desired, a time delay circuit can be inserted in one microphone channel to shift one dot to a convenient position for observation relative to the other. This can be made variable and used to time-delay the dots into coincidence and then, after a measured time, bring them back into coincidence again. Once it was calibrated, the time delay control knob would give directly the error in seconds per day. Time delay, introduced in a mechanical or an electronic manner, can similarly be used in the original set-up by twice bringing the dot to some fixed reference point. The delay time need not be known too accurately, since a small error in it merely produces a small error in the presumably already small necessary correction in timing.

The variable time delay can be a properly constructed one-kick multivibrator or a welding type interval timer in which a given number of cycles from an oscillator determines the end of the delay period.

For variation, the tick pulses of the two watches can be fed into a two-tube trigger circuit having two stable states of equilibrium, in which one tube or the other is conducting but not both. An impulse shifts conduction to the other tube. Since two successive impulses would always arrive one from one source and one from the other, the length of time during which the second tube conducts is proportional to the phase difference existing between the two sources. The rate of change of this time then measures the error of the watch.

If conduction in the second tube is used to apply a constant small positive voltage to the grid of a cut-off pentode having fixed screen

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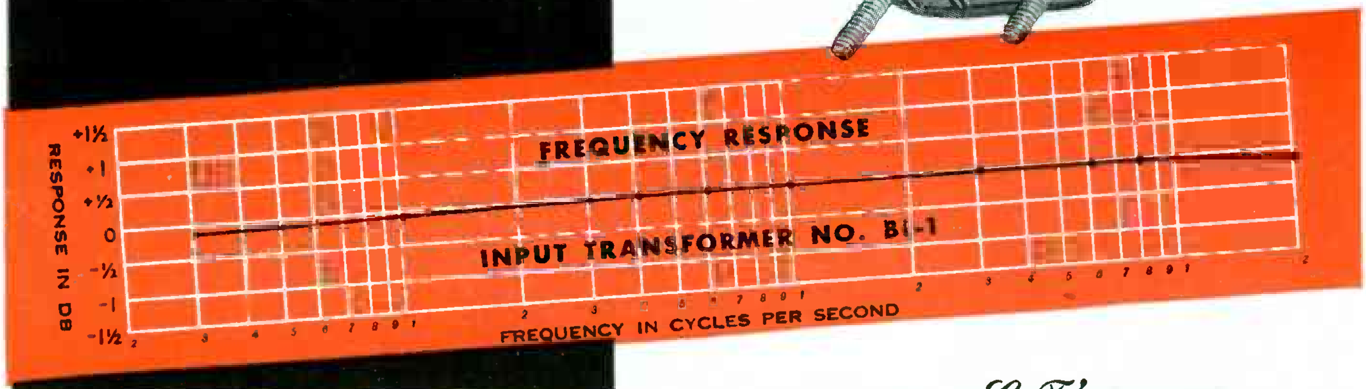

INPUT TRANSFORMERS

Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
BI-1	Line to Single or P.P. Grids	*Pri.—600/150 ohms CT *Sec.—50,000 ohms CT	+20 dbm.
BI-2	Line to Single or P.P. Grids	*Pri.—600/150 ohms CT *Sec.—50,000 ohms CT	+20 dbm.
BI-3	Line bridging to P.P. Grids	*Pri.—8,000/6,000 ohms CT *Sec.—50,000 ohms CT	+20 dbm.
BI-4	Line to line	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT	+20 dbm.
BI-5	Line to line	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT	+30 dbm.
BI-6	Interstage—P.P. Plates to Single or P.P. Grids	*Pri.—20,000 ohms CT *Sec.—50,000 ohms CT	+20 dbm.

OUTPUT TRANSFORMERS

Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
BO-1	Single Plate to Line	Pri.—15,000 ohms at 0 to 10 ma d-c *Sec.—600/150 ohms CT	+20 dbm.
BO-2	P.P. Plates to Line	*Pri.—20,000 ohms CT *Sec.—600/150 ohms CT	+30 dbm.
BO-3	P.P. Plates to Line	Pri.—5,000 ohms CT *Sec.—600/150 ohms CT	+40 dbm.
‡BO-4	P.P. Plates to Line	Pri.—7,500 ohms CT *Sec.—600/150 ohms CT	+43 dbm.
BO-5	P.P. Plates to Line	Pri.—10,000 ohms CT *Sec.—600/150 ohms CT; 16/8/4 ohms	+37 dbm.

‡Has tertiary winding to provide 15% inverse feedback.
*Split and balanced windings.

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voltage, then the average plate current of a pentode (which is a constant-current device) is a measure of the time between pulses and the rate of change of this current is a measure of the error. A pulse shaper should be introduced to prevent erratic operation if the two pulses come almost exactly into phase. As before, an accurate 5-cps oscillator could replace the chronometer.

All-Electronic Timer

A cathode-ray tube may be used in place of the synchronous motor if an all-electronic watch timer is desired. An accurately controlled frequency that is some small integral multiple of 5 cps is passed through a 90-degree phase shifter, and the resultant equal-amplitude voltages are applied to the two sets of deflecting plates of a cathode-ray tube, as shown in Fig. 2. It is thus possible to produce a circular trace that makes one revolution in the period between ticks for a 5-cps standard, or two revolutions for a 10-cps standard.

The grid of the cathode-ray tube is biased so no electrons get through (no spot is produced) until a suitably amplified sound impulse is applied. Thus a glowing spot will appear at each tick just as with the mechanical scheme, and will appear to drift in a similar manner for an unadjusted watch. One disadvantage of this method is the number of extra tubes needed to divide the known frequency down to a usable value.

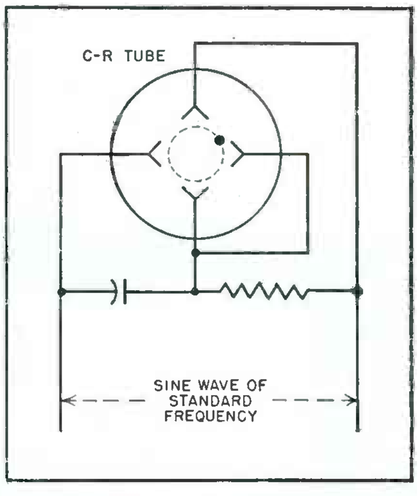

FIG. 2—Alternate indicating means, using cathode-ray tube in place of synchronous motor

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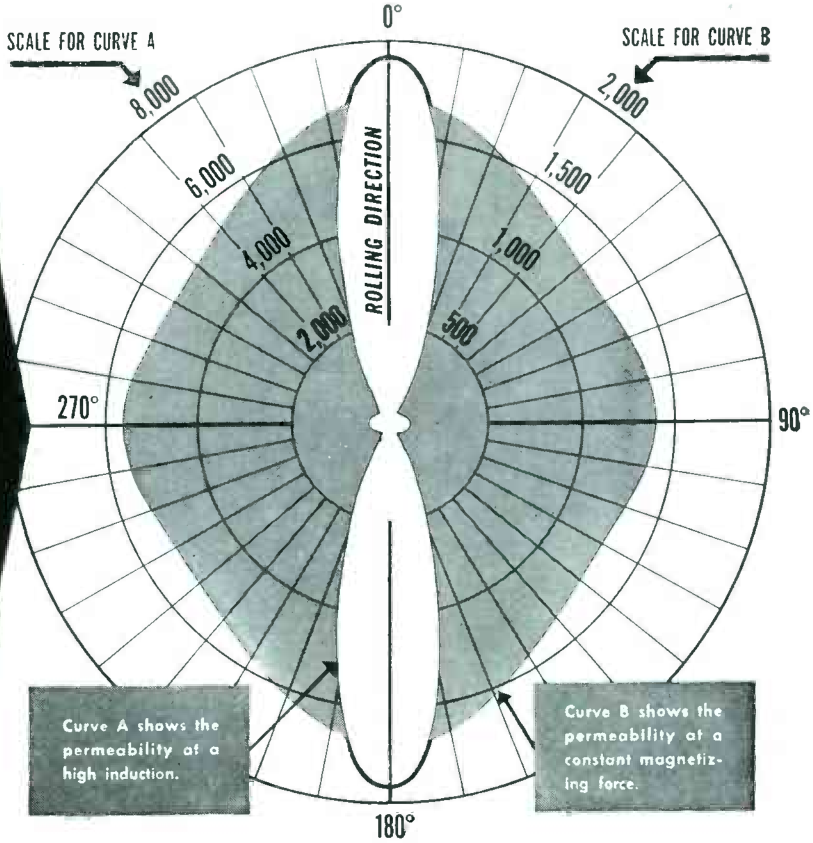
Oriented Steels with LOWER Core Loss and HIGHER Permeability

POLYDIRECTIONAL PERMEABILITY CHART



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ARMCO TRAN-COR XX	0.90 watt per pound
ARMCO TRAN-COR XXX	0.80 watt per pound

Core loss tests on Armco oriented electrical steels are made at an induction of 96,750 lines psi. (15 kilogausses). Test limits are based on the general testing procedure approved by the American Society for Testing Materials, except that parallel-grain specimens are given a stress-relieving anneal after shearing.

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They make possible the design of lighter cores with higher operating inductions. And they give the transformer designer three cold-reduced grades with these unusual advantages: *lower* core loss concurrent with *higher* permeability in the rolling direction, and a higher space factor. Heretofore, lower core loss has been obtained only at the expense of permeability.

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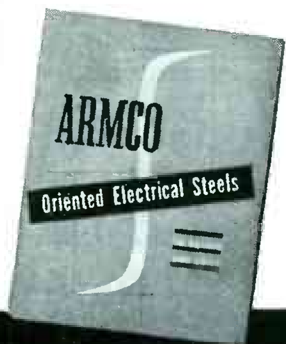


ARMCO ORIENTED STEELS

THE ELECTRON ART
(continued from p 140)

sure drops, the gage conducts and the eye opens and remains open until the preset pressure is reached. With the arrangement shown, by adjusting the 7,000-ohm potentiometer, the reclosing pressure can be selected in the range from 70 microns down to about 10^{-2} micron (7×10^{-2} mm to 1×10^{-5} mm) of mercury. The action of any one unit depends on gage tube construction, voltages used, and the series resistor. The technique can be extended to a relay operated by an amplifier tube.

(1) F. M. Penning, *Physica*, p 873, 3, 1936; p 71, 4, 1937.

Stabilizing Frequency of Reflex Oscillators

By GEORGE G. BRUCK

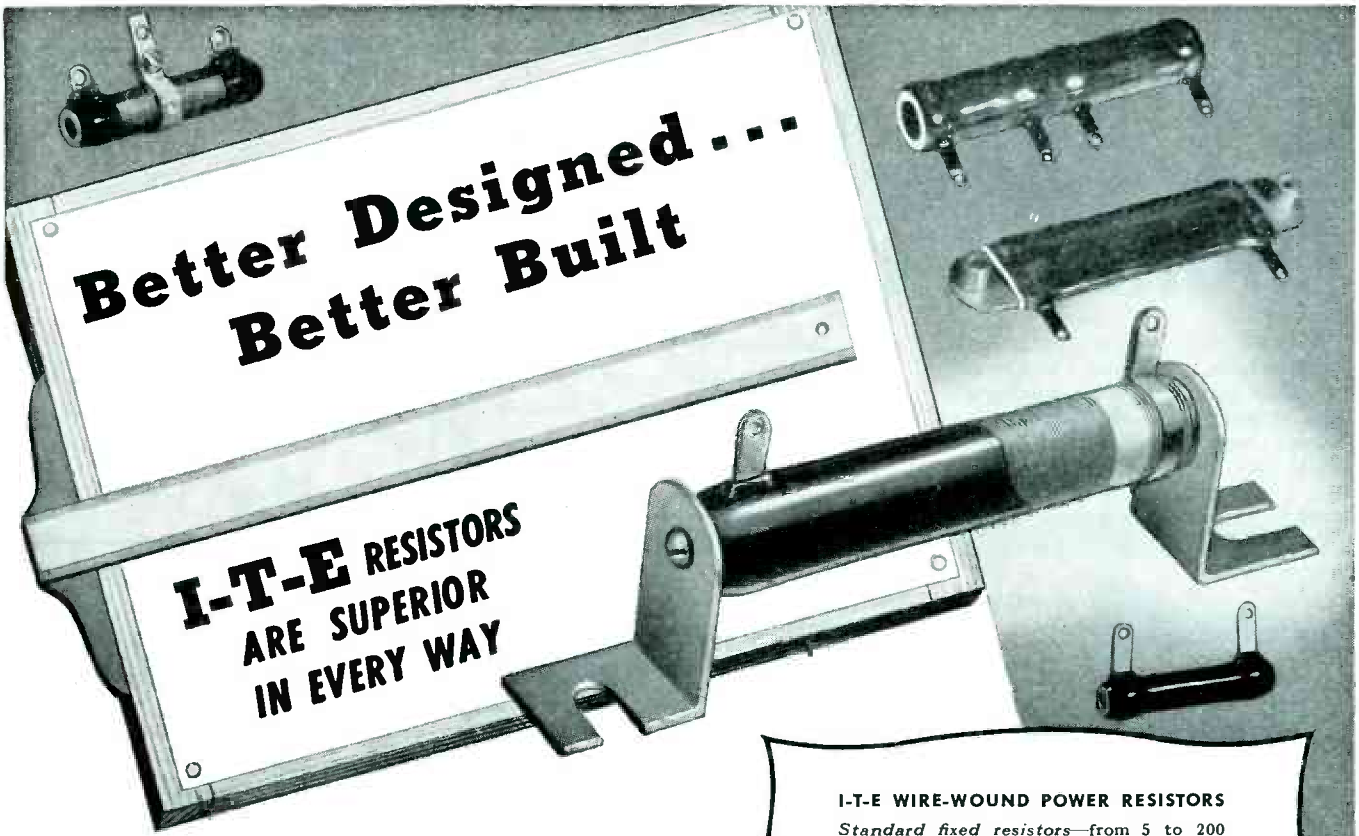
Research Physicist
Specialties, Inc.
Syosset, N. Y.

MICROWAVE GENERATORS can be stabilized in frequency in several ways. The method to be described is advantageous in that it is all electronic, uses fewer circuit components than some methods, and incorporates several simplifications of the plumbing. Used with a 10-kmc oscillator, this circuit maintains the frequency within one part in 10^8.

Duplex Heterodyne

The operating principle can be followed through the block diagram. Microwave energy from the oscillator enters the main waveguide G by way of the probe P and flows in the indicated direction. The energy is tapped through the first iris I_1, which admits a small amount of energy to the upper cavity C_1. This cavity has low Q (of the order of 1,000) and serves chiefly to isolate the subsequent portions of the circuit from the main guide.

A fraction of this energy is admitted to the first crystal X_1 (such as a 1N/23B) where it mixes with energy from the intermediate-frequency amplifier output (approximately 30 mc). The resulting sum (or difference) frequency is transferred into the second cavity C_2 through the third iris I_3. This cavity has a high Q and is used as the



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Standard fixed resistors—from 5 to 200 Watts

Adjustable resistors—from 10 to 200 Watts

Oval resistor assemblies, for limited space requirements—from 30 to 75 Watts

Ferrule resistors, for connections through fuse-clips in installations where rapid insertion and removal is a factor—from 13 to 200 Watts

Resistors for special applications made to specifications. I-T-E Power Resistors are made with a normal tolerance of 10%. Tolerances of 5% and less are made to order.

FROM FOUNDATIONS to terminals, I-T-E wire-wound Power Resistors receive the same engineering skill, the same care in fabrication that the most complicated unit of switchgear receives. The result is a superior resistor of balanced design—ruggedly built for dependable performance over a long period of heavy service.

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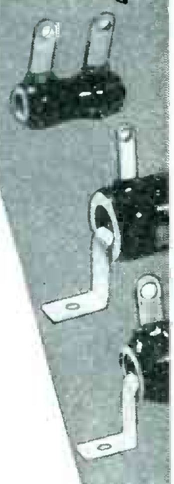

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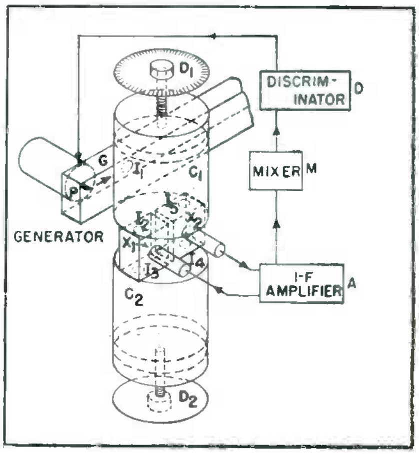

Microwave plumbing is shown pictorially in block diagram of stabilizer

frequency reference. The energy in the second cavity is coupled through the forth iris I_4 to the second crystal X_2 where it is mixed with energy from the first cavity coming through the fifth iris I_5. The result is the intermediate frequency, which is returned to the i-f amplifier input to produce oscillation through the system at or near the intermediate frequency.

Oscillation occurs only if the microwave generator delivers sufficient power to the mixer crystals, which condition is dependent upon the coupling of the irises. Because the crystals require voltages of a given magnitude for best operation as mixers, the irises have optimum size, but are not critical. The choice of cavity and coupling in the upper section should be such as to sufficiently attenuate the uhf generated in the first crystal, so that feedback through any channel but the high Q cavity is avoided. Using the highest possible i-f will make attenuation of this uhf easier.

Criteria for Oscillation

The system will oscillate at the nominal frequency of the amplifier if the phaseshift through the two crystals and the second cavity is zero. A change in phaseshift will change the intermediate frequency. If f_1 is the original microwave frequency, f_2 is the heterodyne frequency produced in the first crystal and to which the second cavity is resonated, f_3 is the nominal frequency of the amplifier, δ_2 is the phaseshift in the second cavity and its associated couplings, and δ_3 is

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the phaseshift in the amplifier and its associated elements, then $f_2 = f_1 \pm f_3$ and, for oscillation, $\delta_2 + \delta_3 = 0$, with the second cavity tuned to f_2. Furthermore, where Q_2 is the loaded Q of the second cavity, δ_2 near resonance is

$$\delta_2 \approx 2(\Delta\omega_2/\omega_2)Q_2$$

where $\Delta\omega_2$ is the deviation from resonance. By introducing Q_3, defined as the equivalent over-all Q of the amplifier, δ_3 can be expressed as

$$\delta_3 \approx 2(\Delta\omega_3/\omega_3)Q_3$$

Using these expressions for phase shift in the criteria for oscillation, selecting the positive sign, and simplifying, one obtains an expression for the frequency deviation of the amplifier

$$\frac{\Delta f_1}{\Delta f_3} = 1 - \frac{Q_3}{Q_2} + \frac{f_1 Q_3}{f_3 Q_2}$$

If the negative sign is taken, all terms of the righthand side of the equation are negative. There are two other possible combinations of signs, but they represent unstable conditions.

For the relationship between frequency deviation of the amplifier and the microwave oscillator to be independent of the circuit elements, Q_3 must be small; that is, the phase changes very little with frequency near resonance; Q_3 can be made zero over an appreciable bandwidth, which, although not indespensable, is desirable. Almost any 30-mc radar i-f strip can be adapted for the purpose, giving an i-f deviation approximately half the microwave deviation, which is favorable for proper stabilization. Because grid current in the amplifier will cause noticable detuning, such nonlinear elements as Thermistors or Thyrites should be introduced to limit the amplitude of oscillations so that detuning is unnoticeable.

Oscillator Control

Recovery of information from the i-f strip is straightforward. Any discriminator, separated by a buffer stage, supplies sufficient output to control a reflex oscillator. The oscillator control completes a negative feedback loop from generator through guide to first cavity through the mixers and second cavity to the oscillating i-f amplifier, hence through the discriminator back to the generator. Phaseshifts

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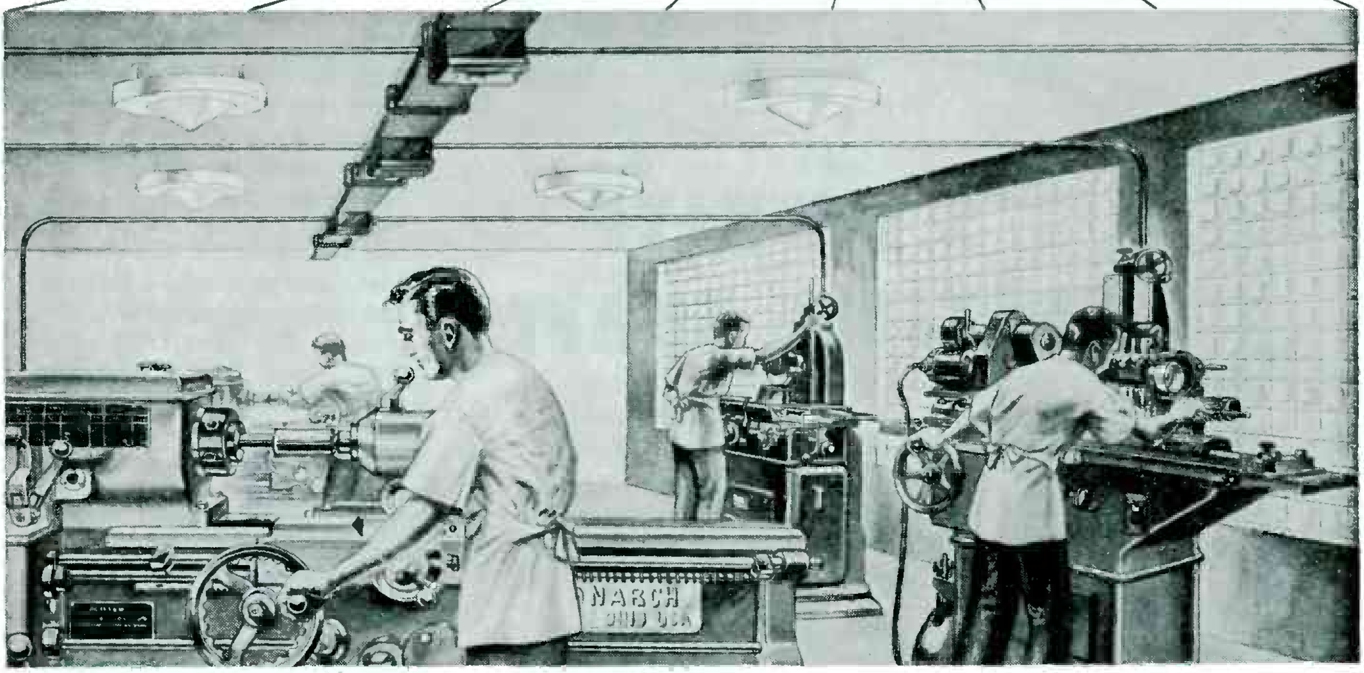

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1201 FLUSHING AVENUE • BROOKLYN 6, NEW YORK throughout this loop must not introduce f-m oscillations in the overall system.

Frequency modulation can be introduced by injecting the audio-frequency signal through an additional mixer between the i-f amplifier and the discriminator. The i-f output (30 mc) is mixed with a frequency-modulated auxiliary oscillator (10 mc); the resulting difference frequency (20 mc) drives the discriminator. Drift in the auxiliary oscillator will, of course, affect the microwave oscillator, the microwave deviation being about twice that of the auxiliary oscillator.

The complete circuit is easy to adjust and operate. The microwave components are not critical, can be assembled in advance, and need no adjustments. The two cavities can be coupled mechanically for tuning. The second or reference cavity must have an effective Q higher than 10,000 and high thermal stability; it is preferably constructed from such low expansion alloys as Invar. The coupling irises should be small. The amplitude control of the i-f amplifier must keep the d-c in the two mixer crystals constant. In testing the circuit, two oscillators were easily kept within 100 cps of each other. The circuit was developed while the author was with Raytheon Mfg. Co., Waltham, Mass, and the inventions are assigned to that organization.

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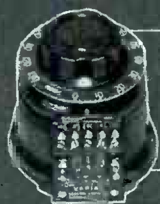


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TYPE V-10	115	10	15	0-115 0-135	1.725	(1) (2) (3)	V-10 V-10M V-10MT	33.00 35.50 40.00
	230	4	5	0-230 0-270	1.15	(1) (2) (3)	V-10H V-10HM V-10HMT	34.00 36.50 41.00
TYPE V-20	115	20	30	0-115 0-135	3.45	(4)	V-20M	55.00
	230	8	10	0-230 0-270	2.3	(4)	V-20HM	55.00
TYPE 50	115	40 80	45 90	0-115 0-135	5 10	(4) (5)	50-A 50-AG2(5)	140.00 310.00
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in distance, can be used to adjust the quench frequency for minimum noise in the earphones, or the control can be preset and the circuit used to give an automatic warning of the approach of a reflecting body within a given distance of the set. (British Patent No. 581982, A. C. Cossor, Ltd., and F. R. W. Strafford)

Optimum Conditions for an R-C Oscillator

By H. A. Whale

Research Department
Auckland Industrial Development Lab.
Auckland, New Zealand

RESISTANCE-CAPACITANCE NETWORKS of the type shown in Fig. 1 occur in many electronic circuits. The network is used in feedback oscillators of the Wein bridge type, in which case the components can be proportioned in accordance with relations presented in this discussion to provide optimum frequency stability. Although these relations are derived for the particular bridge oscillator under examination, they are also valid for a resistance-capacitance amplifier made frequency selective by choice of coupling or where feedback is used to give an amplifier having rejection for a narrow band of frequencies.

Wein Bridge Oscillator

In the common R-C cathode-coupled oscillator of the Wein bridge type[1], the components of the feedback network are proportioned so that R_1C_1 equals R_2C_2, under which condition the ratio of output voltage E_2 to input voltage E_1 varies with frequency in the manner

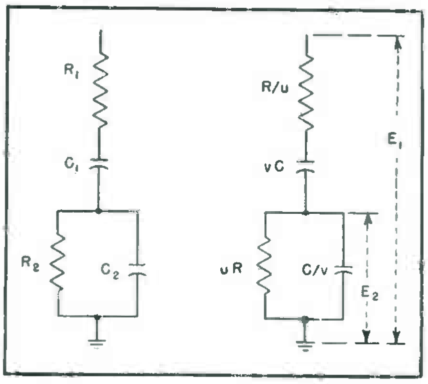

FIG. 1—Circuit under consideration is common to many applications

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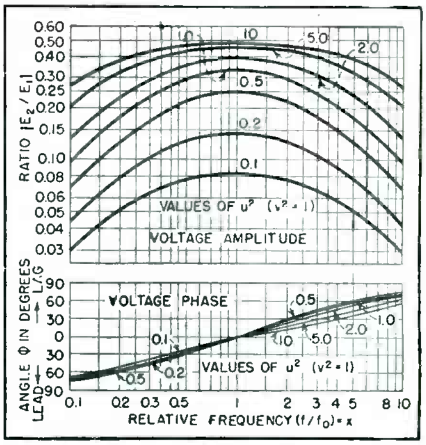

FIG. 2—Normalized amplitude and phase characteristics of circuit

shown in Fig. 2 by curve for $U^2 = 1$[2,3]. The frequency selectivity of this particular type of oscillator is due to the comparatively rapid change with frequency of the phase between the input and output voltages in the vicinity of the oscillating frequency, $1/[2\pi(R_1R_2C_1C_2)^{1/2}]$ cycles per second.

In designing such oscillators for the greatest frequency stability, the conditions for the most rapid change of phase with frequency and for the most sharply peaked $|E_2/E_1|$ curve are required. These conditions can be found by replacing R_1, C_1, R_2, C_2 respectively by R/u, vC, uR, and C/v, in which case the oscillating frequency is $f_0 = 1/2\pi RC$. For any frequency f

$$\frac{E_2}{E_1} = \frac{y(f/f_0)^2 + j(f/f_0)[1 - (f/f_0)^2]}{[1 - (f/f_0)^2]^2 + y^2(f/f_0)^2}\, uv \quad (1)$$

where $y = (u^2 + v^2 + u^2v^2)/uv$. Let $(f/f_0) = x$, then

$$\left|\frac{E_2}{E_1}\right| = \frac{uvx}{[(1 - x^2)^2 + (xy)^2]^{1/2}} \quad (2)$$

$$\phi = \tan^{-1} (1 - x^2)^2/xy \quad (3)$$

For maximum rate of change of phase with frequency, differentiate ϕ with respect to x. Inasmuch as interest is in values near $\phi = 0$ at which $x = 1$

$$\phi = (1 - x^2)^2/xy \quad (4)$$

therefore

$$\frac{d\phi}{dx} = -(x^{-2} + 1)/y \quad (5)$$

$$\approx -2/y \qquad (\text{near } x = 1)$$

Because x is nearly unity near the oscillating frequency

$$\left|\frac{E_2}{E_1}\right| = \frac{uv[1 - (1 - x^2)^2/2(xy)^2]}{y} \quad (6)$$

The magnitude of the term $(1 - x^2)^2/2(xy)^2$ determines the sharpness of the resonance peaks, for the smaller is y the more rapid the

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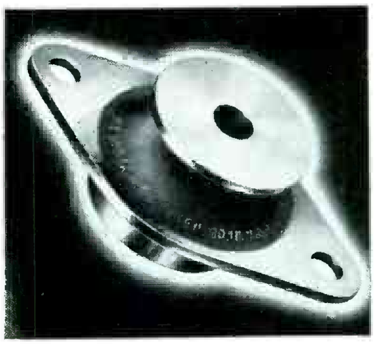

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change with x. Thus, as would be expected, the rate of change of phase and the sharpness of the resonance peak both depend on the same parameter y.

The problem is to determine the values of u and v for which y is a minimum. To do so, let $v^2 = 1$, in which case $C_1 = C_2$, and then $y = (2u^2 + 1)/u$. This relation is a minimum when $u^2 = 0.5$. Various calculated amplitude, and phase curves for $v^2 = 1$ and different values of u^2 are shown in Fig. 2 with the value of u^2 indicated for each curve.

For any general value of v^2 there is an optimum value of u^2 and vice-versa. The general expressions are obtained.

$$\frac{dy}{du} = \left(\frac{d}{du}\right)\frac{u^2 + v^2 + u^2v^2}{uv} \qquad (7)$$

$$= -(v/u^2) + (1/v) + v \qquad (8)$$

which equals zero when

$$u^2 = v^2/(1 + v^2) \qquad (9)$$

Similarly, for a given value of u^2 the optimum value of v^2 is

$$v^2 = u^2/(1 + u^2) \qquad (10)$$

Carrying the logic further, put Eq. 9 into the expression for y, then

$$y^2 = 4(1 + v^2) \qquad (11)$$

which has its minimum when $v^2 = 0$, and then $u^2 = 0$. Thus the criteria for the sharpest resonance curves and the most rapid change of phase near the resonant frequency are that u and v are as small as possible consistent with maintaining either Eq. 9 or 10. When u and v are both small, they are nearly equal.

Figure 3 presents curves for various values of (u^2, v^2). These curves include the cases for u^2 and v^2 both vanishingly small; that is, the theoretically best conditions that can

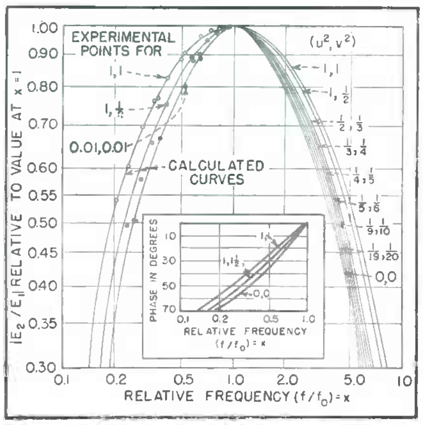

FIG. 3—Experimental points fall close to the calculated resonance curves

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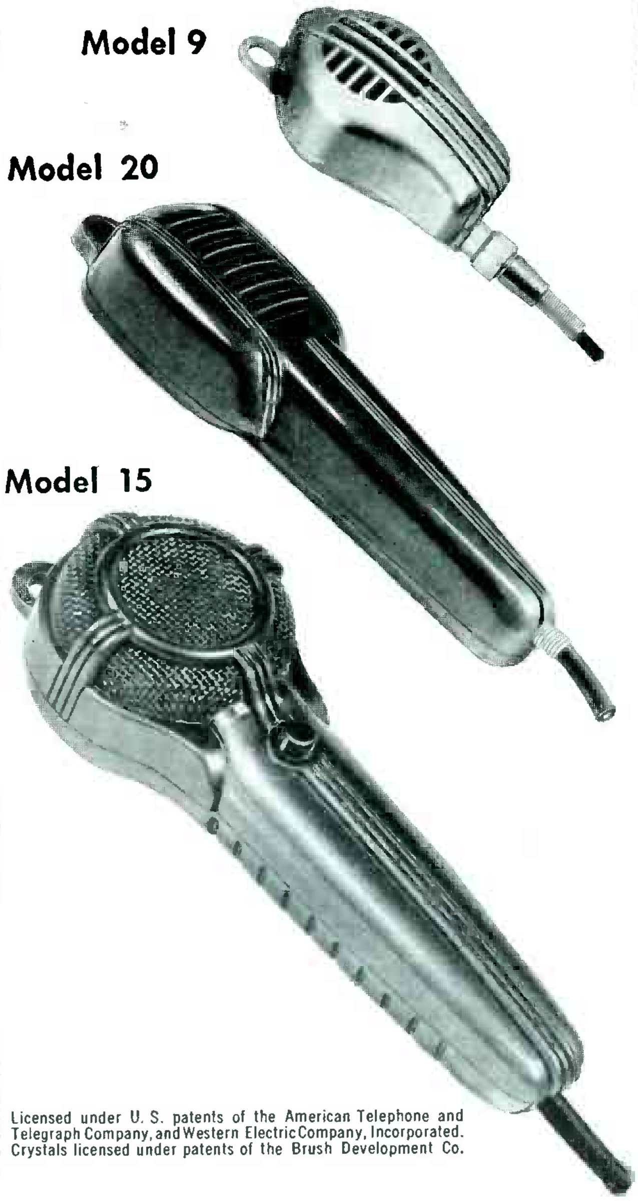

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be obtained. Also included in Fig. 3 are some experimental points obtained with the indicated values.

For the conventional case at $x = 1$

$$u^2 = v^2 = 1;\ d\phi/dx = -2/3$$

while for the optimum case at $x = 1$

$$u^2 = v^2 \rightarrow 0;\ d\phi/dx = -1$$

Practical Considerations

The foregoing analysis indicates that for maximum stability the ratios C_2/C_1 and R_1/R_2 should be as large as possible consistent with a given (frequency) relationship between them. In oscillators employing this type of feedback circuit; condition for oscillation is

$$1 + R_1/R_2 + C_2/C_1 < A \qquad (12)$$

where A is the gain in the auxiliary amplifying circuit. Using the foregoing notation, this condition can be expressed as

$$1 + 1/u + 1/v < A \qquad (13)$$

Thus the minimum values of u and v that can be employed are determined by the gain that is available from the amplifier.

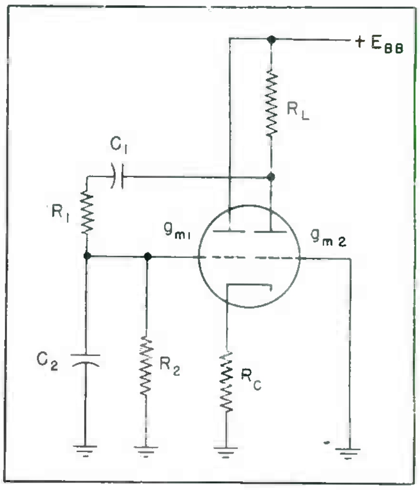

FIG. 4—Typical oscillator circuit to which design can be applied

For example, in the cathode-coupled oscillator[4] shown in Fig. 4, the condition for oscillation is

$$E_2 > AE_1 \qquad (14)$$

or

$$\frac{uv}{y} > A = g_{m1}g_{m2}R_C\,R_L \qquad (15)$$

which means that

$$1 + 1/u + 1/v < g_{m1}g_{m2}R_C\,R_L \qquad (16)$$

where g_{m1} and g_{m2} are the mutual conductances of the two triode sections under the operating conditions.

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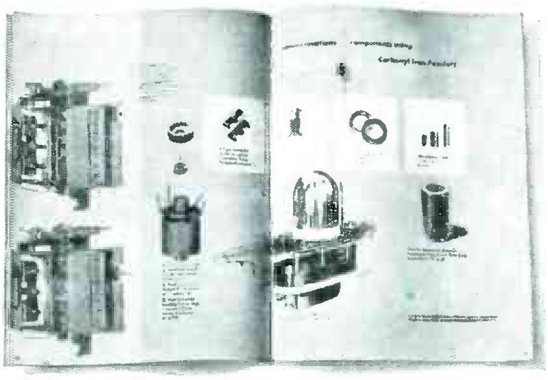

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range of frequencies, the ratio C_2/C_1 must remain constant over the band. This consistancy can be accomplished by using a ganged tuning capacitor with, for example, C_2 consisting of three sets of plates in parallel and C_1 the other set. Then $v^2 = 0.33$. Thus for optimum stability with this value of v^2, $u^2 = 0.25$. The condition for oscillation becomes

$$g_{m1}g_{m2}R_cR_L > 8 \quad (17)$$

For usual triodes, R_c is approximately 500 ohms, and g_m is approximately 2,000 microhms, therefore R_L should be greater than 4,000 ohms.

(1) H. H. Scott, A New Type of Selective Circuit and Some Applications, *Proc. I. R. E.*, p 226 Feb. 1938.
(2) F. E. Terman, R. P. Buss., W. R. Hewlett, and F. C. Cahill, Some Applications of Negative Feedback with Particular Reference to Laboratory Equipment, *Proc. I. R. E.*, p 649 Oct. 1939.
(3) F. E. Terman, "Radio Engineers' Handbook", McGraw-Hill Book Co., New York, p 505 1943.
(4) Keats A. Pullen, The Cathode Coupled Amplifier, *Proc. I. R. E.*, p 402 June 1946.

Differential Input Circuits

By E. E. Suckling
Physiology Department
Medical School, University of Otago
Dunedin, New Zealand

Electromedical and other low-level amplifiers often use a differential input circuit to prevent hum and other interferences from entering the equipment. In addition, if the potential to be amplified appears across two points both above ground a balanced input circuit may be necessary even though the amplifier is single ended.

Balance to Unbalance Conversion

Wide use of the Toennies circuit[1] for producing a differential effect and for converting from balanced to unbalanced circuits while retaining inphase cancellation is due to the ease with which this circuit is adjusted and the high rejection ratio obtained with it. Rejection ratio is measured by connecting the two input terminals together and measuring the amplifier sensitivity to a signal between the grids and the ground, and comparing that value with the one obtained under normal conditions (input signal between the two grids or between one grid and ground). A 1,000-fold

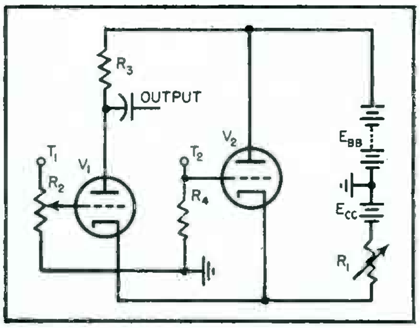


FIG. 1—Conventional differential input circuit has high rejection to unbalanced potentials

reduction in sensitivity with the grids tied together is easily obtained with a Toennies circuit, and indicates that, if hum is present equally on the two output leads, it will be attenuated 60 db compared with potentials between the two grids. A common form of the Toennies circuit is shown in Fig. 1.

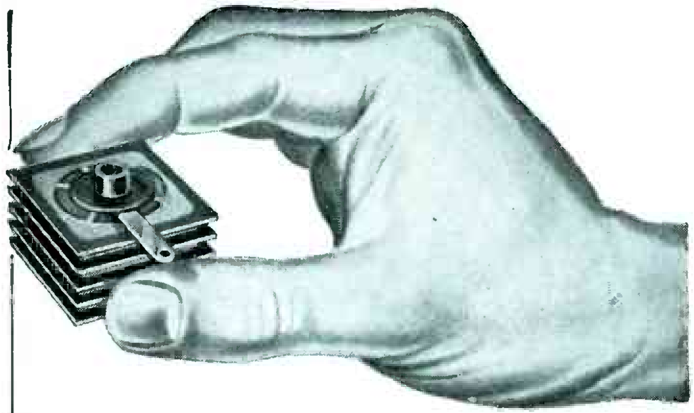
In the circuit, R_1 is adjusted so that the cathode potential is a few volts positive relative to ground in order that the tubes will operate with normal bias. Potentiometer R_2 is then adjusted so that the signal on the grid of V_1 from terminal T_2 equals the signal between cathode and grid (ground) impressed on V_1 by the cathode follower V_2. In this way, cancellation of voltages that are in phase at T_1 and T_2 is obtained.

A disadvantage of this circuit is that the cathodes are not at ground potential. Because the differential input is usually used at the beginning of a sensitive amplifier normally handling input signals of a millivolt or less, this disadvantage precludes using alternating current for heating the tubes; any hum transferred from heaters to cathodes develops a voltage across R_1, which may be 50,000 ohms, and is fed to the amplifier. The usual arrangement is to heat the cathodes from a storage battery.

Improved Circuits

Rearrangement of the circuit enables the cathodes to be connected directly to ground, and thus permits a-c operation of the heaters. Figure 2 shows one rearrangement in which the ground is transferred from the junction of the two batteries to the cathode. If this cir-

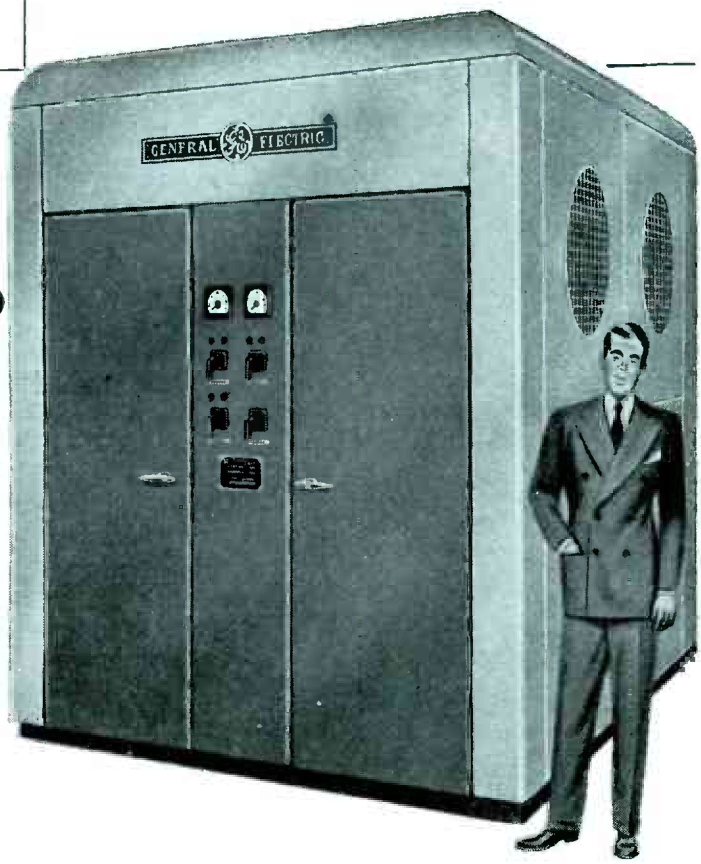
need a mite



To meet requirements for weight- and space-saving rectification in small radios, General Electric engineers have developed this tiny selenium rectifier. Less than one inch square, its use has resulted in important manufacturing economies, without loss of efficiency.

This two-ton copper-oxide rectifier is one of the largest ever made. Designed and engineered by General Electric, the ten-foot-tall unit is rated at 80 kw. It will be used in an electrochemical process, to supply constant unvarying flow of electricity over a wide range of load.

or a mammoth?



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Even if your application is entirely new, our engineers have a background of experience that is invaluable in selecting the type and the design of rectifier that will give you the utmost in operating economy and output efficiency.

Because we make all three of the most commonly used types of rectifiers, you can be sure of unbiased recommendations for the one that is best suited to your application.

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GENERAL ELECTRIC

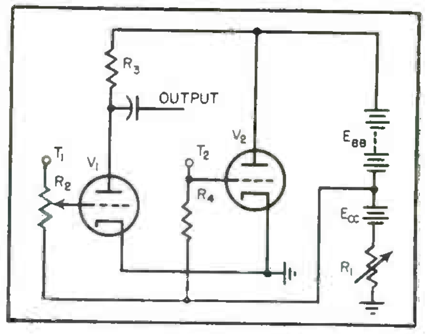

FIG. 2—Rearranged circuit grounds the cathodes so that a-c heater operation is possible

cuit is used, both batteries are above a-c ground potential and must be shielded. But further rearrangement overcomes this difficulty.

In Fig. 3 resistors R_1 through R_4 have the same functions as in Fig. 1. Resistors R_5 and R_6 form a high-impedance network that supplies feedback from V_2 to V_1 and also maintains the grids negative for correct operation. With the values shown, the circuit gives a gain of 12 measured with the signal injected between one grid and ground, and a rejection ratio for

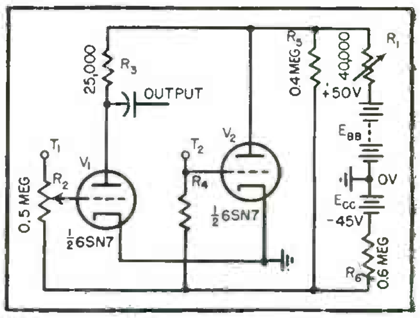

FIG. 3—Feedback enables cathodes and batteries to be grounded; typical values are shown

50-cycle in-phase potentials of 300. The circuit is of considerable value for electromedical equipment because it enables an a-c operated amplifier to be used with a 45-volt bias battery as the only additional voltage source required for differential input.

(1) J. F. Toennies, A Differential Amplifier, *Review of Scientific Instruments*, p 95, 9, 1938.

SURVEY OF NEW TECHNIQUES

METALS FOR TUBES are basic product design determinants. At the Radium Elektrizitaets factory (Wipperfurth, Germany) tungsten

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(continued from p 144)

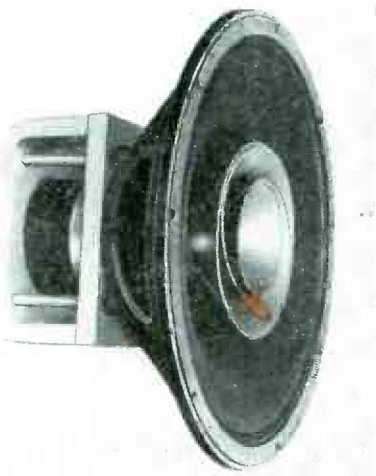
alignment of f-m receivers in the 88–108 megacycle band. I-f signals are available from 8.3 to 10.8 mc. Sweep width is adjustable. Terminals are provided for obtaining oscilloscope deflection voltages.

Registration Control

RIPLEY CO., INC., Middletown, Conn. A new registration control that corrects the positioning of wrapping materials with colored index marks as fine as 0.015 inch can be used on either transparent or translucent materials. Operation rate is 750 per minute with correction on any sequence of registration marks such as every 5th or 10th. Standard tubes and lamps are used.

Spiral Cone Speaker

STEPHENS MFG. CORP., 10416 National Blvd., Los Angeles 34, Calif. The Tru-Sonic model P-52FR cospiral speaker has a frequency range from 40 to 14,000 cycles. The response is not flat but its characteristic has been accentuated at certain frequencies for desired



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HiVolt PS-1

Specifications:

Volts Input: 118 VAC, 60 cycles.
Volts Output: 2400 VDC (capacitor load)
Current Output: .006 Amps., half-wave DC.
Max. Watts Input: 15 watts.
Type of Filter: Not filtered.
Terminals: 8-32 screw and nuts.
Insulation: 118 VAC—2 bakelite washers;
2400 VDC—1 porcelain standoff;
2400 VDC—lug spotwelded to case.
Container: Terne plate steel—gray lacquer finish.
Size: 3¾" x 3 3/16" x 5½".
Weight: 2.2 lbs.

List Price $18.95 F. O. B. Chicago

NOTE: The PS-1 is designed to charge a parallel-wired bank of not more than 15 AOCOE-22C3 Plasticon Energy Storage Capacitors (48 mfd.).

HiVolt PS-2

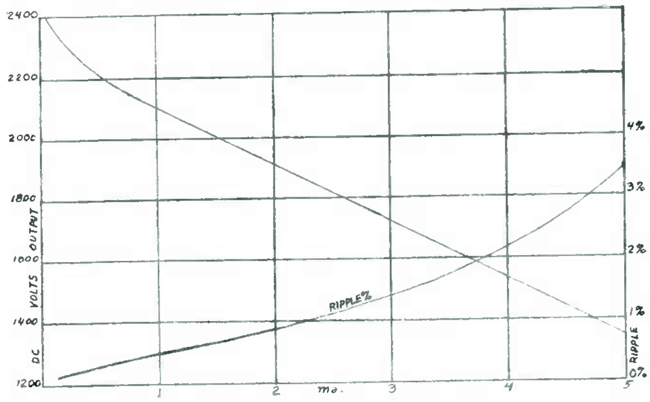
Specifications:

Volts Input: 118 VAC, 60 cycles.
Volts Output: 2400 VDC, maximum.
Current Output: .005 Amps. DC. maximum.
Max. Watts Input: 10 watts.
Type of Filter: R. C. Filter: 50,000 ohms, 2x.1 mfds.
Terminals: 8-32 screw and nut.
Insulators 118 VAC—2 bakelite washers;
2400 VDC—2 porcelain standoffs;
container neutral.
Container: Terne plate steel—gray lacquer finish.
Size: 3¾" x 3 3/16" x 5½".
Weight: 2.5 lbs.

List Price $25.75 F. O. B. Chicago

NOTE: The PS-2 is similar in appearance to the PS-1 except that all four terminals are on the recessed top of the container.

Regulation and Ripple Curves

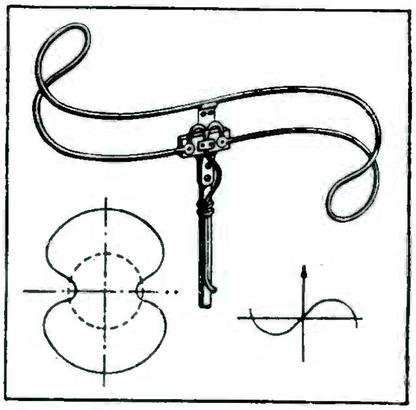


Condenser Products Company

1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS audio effects. Bulletin 109 describes the speakers available in both 12- and 15-inch cone diameters.

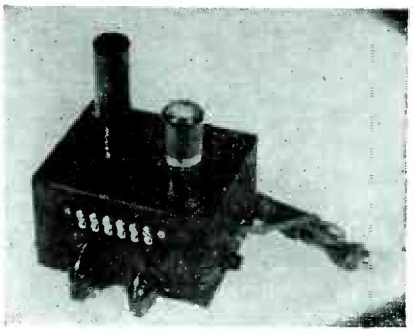
Nondirectional Antenna

TECHNICAL APPLIANCE CORP., Sherburne, N. Y. Taco type 624 folded-dipole is a horizontally polarized antenna that is essentially nondirectional and is designed for television and f-m broadcast reception. A 300-ohm transmission line is furnished.



Repeat Cycle Timer

G. C. WILSON & CO., 2 N. Passaic Ave., Chatham, N. J. A process control timer operating from 115 volts, 60 cycles has independently variable on and off intervals ranging from 0.1 second to 4.0 minutes.



Wide variations in line voltage have a negligible effect on timing intervals. Relay contacts up to double-pole double-throw each rated at 10 amperes can be provided.

Small Selenium Rectifiers

RICHARDSON-ALLEN CORP., 15 W. 20th St., New York 11, N. Y., announce two new small selenium variable platers designed for jewelry manufacturers and laboratories. Model D-513A is a 4-amp, 6-volt rectifier, and D-514A is a 10-amp,

8-volt rectifier, both operating on 115 a-c single phase 60 cycle current.

High-Frequency Tetrode

EITEL-MCCULLOUGH, INC., 189 San Mateo Ave., San Bruno, Calif. Type 4-400A tetrode is radiation cooled in a special socket and air duct. A pair of the 400-watt tubes operated

conservatively will provide over a kilowatt of output power at 4,000 plate volts on the 88 to 108 mc f-m band.

Electroplater

HANSON - VANWINKLE - MUNNING CO., Matawan, N. J. A new process for improved electroplating that reduces polishing costs involves a periodic reverse plating cycle. Equipment now available handles

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For example, silicone rubber—an amazing material which retains its elasticity at temperatures as high as 520 F—has been found to be ideal for making gaskets for jet airplane engines. Other motors can benefit by the application of silicone resin insulating varnish to windings. By using this varnish—capable of withstanding a temperature of 355 F—longer life under extreme service conditions may be obtained.

If molding is your business you'll be interested in General Electric silicone oils and greases. Displaying the typical silicone family traits, these products resist heat even at 575 F. This means you may apply them to extremely hot molds to prevent sticking of the binder and molded piece. Silicone oils and greases are real "efficiency experts" when it comes to saving on broken parts and speeding up production.

In the finishing field you'll find G-E silicone resins which impart unusual weather-resistance to paints and finishes. Still another product of General Electric research is DRI-FILM* water repellent materials. They have proved exceptionally effective for treating glass, ceramics, plastics, textiles, and paper.

WANT TO KNOW MORE ABOUT GENERAL ELECTRIC SILICONES? They have other interesting characteristics and their uses are many and varied. Perhaps they are what you are looking for in your particular industry. We'll be glad to discuss them with you. *Chemical Department, General Electric Co., Pittsfield, Mass.*

*REG. U. S. PAT. OFF.

Please address inquiries about G-E silicones to Resin and Insulation Materials Division, Chemical Department, General Electric Company, Schenectady 5, N. Y.

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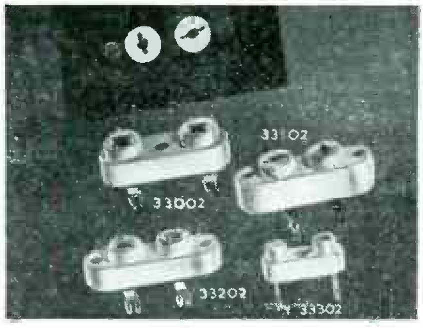
up to fifty amperes with a range of a fraction of a second to 25 seconds for each portion of the time cycle.

Midget Crystal Socket

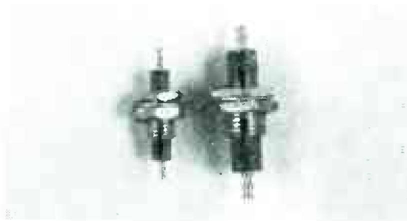
JAMES MILLEN MFG. CO., INC. 150 Exchange St., Malden 48, Mass. A new midget crystal holder socket type 33302 has been designed for



use with the midget hermetically sealed type CR7 crystal. Silver-plated phosphor bronze contacts are used, mounted in Steatite. Pin spacing is a half inch.

Feed Through Terminal

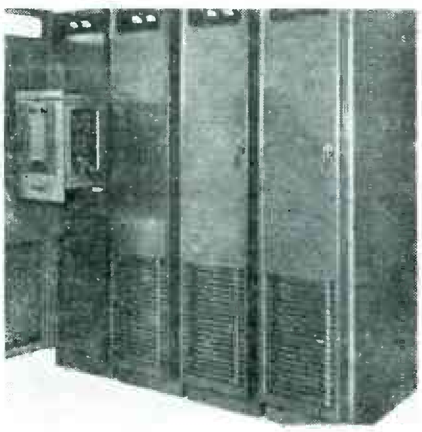
CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass. New feed-through terminals are



available for ¼ or ⅜-inch hole mounting, each type in two lengths. The larger terminal illustrated will withstand 8,000 volts, 60 cycles

Multichannel Transmitter

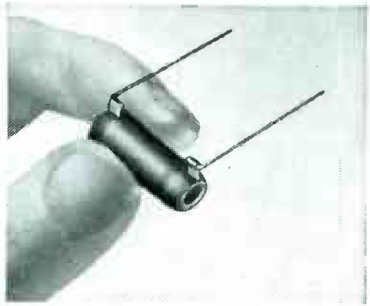
RADIO RECEPTOR CO., INC., 251 West 19th St., New York 11, N. Y. Tele-



pak multichannel transmitting equipment consists of two sizes of functional power, r-f and modulator units or cells of 500 and 1,000 watts. R-f cells are available in frequencies from 200 kc to 150 mc. Special cells can be had for various types of modulation, including homing beacon service.

Five-Watt Resistors

OHMITE MFG. CO., 4952 Flournoy St., Chicago, Ill. The Brown Devil line of resistors now includes a 5-watt wire-wound series in resistance values from 1 to 10,000 ohms. Standard tolerance is plus or minus 10 ohms. See Bulletin 132.



Geiger Counter

INSTRUMENT DEVELOPMENT LABORATORIES, 223 West Erie St., Chicago 10, Ill. A new selfquenching Geiger counter has a plateau of about 250

volts at a slope of 2 percent per hundred volts. Threshold is between 850 and 950 volts and expected tube life is 10^8 counts.

F-S Receiver Terminal

HEINTZ AND KAUFMAN, LTD., 50 Drumm St., San Francisco, Calif. Type A-4601 dual diversity receiver terminal permits an improvement of 11 db in signal-noise ratio over make-break systems, by virtue of using the frequency-shift method alone, and the gain of the dual diversity system over a single channel make-break approximates 22 db improvement. High-speed keying is also possible with no loss in selec-

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The type RL14MS sinusoidal potentiometer is illustrated. It is wound to a total resistance of 35,400 ohms and provides two voltages proportional to the sine and cosine of the shaft angle. It will generate a sine wave true within ±.6%. Overall dimensions are 4⅜" diameter x 4 11/32 long plus shaft extension ¼" diameter x 1¼" long.

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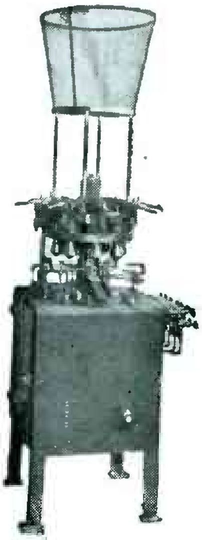

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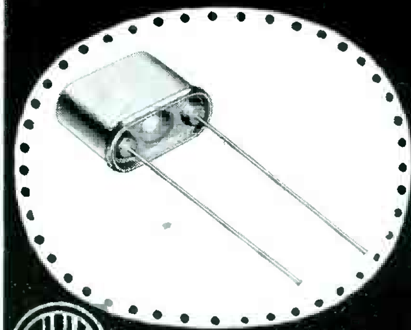

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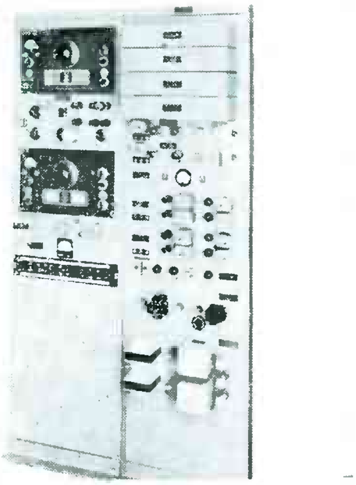
The IF-17W is one of three new filter crystals, hermetically sealed which permit operation from the Arctic to the Tropics. They are silver plated and wire mounted for higher Q, faster starting and elimination of sudden shift of peak frequency characteristics of the old air-gap type. Cut for low series resistance approx. 4,000 ohms. Spurious responses are none plus or minus 10 kc. Type IF-17 has pins .050" in dia. spaced ½" centers, type IF-17L has pins .093" in dia. spaced ½" centers and type IF-17W has the RMA, standard wire lead pigtails.

Write For Illustrated Folder

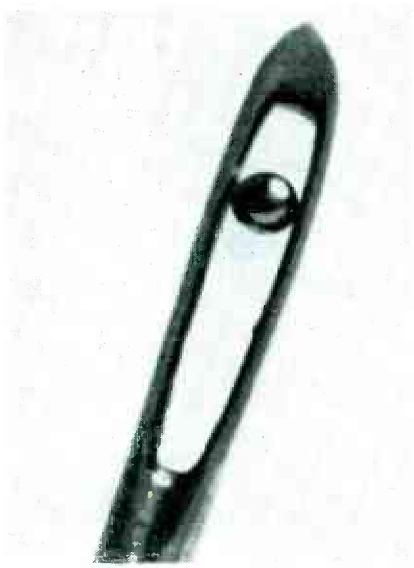
The JAMES KNIGHTS CO.
SANDWICH, ILLINOIS



tivity. Various types of recording devices can be attached to the output of the receiving system.

Steel and Nonmagnetic Balls

NEW HAMPSHIRE BALL BEARINGS, INC., Peterborough, N. H. A newly developed line of precision grade steel balls is available in sizes between 0.0394 and 0.0469 inch. They are finished to a surface within 20



millionths of a perfect sphere. Also available are small nonmagnetic and noncorrosive ball bearings made from beryllium copper hardened to about 42 Rockwell C.

Temperature Probe

G. M. GIANNINI & CO., INC., Pasadena, Calif. Type 4915 Autoflight temperature probe simplifies data reduction in test flights and guided missiles by measuring total air temperature,—ambient air temperature plus all of the temperature rise owing to velocity. Full calibration

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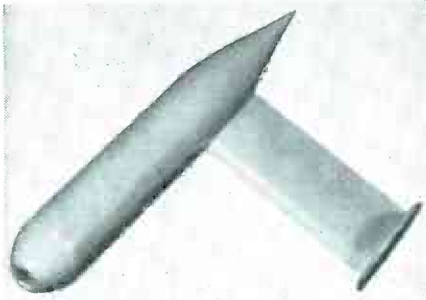

data is available from the manufacturer.

Radiation Survey Meter

TRACERLAB INC., 55 Oliver St., Boston, Mass. An improved version of the Cutie Pie radiation meter recently declassified is now available for hot laboratory work where radioactivity of the order of millicuries is handled. A thin window at the end of the ionization chamber

permits entry of beta particles with energies less than 0.1 mev, or a bakelite shield can be rotated to eliminate passage of beta radiation. Power is supplied from batteries that can be replaced.

R-F Heating Tubes

MACHLETT LABORATORIES, INC., Springdale, Conn. Five new tubes have been developed expressly for r-f heating applications, but usable in communications, in the power range from 5 to 50 kw. One tube is water cooled; the other four are available in either water- or air-cooled types. Of prime importance is a new type of water jacket that

can be sealed or released with one hand. The tubes are in general more rugged than comparable communications types and can be provided with special length leads for the customer's individual application.

Console Recorder

FAIRCHILD CAMERA AND INSTRUMENT CORP., 86–06 Van Wyck Blvd., Jamaica 1, N. Y. A new console recorder in the medium-price field is Unit 539 comparable to the larger

Unit 523. Primarily designed for studio work, the unit can be procured with a trunk for portable recording. The spiraling device and microscope are not standard equipment with the portable gear.

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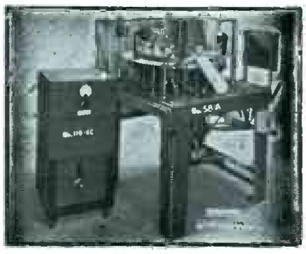

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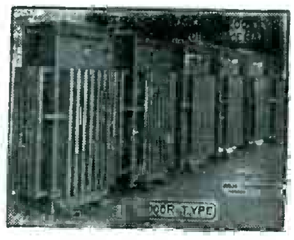

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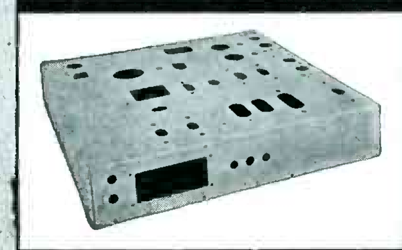

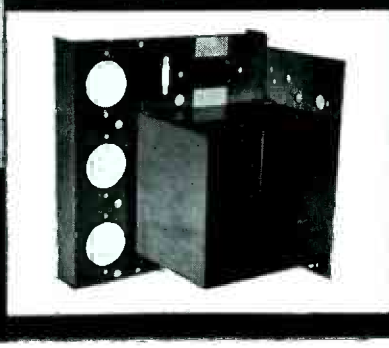

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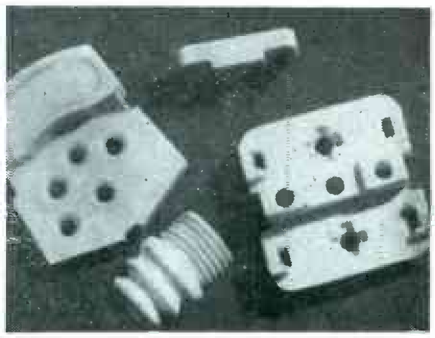

Lavite STEATITE CERAMIC

Properties and Characteristics of Our LAVITE S1-5 Steatite Ceramic Body

Compressive Strength	96,000 lbs per square inch
Tensile Strength	7,200 lbs per square inch
Flexural Strength	10,500 lbs per square inch
Modulus of Rupture	20,000 lbs. per square inch
Dielectric Strength	235 volts per mil
Dielectric Constant	6.42 (Frequency of 1 megacycle)
Loss Factor	7.90 (Frequency of 1 megacycle)
Power Factor	4.46 (Frequency of 1 megacycle)
Bulk Specific Gravity	2.664%
Density (from above gravity)	0.096 lbs. per cubic inch
Hardness (Mohr scale)	7.0
Softening temperature	2,350°F.
Linear Coefficient of Expansion	8.13x10—6
Moisture Absorption (ASTM D-116-42-A)	0.009%

Design engineers and manufacturers in the radio, electrical and electronic fields are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY
Main Office & Works: Chattanooga, Tenn.
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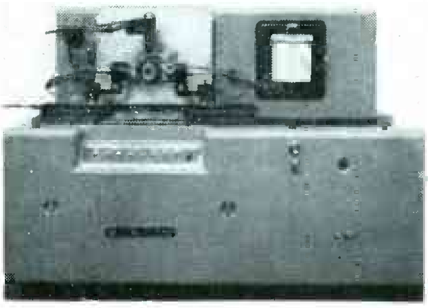
that has been repackaged and improved is now available under the designation HRO-7. A new automatic adjustable-threshold noise limiter has been included and miniature tubes have been employed to insure a high order of oscillator stability. Plug-in coils have been arranged for easier changing and calibration charts facilitate conversion of dial reading to frequency.

Hardening Control

CINCINNATI MILLING MACHINE CO., Cincinnati 9, Ohio. The Flamatic hardening machine is an electronically controlled device that can be



used, for instance, to harden automotive ring gears at the rate of 250 per hour. Details are given in publication M-1611.

Adjusting Transformer

GULOW CORP., 99 Park Place, New York 7, N. Y. Several types of manual line-voltage correction transformers are now available

with two indicating lamps that show, without the aid of additional meters, when the adjustment is correct. One unit can be used to insure output voltage of 115 volts with input variations from 60 to 140 volts. Power ratings run from 100 to 5,000 volt-amperes.

Appliance Tester

HANLAN CO., 1419 W. Jefferson Blvd., Los Angeles 7, California. The Model 60 is a compact, portable

electric appliance tester, useful for trouble shooting, checking open circuits, continuity, grounds and short circuits. It carries an a-c ammeter range of from 0 to 15 amps. A high sensitivity neon tube is provided for making high resistance tests, at which time test leads are automatically disconnected.

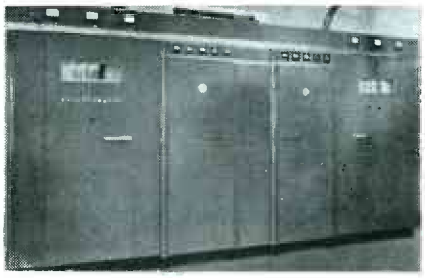
D-C Amplification

MANNING, MAXWELL & MOORE, INC., Bridgeport 2, Conn., introduce their Microsen Amplifier which measures and amplifies power impulses as low as 0.2 microvolts. Featured in the

instrument are an electromechanical balance which amplifies power inputs, an isolated input circuit, a feedback circuit, and a mechanical zero adjustment,—all making for high sensitivity and stability.

10-Kw F-M

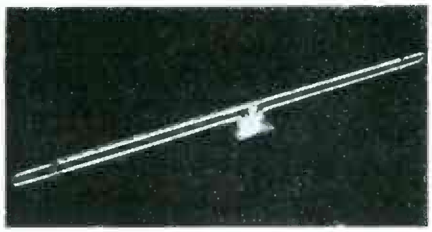
GENERAL ELECTRIC CO., Syracuse, N. Y. A new 10-kw f-m transmitter type BT-4-A employs a grounded-grid high-power amplifier with two newly-developed high-frequency triodes. The Phasitron modulator gives direct carrier-frequency control with a single crystal. Frequency deviation of 75 kc is possible with a multiplication of 432



times. The complete transmitter is 178 inches long and 38 inches deep, but is divided into units that will go through a doorway 36 inches wide.

Folded Dipole

HEINTZ AND KAUFMAN, LTD., 50 Drumm St., San Francisco, Calif. A folded dipole that can be adjusted in length to tune to any frequency from 85 to 150 mc is designed for



use with 300-ohm ribbon transmission line. Parasitic elements for construction of beam antennas are also available.

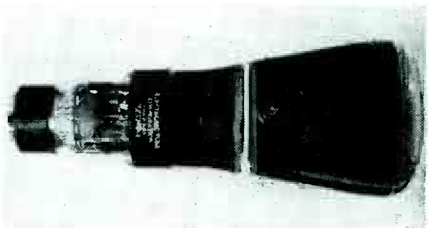
Compact Motor Capacitors

AEROVOX CORP., New Bedford, Mass., introduces a line of bracket-mounted, armored, space-saving motor-starting capacitors. The steel casing measures 2 1/16 in. in diameter by $2\frac{7}{8}$ in. to $3\frac{3}{4}$ in long depending on voltage and capacitance ratings. Standard ratings are 110, 220, 330, 440 and 660 volts

a-c, and capacitances range from 1 to 8.5 μf.

Five-Gun Tube

ELECTRONIC TUBE CORP., 1200 E. Mermaid Ave., Philadelphia 18, Pa. Type 7Z5P7-A is a 5-gun electrostatic focus and deflection cathode ray tube for applications in which electronic switching is either undesirable or impossible. As many as five independent phenomena can be registered upon the single screen. The tube can be supplied with any of the standard phosphors. Details can be supplied by the manufacturer



Video Frequency Monitor

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. Type 1175-B frequency monitor can be used with the type 1176-A frequency meter for television video or other single-channel a-m transmitters in the frequency range from 1,600 kc to 220 mc for monitoring to an accuracy of 0.001 percent. A

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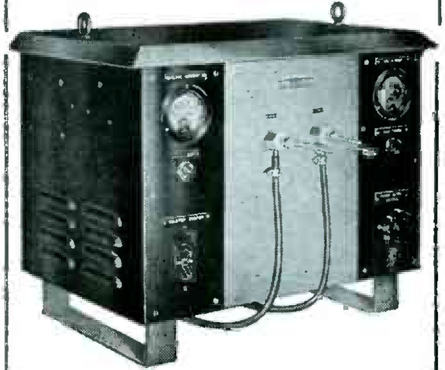
A QUALITY
2-KW INDUCTION HEATING UNIT



For Only $650.

Never before a value like this new 2-KW bench model "Bombarder" or high frequency induction heater . . . for saving time and money in surface hardening, brazing, soldering, annealing and many other heat treating operations.

Simple . . . Easy to Operate . . . Economical Standardization of Unit Makes This New Low Price Possible

This compact induction heater saves space, yet performs with high efficiency. Operates from 110-volt line. Complete with foot switch and one heating coil made to customer's requirements. Send samples of work wanted. We will advise time cycle required for your particular job. Cost, complete, only $650. Immediate delivery from stock.

Scientific Electric Electronic Heaters are made in the following range of Power: 1-3-5-7½-10-12½-15-18-25-40-60-80-100-250-KW.—and range of frequency up to 300 Megs. depending on power required.

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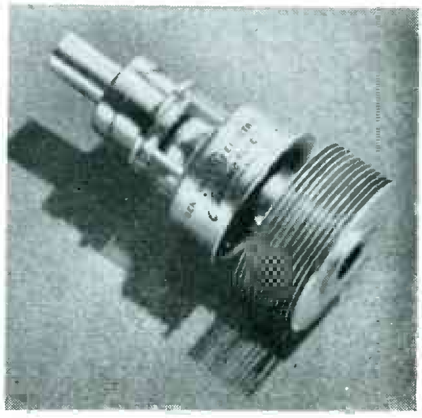
12 VESTRY ST., NEW YORK 13, N. Y.

low-pass filter eliminates the picture line frequency and allows a maximum frequency deviation of plus or minus 12 kc to be monitored.

UHF Tube

GENERAL ELECTRIC Co., Schenectady, N. Y. has developed type GL-



5648, a uhf tube for oscillator service and grounded-grid power amplifier applications up to 2,500 mc. It has a cathode voltage of 6.3 volts. When used as a grid-separation oscillator at 500 mc its power output is 25 watts.

Geiger Pulse Generator

EL-TRONICS, INC., 1920 Lincoln Liberty Bldg., Broad & Chestnut, Phil-

adelphia, Pa. Model GPG2 is a low-frequency pulse generator made especially for testing and calibrating Geiger counter apparatus. It has a frequency range from 3 to 960 cycles and is completely a-c operated.

Flow Meter

CHARLES ENGELHARD INC., East Newark, N. J. A flow meter designed for measurement of aviation gasoline illustrated has a linear

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scale that covers the range from 0 to 2,000 pounds per hour with the same accuracy for small or large flow rates. The electronic receiver unit can be installed at any distance from the transmitter unit (not shown).

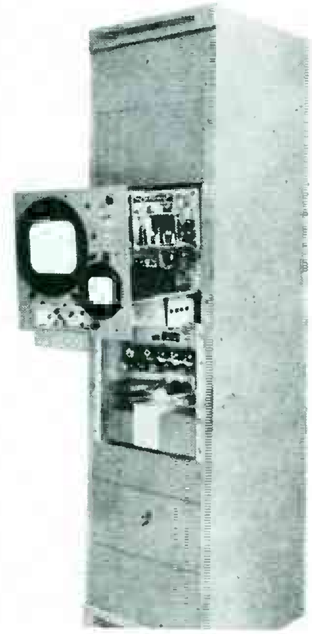
Wheatstone Bridge

INDUSTRIAL INSTRUMENTS, INC., 17 Pollock Ave., Jersey City 5, N. J. A new line of Wheatstone bridges complete with batteries and hardwood case have both Murray and

Varley loop connections. Galvanometer sensitivity is one microampere per millimeter division.

Television Monitor

POLARAD ELECTRONIC CO., 9 Ferry St., New York 7, N. Y. Television picture and waveform monitor model M102 comprises a high voltage supply, a kinescope and an oscilloscope, voltage calibrator for waveform monitor, horizontal and vertical bar generator, phaseable horizontal and vertical pulse cross, and associated equipment. The unit is



designed for general supervision and investigation of composite video signals at a studio or remote point.

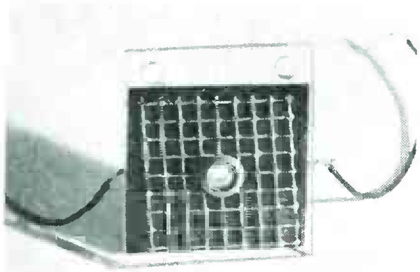
Motor-Capacitor Housing

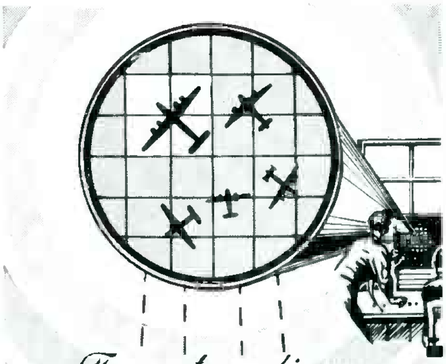
AEROVOX CORP., New Bedford, Mass. announces availability of its heavy-

gauge metal motor-capacity housing. It completely covers and protects capacitor and terminals requiring no auxiliary caps or brackets.

Photoelectric Cell

AMERICAN SCIENTIFIC CO., 137 Marcy Place, New York 52, N. Y. The Iris barrier-layer cell produces





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PRECISION PAPER TUBE CO.
2041 W. CHARLESTON ST., CHICAGO 47, ILL.
PLANT NO. 2, 79 CHAPEL ST., HARTFORD, CONN.

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You'll Solve
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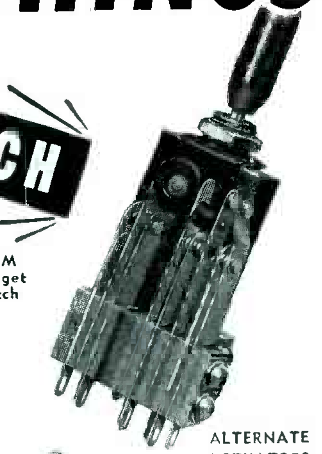


Model MCM Master Midget Lever Switch

It's adaptable . . . it gangs enough contact arrangements to handle nearly every circuit change you can conceive.

It's compact . . . small enough to fit in the tightest spots; extends only 2¾ inches behind panel; weighs only 3½ ounces complete with twelve springs.

It's positive . . . each detent action is fixed by patented stainless steel inserts; full throw in non-lock as well as in locking action.

It's convenient . . . has single-hole mounting; contact assemblies are detachable for easy wiring.

It's dependable . . . contacts handle 5 to 10 amperes at 115 volts a-c, depending on load characteristics; tested at 2500 volts a-c to ground.

ALTERNATE ACTUATORS

Waterproof handle for marine use.

Rotary actuator and lever arm for mounting parallel to panel.

WRITE TODAY for detailed information about the Model MCM Switch

GENERAL CONTROL COMPANY
1202 Soldiers Field Rd., Boston 34, Massachusetts

several hundred microamperes in strong light. A circular supplied by the manufacturer suggests various uses including burglar alarms and a color-matching device. List price is $1.50.

R-F Amplifier

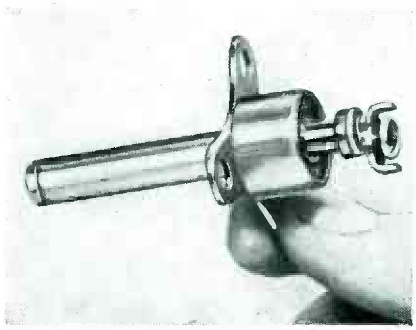
JAMES MILLEN MFG. CO., INC., 150 Exchange St., Malden 48, Mass. The r-f amplifier illustrated uses a type 829B tube and plug-in inductors to cover the amateur 2- to 20-meter bands or commercial frequencies. Adapted to either panel or table mounting the unit has 75 watts power output.

Flexible Waveguide

AIRTRON, 650 Bloomingdale Road, Pleasant Plains, Staten Island 9, N. Y. Flexible waveguide with electrical properties equivalent to rigid brass type and a constant-power standing-wave-ratio throughout the flexing cycle is available in all sizes.

Fire Detector

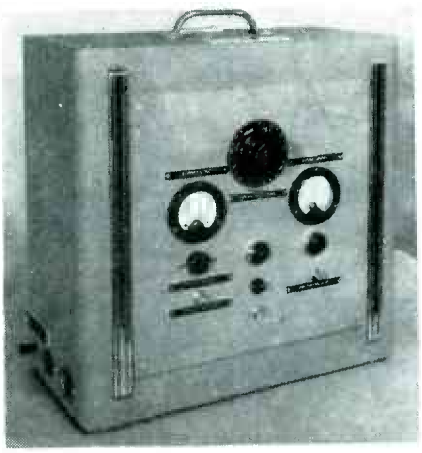
CONTROL PRODUCTS, INC., 306 Sussex St., Harrison, N. J. The air-



craft fire detector illustrated weighs 1 ounce and operates in a normally open circuit. False alarms can not develop under vibration because the contactor has small mass and operates only with heat.

Portable High Voltage

Beta Electronics Co., 1762 Third Ave., New York 29, N. Y. Model 201 portable power supply operates from socket power to provide from 0 to 30 kilovolts of d-c power at currents up to 300 microamperes. Output ripple at 30 kv is less than 2 percent. A current limiting resistor is included in the output circuit in case of flashover. Applications for the device are television testing, cathode-ray oscillography, and high-voltage insulation testing.



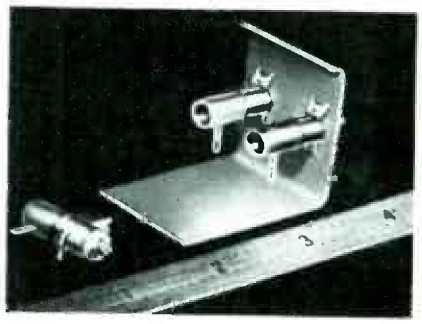
Continuous-Recording Camera

Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J. Type 314 oscillograph-record camera is applicable to all standard 5-inch c-r oscillographs. The shutter remains open for continuous-record operation or can be opened momentarily for a stationary image. Film

speed being electronically controlled and indicated on a calibrated dial, is continuously variable from 1 inch per minute to 5 feet per second.

Tubular Trimmer

ERIE RESISTOR CORP., 640 West 12 St., Erie, Pa. Types 531 and 532 tubular trimmers have a low minimum capacitance in the range 1 to 8 micromicrofarads, power factor



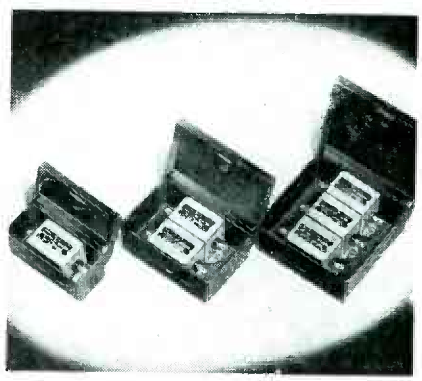
of 0.1 percent, and rated voltage of 350 volts d-c. Complete specifications are available.

Fuse Holders

LITTELFUSE INC., 4757 Ravenswood Ave., Chicago 40, Ill. The fuse holders illustrated are suitable for type 4AG and 3AG instrument fuses. The improved extractor posts feature dead-front panel installation and are further described in catalog 9.

Heavy-Duty Filters

SOLAR MFG. CORP., 1445 Hudson Blvd., North Bergen, N. J., has



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CIRCUIT FEATURES: *Self-contained power supply* for 110V D.C. A.C. 50-60 cycles . . . *Three tube circuit* of conventional design, using the *latest miniature and dual purpose tubes*. Oscillator-converter; I.F.-2nd detector; A.C. rectifier . . . Permeability tuned drift-free I.F.'s . . . Approx .5 volt audio output across interval .5 megohm internal load resistor, on average B.C. signal with five foot antenna . . . Units individually tracked at FOUR points through tuning range of 540-1700 kc . . . **COMPACT:** Approximately 4½"x3½"x3-¾".

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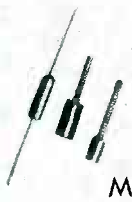

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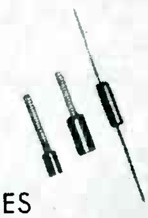

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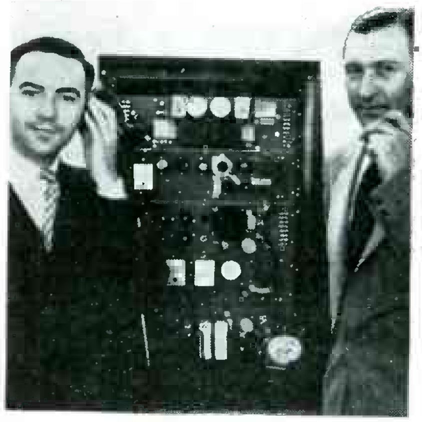
Long Distance Telephone CEntral 5830

made available the type EB series of heavy-duty radio interference filters for wiring circuits, screen rooms and industrial electrical equipment. The assemblies have a noise elimination range of from 150 kc to 250 mc.

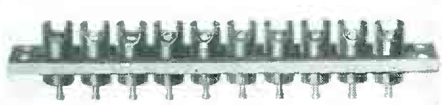
Carrier System

GENERAL TELEPHONE SERVICE CORP., 80 Broad St., New York 4, N. Y. The GTC-411 is a simple short-haul carrier system, adaptable for ring-down-toll, remote-community, or subscriber service. Plug-in type connections are used between its five panels. The unit will soon be available to the industry at a moderate cost.



Terminal Block

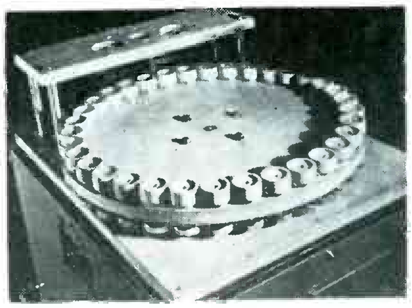
CURTIS DEVELOPMENT & MFG. CO., 1 North Crawford Ave., Chicago 24, Ill. Type FTS feed-through terminal block has clearances for use in circuits carrying up to 300 volts and currents of 20 amperes. Any



number of terminals can be furnished up to 16. A solder connection is used on one side and a screw terminal on the other.

Brazing Turntable

LEPEL HIGH FREQUENCY LABORATORIES, INC., 39 West 60th St., New York 23, N. Y. A new automatic turntable for continuous soldering of small parts uses cup receptacles to simplify positioning of parts as they pass through the work or heat-



ing coil. Speed of the table can be varied from ½ to 3 rpm.

Literature

Precipitation Static. Dayton Aircraft Products, Inc., 342 Xenia, Dayton, Ohio, has just released an 8-page booklet telling about means of reducing precipitation static in aircraft radio.

Instrument Catalog. Roller-Smith Div., Bethlehem, Pa. A large 5-section catalog describing the complete line of meters, rotary switches, relays, precision balances, and accessories is just off the press.

Voltage Doubler Capacitor. Cornell-Dubilier Electric Corp., South Plainfield, N. J., has just issued a data sheet NB-101 on the type T-121 television voltage doubler capacitor.

Parts Catalog. Insuline Corp. of America, Long Island City 1, N. Y. ICA's new catalog N-48 has 52 pages and lists more than 2,000 radio and electronic components, as well as several thousand standard parts.

A-C Contactors. Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y., has just issued bulletin 4451 telling about a new line of solenoid-operated a-c contactors suitable for carrying currents up to 25 amperes.

Plastic Knobs. Rogan Brothers, 2500 W. Irving Park Blvd., Chicago 18, Ill. Plastic knobs, control handles, instrument knobs, and materials for their manufacture are listed in a new illustrated catalog.

Dust and Fume Sampler. Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh Pa. Bulletin CT-3 briefly describes the catalog no. CT-14650 dust and fume sampler for use in stacks or ducts at rates up to 3 cubic feet per minute.

Plastic Insulated Conductors. Phalo Plastics Corp., 25 Foster St., Worcester 8, Mass. A new 18-page catalog lists all kinds of plastic insulated wire and cables, cord sets and miscellaneous assemblies.

Artificial Atmospheres. Bowser Inc., Terryville, Conn. Controlled relative humidity, low pressure, and temperature are available in packaged form with simulation units described in brochures recently issued.

Wire Recording. Lear Inc., 11916 West Pico Blvd., Los Angeles 34, Calif. Specifications and booklets are available on the WR-105 wire recorder.

Radioactivity Measuring Equipment. Tracerlab, Inc., 55 Oliver St., Boston, Mass. Issue 7 of Tracerlog includes articles on radioactivity measuring equipment, radioassay techniques, radioactivity reference sources, and radiochemical services.

Time Switch. Sangamo Electric Co., Springfield, Ill. Type S time switch is described in bulletin 1050.

Strain Gage Instruments. Anderson-Fluke Engineering Co., Springdale, Conn. Two new 24-channel strain gage instruments, model 301 Strainmeter, and model 302, Bridge Balancer are reviewed in a brochure available from the manufacturer.

High Voltage Resistors. Resistance Products Co., 714 Race St., Harrisburg, Pa. Bulletin 2 is a single sheet filled with information about the type B high voltage resistor.

Tube Manual. Commercial Engineering, RCA Tube Dept., Harrison, N. J. will send you a copy of Manual RC-15 upon receipt of 35

cents. The familiar handbook, just brought up to date is also available from distributors and stores. Tubes, circuits, R-C amplifiers, and a receiving tube classification chart are among the features.

Test Speaker. Test-Craft Instrument Co., 42 Warren St., New York 7, N. Y. Send for an illustrated circular on the new model TC-48 universal combination test speaker.

Service Test Equipment. General Electric Co., Syracuse, N. Y. Catalog ESD-129 lists specifications of nine instruments used for testing receivers and electronic equipment.

Resistors, Rheostats and Relays. Ward Leonard Electric Co., 53 W. Jackson Blvd., Chicago 4, Ill. Catalog D-30 covers all sorts of resistors and rheostats as well as a stock line of relays for radio amateurs.

High-Frequency Dielectric. General Aniline & Film Corp., 444 Madison Ave., New York 22, N. Y. Electric Polectron Dielectrics is the title of a 21-page slick-paper treatise on a new plastic material.

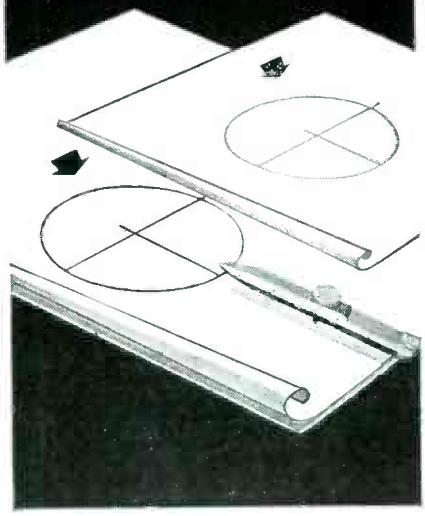
Radio Predictions. Superintendent of Documents, Washington 25, D. C. (send no stamps) has copies of Circular C465 at 25 cents telling how to use the monthly publication, "Basic Radio Propagation Predictions—Three Months in Advance".

Audio Components. Audio Development Co., Minneapolis 7, Minn. Catalog 46A covers transformers, patch cords and plugs, filters, jacks and jack panels in 15 pages.

Air Filter. Trion, Inc., 1000 Island Ave., McKees Rocks, Pa. A data file with illustrations is available on a new electronic air filter now available in several capacities.

Tape Recording. Magnephone Div., Amplifier Corp. of America, 398-7 Broadway, New York 13, N. Y. A series of tape recorders and accessory equipment for sound up to 12,500 cycles is pictured in eight

Tracing cloth that defies time



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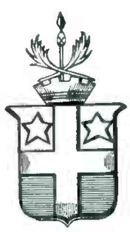

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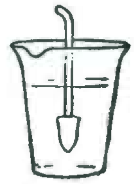
If corrosion resistance of small parts is important to your product, it's worthwhile to consider LINDE synthetic sapphire. This new raw material resists chemical attack and wear. It has high electrical resistance—low thermal conductivity.



1. Chemical Resistance . . All acids
2. Hardness (Knoop) 1,525 to 2,000
3. Thermal Conductivity . . 0.015 (cal. sec.$^{-1}$ cm^{-1} deg. C.$^{-1}$ at 500 deg. C.)
4. Dielectric Constant . . . . . . 7.5 to 10

Send for Data Sheet No. 5 for all the specific properties of this advantageous material—LINDE synthetic sapphire.

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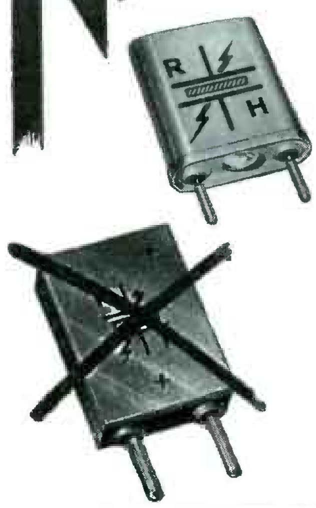
NEW! RH-7-C

SUCCESSOR TO *RH-243*



An adaptation of the famous RH-7 crystal unit, RH-7C offers such advantages as:

- Smaller Size (1" x ¾" x 11/32", more than ⅓ smaller than RH-243)
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- Improved Accuracy (can be made to ±0.005% over a temperature range of – 55° C to + 90° C).
- Greater Frequency Range (3-15 mc Fundamental and 15-75 mc Harmonic Mode, compared to RH-243's 3100-10,000 kc.)
- True Hermetic Seal
- The Greater Stability of Wire Mounting
- Completely Interchangeable with RH-243

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PLANT: 321 CHERRY STREET, CARLISLE, PA.

pages now available. Included is information on an 8-hour continuously playing model.

Insulation. Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y. Just received is a 43-page booklet describing the company's many insulating products indexed from "air drying varnish no. 15" to "wire solder" (sic!).

Electrical Laminations. Thomas & Skinner Steel Products Co., 1122 East 23rd St., Indianapolis, Ind. Catalog 47 gives complete information on the company's stock lamination dies, and additional data on weights, characteristics, and applications of electrical steels.

Vibration Mounts. Hamilton Kent Mfg. Co., Kent, Ohio. Rexon vibration mounts are illustrated and their characteristics and specifications given in an 8-page brochure.

Nylon Strip. Polymer Corp., Reading, Pa. A folder has just been printed that outlines some of the applications of nylon rod and strip and a process for coloring molded nylon.

Industrial Controls. Langevin Mfg. Corp., 37 West 65th St., New York 23, N. Y. Bulletin 1022 contains information on the model PR-400 series photoelectric control-amplifier used as a transducer between phototube and machinery control.

Ceramics Data. American Lava Corp., Chattanooga 5, Tenn., has issued Bulletin No. 246 describing the mechanical and electrical properties of Alsimag ceramics with detailed charts and tables.

X-Ray Diffraction Camera. North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y. A 4-page folder shows the construction and explains the application of the new x-ray diffraction camera which is especially adapted to fiber analysis.

Relay Data Sheets. Globe Electrical Mfg. Co., 11019 Buford Ave., Inglewood, Cal. Three loose-leaf

FOR PERSONALIZED ATTENTION TO YOUR RESISTANCE WIRE PROBLEMS

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CHICAGO, ILL. Phone: STATE 5292
William Maxwell Co., 107 N. Wacker Drive

CLEVELAND, OHIO Phone: MAIN 8585
A. J. Loeb Sales Co., 1836 Euclid Ave. So.

LOS ANGELES, CALIF. Phone: TRINITY 7353
Perlmuth-Colman Associates, 942 Maple Ave.

MINNEAPOLIS, MINN. Phone: GENEVA 3373
Volco Company, 622 McKnight Building

NEW YORK, N. Y. Phone: CALEDONIA 5-1776
R. B. Dana Company, 101 Park Ave.

PHILA., PA. Phone: KINGSLEY 5-1205
S. K. MacDonald, 1531 Spruce St.

PITTSBURGH, PA. Phone: CEDAR 3000
Wm. M. Orr Co., 1228 Brighton Rd.

ROCHESTER, N. Y. Phone: MONROE 5392
J. R. Hanna, P. O. Box 93, Brighton Station

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Perlmuth-Colman Associates, 704 Third Avenue

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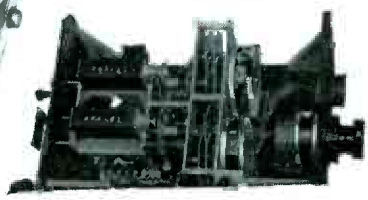
WIRE PRODUCTS — Jelliff — SINCE 1880

RESETABILITY

for Accurate Computing



Fairchild Precision Linear Potentiometer

In this integrating computer accurate resetability in both the single-solution computer potentiometer and the integrating potentiometer eliminates hunting and carry-over errors.

Fairchild's low-torque Linear Potentiometer—which is a small precision instrument—can be reset to any selected resistance or angle of rotation with an accuracy that is unsurpassed in any other single-turn potentiometer.

This precision performance is maintained over a million cycles of operation with long-life precious metal alloy contacts. For complete data address: Dept. 'G', 88-06 Van Wyck Boulevard, Jamaica 1, New York.

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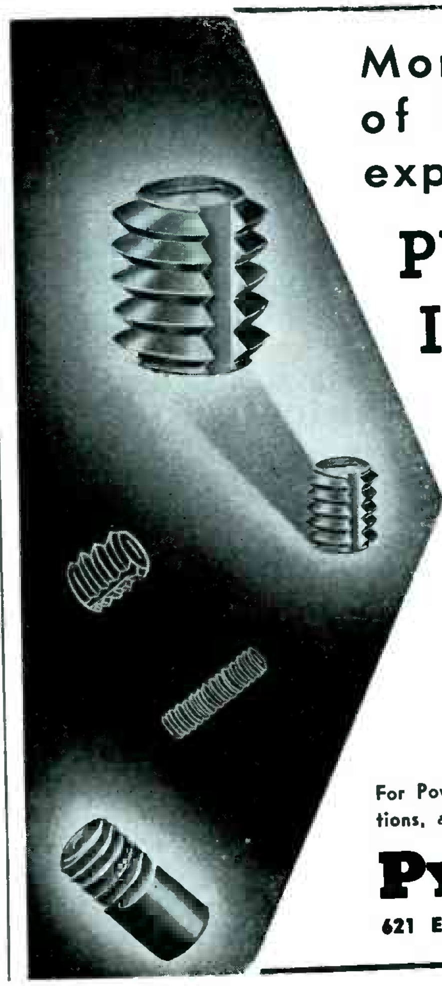

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621 East 216 Street, New York City 67

insert sheets thoroughly describe a variety of circuit control and time delay relays, giving applications, specifications, contact combinations and prices.

Crystal Bulletin. Premier Crystal Laboratories, Inc., 57–67 Park Row, New York 7, N. Y. Extensive technical data covering twelve widely used crystal types are given in a profusely illustrated bulletin, No. 201. Information on ultrasonic crystal blanks and helpful hints on ordering are also given.

Sweeping Oscillator. Kay Electric Co., 34 Marshall St., Newark 2, N. J., has made available a reprint from ELECTRONICS on the wideband sweeping oscillator, as well as specification sheets on the Megamatch, an instrument for displaying transmission-line mismatch over wide frequency range.

Liquid Control Devices. Magneswitch Inc., 4259 South Western Blvd., Chicago 9, Ill. A six-page folder illustrates about a dozen types of industrial liquid control devices. All operate in any temperature at any pressure.

R-F Heating. Delapena & Son Ltd., Cheltenham, Gloucestershire, England. A description and specifications of apparatus for r-f heating of dielectrics are given in an eight-page pamphlet. Also pointed out are the production benefits from its use, the lower costs involved and the method of operation.

Low Current Tube. General Electric Co., Schenectady, N. Y. Pliotron 5674 is a six-electrode high-vacuum dual anode with dual control grids that can be used to measure current of 5 x 10^{-16} ampere. See bulletin ET-H33 for details.

Regulated A-C Generator. Electric Machinery Mfg. Co., 821 Second Ave. S. E., Minneapolis 14, Minn. Volume 8, no. 3a of the E-M Synchronizer describes, among other items, a new packaged a-c generator with a built-in automatic regulator for constant voltage output.

Flexible Waveguides. Technical Laboratories, Inc., 237 East Aurora St., Waterbury, Conn. Bul-

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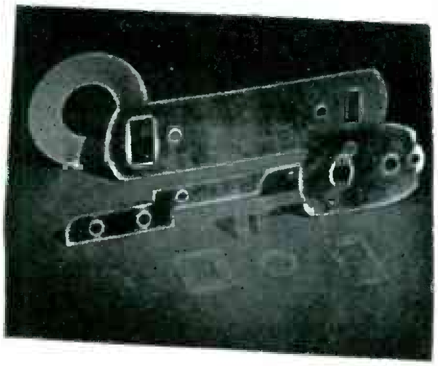
*

PLASTICS



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Years of experience in fabricating parts and products of plastics make Sillcocks-Miller an ideal source for developing practical and economical answers to your individual needs.

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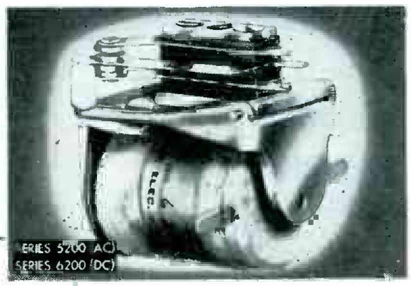
Midget telephone-type relay



A new Advance relay. Series 5200 and 6200 are similar to series 5000 and 6000 but have single contacts. This compact relay is ruggedly made to withstand vibration. Operates on 1/10 to 2 watts of power. Thoughtful design, finest materials, and skilled craftsmanship make this the finest relay of its type.

SPECIFICATIONS:

• Any contact combination SPST to 4PDT • Pure silver contacts 1/8" to 3/16" • Universal wound, varnished, vacuum impregnated coil • 1 to 16000 ohms DC resistance • 1 to 220 volts AC or 1 to 150 volts DC • Phosphor bronze blades and armature pin • Pivot hinge with phosphor bronze bearing (low friction)

Write for new catalog, issued May, 1947

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ADVANCE ELECTRIC & RELAY CO.
1260 West 2nd St., Los Angeles, California • Phone MIchigan 9331

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NEW PRODUCTS (continued)

letin F-1 issued by the organization that succeeds the Metal Hose Branch of the American Brass Co., in the manufacture of all types of flexible waveguides, lists the various sorts now procurable.

What is GCA? Bendix Radio Div., Baltimore 4, Md., has the answer presented as a 16-page brochure. Write direct for a free copy, attention John M. Sitton.

Data Sheets. Dow Corning Corp., Midland, Michigan. Preliminary data sheets No. B-30-1 list on two pages all of the materials necessary to ensure maximum service life in motors rewound with Silicone insulation.

Servicing Meter. Bradshaw Instruments Co., 942 Kings Highway, Brooklyn 23, N. Y. The Range Master model 10 servicing meter has a number of uses that are covered in the 4-page leaflet that outlines its measurement ranges.

R-F Heating Course. Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa. A series of slides, records, and review booklets comprising eight 2-hour lecture units is announced. Metalworking applications, bonding of wood, preheating of plastics, drying and curing of rubber and textiles, and thawing of food products by dielectric heating are covered. Cost of the kit for 20 class-members is $185.

Light Integration Device. Electronic Mechanical Products Co., 13 N. Virginia Ave., Atlantic City, N. J., has a four-page folder telling what the Luxometer does and how it is applied. The instrument measures the quantity of illumination being received by any light-sensitive material regardless of fluctuations at the source. It can be used on cameras, remote control units, and the like.

Tube Wall Chart. Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh 30, Pa. Basic information on operation, types, and applications of electron tubes is presented in a new 25 by 36-inch wall chart. Price is $2.00.

(continued from p 148)

City and Applicant	Call Letters	Channel No.	Power in kw Visual	Power in kw Aural
FLORIDA				
Miami				
Southern Radio & Tele. Eqpt. Co.— CP	WTVJ	4	1.57	0.786
Miami Broadcasting Co.— A	....	5	.....	.....
GEORGIA				
Atlanta				
Liberty Broadcasting Corp.— A	....	5	.....	.....
ILLINOIS				
Chicago				
American Broadcasting Co., Inc.— CP	WENR-TV	7	30	15
Balaban & Katz Corp.*	WBKB	4	1.8 CP12.42	1.8 7.50
National Broadcasting Co., Inc.— CP	WNBY	5	21.8	21.8
WGN, Inc.— CP-O	WGNA	9	18.4	9.4
Sun & Times Co.— A		13	.....	.....
Columbia Broadcasting System, Inc.— A	....	11	.....	.....
Johnson-Kennedy Radio Corp.— A	....	2	.....	.....
INDIANA				
Bloomington				
Sarkes & Mary Tarzian — CP	WTTV	10	1	1
Indianapolis				
Wm. H. Block Co.— CP	WWHB	3	14.44	7.6
WFBM, Inc.— A	....	6	.....	.....
IOWA				
Ames				
Iowa State College of Agr. & Mech. Arts — CP	WOI-TV	4	13	10–4
KENTUCKY				
Louisville				
Courier-Journal & Louisville Times Co.— CP	WHAS-TV	9	9.6	7.2
WAVE, Inc.— A	....	5	.....	.....
LOUISIANA				
New Orleans				
Maison Blanche Co.— CP	WRTV	4	13.6	7.2
MARYLAND				
Baltimore				
A. S. Abell Co.— CP-O	WMAR	2	17.1	17.1
Hearst Radio, Inc.— CP	WBAL-TV	11	32.6	17.2
Radio-Television of Baltimore, Inc.— CP	WAAM	13	31.65	20
MASSACHUSETTS				
Boston				
Westinghouse Radio Stations, Inc.— CP	WBZ-TV	4	14.3	7.13
Yankee Network, Inc.— CP	WNAC-TV	7	32.7	32.7
Boston Metro. Tele. Co.— A-H	....	9	.....	.....
Empire Coil Co., Inc.— A-H	....	9	.....	.....
Massachusetts Broadcasting Corp.— A-H	....	9	.....	.....
New England Tele. Co., Inc.— A-H	....	13	.....	.....
New England Theatres, Inc.— A-H	....	13	.....	.....
Fall River				
New England Tele. Co., Inc.— A	....	8	.....	.....
New Bedford				
E. Anthony & Sons, Inc.— A	....	1	.....	.....
Waltham				
Raytheon Mfg. Co.— CP	WRTB	2	.....	.....
MICHIGAN				
Detroit				
Evening News Assn.— CP-O	WWJ-TV	4	17.1	17.7
Fort Industry Co.— CP	WTVO	2	14.26	7.51
King-Trendle Broadcasting Corp.— CP	WDLT	7	32.1	16.7
United Detroit Theatres Corp.— A-H	....	5	.....	.....
WJR, The Goodwill Station, Inc.— A-H	....	5	.....	.....
MINNESOTA				
Minneapolis				
Minn. Broadcasting Corp.— CP	WTCN-TV	4	17.9	9.2
Saint Paul				
KSTP, Inc.— CP	KSTP-TV	5	13–68	6.48
MISSOURI				
St. Louis				
Pulitzer Publ. Co.— CP-O	KSD-TV	5	18.15	18.7
NEW JERSEY				
Newark				
Bremer Broadcasting Corp.— CP	WATV	13	17	8.3
Trenton				
Trent Broadcasting Corp.— A	....	1	.....	.....
NEW MEXICO				
Albuquerque				
Albuquerque Broadcasting Co.— CP	KOB-TV	4	4.5	4.5
NEW YORK				
Buffalo				
WBEN, Inc.— CP	WBEN-TV	4	15	8
New York				
American Broadcasting Co., Inc.— CP	WJZ-TV	7	16.25	8.25
Bamberger Broadcasting Service, Inc.— CP	WOR-TV	9	30–25	24.5
Columbia Broadcasting System, Inc.*	WCBS-TV	2	1.72	1.67
Allen B. DuMont Labs., Inc.*	WABD	5	1.81 CP14.25	0.723 9.45
National Broadcasting Co., Inc.*	WNBT	4	7	5.75
News Syndicate Co., Inc.— CP	WLTV	11	16.3	8.17
Schenectady				
General Electric Co.*	WRGB	4	40 CP18.25	21.3 9.125
OHIO				
Cincinnati				
Crosley Broadcasting Corp.— CP	WLWT	4	23.5	19.5
Allen B. DuMont Labs., Inc.— A-H	....	2	.....	.....
Cleveland				
Empire Coil Co., Inc.— CP	WXEL	9	21	13

City and Applicant	Call Letters	Channel No.	Power in kw. Visual	Power in kw. Aural
National Broadcasting Co., Inc.— CP	WNBK	4	18.8	9.6
Scripps-Howard Radio, Inc.— CP-O	WEWS	5	18.2	9.1
Allen B. DuMont Labs., Inc.— A-H	.....	2	.....	.....
The WGAR Broadcasting Co.— A-H	.....	7	.....	.....
United Broadcasting Co.— A-H	.....	7	.....	.....
Columbus				
Crosley Broadcasting Corp.— CP	WLWL	3	15.5	5.25
Dayton				
Crosley Broadcasting Corp.— CP	WLWD	5	30	25
Toledo				
Fort Industry Co.— CP	WTVT	13	27.4	14.4
OREGON				
Portland				
Oregonian Publ. Co.— CP	KGWG	6	10	11.2
PENNSYLVANIA				
Harrisburg				
Harold O. Bishop — A-H	.....	8	.....	.....
WHP, Inc.— A-H	.....	8	.....	.....
Johnstown				
WJAC, Inc.— CP	WJAC-TV	13	6.5	7
Lancaster				
WGAL, Inc.— A	.....	4	.....	.....
Philadelphia				
Wm. Penn Broadcasting Co.— CP	WPEN-TV	10	25	26.4
The Phila. Inquirer — CP-O	WFIL-TV	6	18.1	9.3
Philco Television Broadcasting Corp.*	WPTZ	3	2.69 CP10.37	2.76 10.7
Daily News Tele. Co.— A-H	.....	12	.....	.....
Penna. Broadcasting Co.— A-H	.....	12	.....	.....
Pittsburgh				
Allen B. DuMont Labs., Inc.— CP	WDTV	3	14.6	7.3
Allegheny Broadcasting Corp.— A	.....	8	.....	.....
Empire Coil Co., Inc.— A	.....	10	.....	.....
Westinghouse Radio Stations, Inc.— A	.....	6	.....	.....
Wilkes-Barre				
Louis G. Baltimore — A	.....	11	.....	.....
RHODE ISLAND				
Providence				
The Outlet Co.— CP	WJAR-TV	11	50	50
TENNESSEE				
Memphis				
Bluff City Broadcasting Co.— A	.....	5	.....	.....
Memphis Publ. Co.— CP	.....	4	13.6	7.12
TEXAS				
Dallas				
KRLD Radio Corp.— CP	KRLD-TV	4	46	TBD
Lacy-Potter Tele. Broadcasting Co.— CP	KBTV	8	35	18.5
Interstate Circuit, Inc.— A-H	.....	3	.....	.....
Fort Worth				
Carter Publications, Inc.— CP	KCPN	5	17.6	8.2
Houston				
W. Albert Lee — A	.....	2	.....	.....
UTAH				
Salt Lake City				
Intermountain Broadcasting Corp.— CP	KDYL-TV	2	13.2	
VIRGINIA				
Richmond				
Havens & Martin, Inc.— CP	WTVR	6	12.16	6.4
WASHINGTON				
Seattle				
Radio Sales Corp.— CP	KRSC-TV	5	18.95	9.79
WISCONSIN				
Milwaukee				
The Journal Co. — CP-O	WTMJ-TV	3	16.1	17

Armstrong Medals Awarded by Radio Club

JOHN V. L. HOGAN, president of radio station WQXR and one of the founders of the Institute of Radio Engineers, was presented on Dec. 5, 1947 with the Armstrong Medal of the Radio Club of America, for his outstanding contributions to the arts of radio, television, and facsimile.

A similar medal was given posthumously to Charles S. Ballantine for his development of radio direction finders in World War I, negative feedback and automatic volume control circuits, mathematical theories of antenna radiation, new microphone calibration techniques, his invention of the throat microphone

John V. L. Hogan (right) receives Armstrong Medal from Alan Hazeltine, president of the Radio Club of America

HIGH FREQUENCY *Power Measurement* IS SIMPLE

with the *Termaline* DIRECT Reading Wattmeter

(Model 61)

for the first time...

● Here is a **RUGGED DIRECT-READING** instrument for power measurement of transmitters in the 30 to 500 mc, 1 to 2000 watt group. Accuracy of a high order, combined with ease of operation plus new design features make the TERMALINE an outstanding development.

GENERAL SPECIFICATIONS

FREQUENCY—30 mc to 500 mc, reading directly in RF watts.
POWER RANGE—1 watt to 2000 watts, choice of dual or triple ranges according to model.
IMPEDANCE—51.5 ohms. VSWR less than 1.1.
FOR USE ON—CW-AM-FM sources.
ACCURACY—Within 5% of full scale absolute. Repeatability 1% for readings on any one instrument.

3 MODELS

Model 61—Small, portable, 1 to 80 watts.
Model 67—Bench type, 1 to 500 watts.
Model 67C—Water-cooled 1 to 2000 watts.

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- Acetate Bobbin
- Acetate Section
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as standardized by the U. S. Army Air Corps, and a host of other contributions to the arts of radio communication and radio broadcasting.

URSI-IRE Meeting

THE ANNUAL joint meeting of the American Section, International Scientific Radio Union, and the IRE will be held in Washington May 3, 4, and 5, 1948. The program will, as usual, be devoted to the more fundamental and scientific aspects of radio and electronics. The program of titles and abstracts will be available in booklet form for distribution before the meeting. Anyone wishing to submit papers for presentation at this meeting should send in title and a 100-word abstract as soon as possible to Dr. Newbern Smith, Secretary, American Section, URSI, the National Bureau of Standards, Washington 25, D. C.

Table of Air-Line Distances

AN EXTENSIVE TABLE of air-line distances between cities in the United States has been published by the Coast and Geodetic Survey, Department of Commerce to meet requirements of air navigation and radio engineering problems. The table was developed in response to an increasing demand for distances that are accurately computed by methods treating the earth as an ellipsoid rather than a sphere. Distances are listed from each of 492 cities to all of the others and are accurate to the nearest mile.

This U. S. Coast and Geodetic Survey Special Publication No. 238, entitled "Air-line Distances Between Cities in the United States", is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at $1.75 per copy (buckram bound).

Fellowship in Electronics

AMONG fellowships being offered for the 1948-1949 academic year by the National Research Council are a number supported by Radio Corporation of America, intended to give special training and experience to young men and women who have demonstrated marked ability in the general field of electronics. Preliminary experience may have been either in the fields of electrical engineering or physics. Although the applicants need not have completed more than one year of graduate work, they should have demonstrated marked ability for graduate work. These fellowships are open only to United States citizens. The fields of study to be undertaken are in the sciences underlying the general science of electronics. Stipends range from $1,600 to $2,100 per annum. Appointments are for one year, but renewable for a second year and in exceptional cases for a third year.

Further particulars concerning these programs may be obtained upon request from the National Research Council Fellowship Office, National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D. C.

Search Radar for N. Y. Area

MICROWAVE EARLY WARNING (CPS-1) surveillance radar has been installed at Queens College, four miles southeast of LaGuardia airport, as an air traffic control aid. The equipment was furnished by the U. S. Air Force, was installed by the Air Transport Association and Airborne Instruments Laboratory, and is operated by the CAA. It gives sky coverage up to 40,000 feet within an elevation angle of 30 deg from the horizontal, and has a reliable range of 100 miles in all directions.

The radar pictures are combined with appropriate maps of the area by means of recently developed video mapping techniques. The combined picture is seen on a number of 12-inch ppi scopes, some of which can be adjusted as expanded sector displays. The composite picture is relayed to the Airways Traffic Control Center of the CAA at LaGuardia airport over a microwave radio circuit developed by AIL.

New Heating Frequencies

AS A RESULT of the recent Atlantic City Radio Administrative Conference, the FCC has changed its rules relating to industrial, scientific, and medical service. Presently assigned frequencies may be used until June 30, 1952, at which time all such equipment must be operating on the newly adopted international frequencies, as follows:

Newly Assigned Band	Center Frequency	Tolerance from Center Frequency
13,553.22-13,566.78 kc	13.560 kc	± 6.78 kc
26,957.28-27,282.72 kc	27,120 kc	±162.72 kc
40,659.66-40,700.34 kc	40,680 kc	± 20.34 kc

These allocations involve only slight changes, the old center frequencies being 13,660 kc, 27,320 kc, and 40,980 kc respectively.

The status of frequencies made available by the Commission's Order of Dec. 26, 1946 but not yet incorporated into rules remains unchanged. The Atlantic City Radio Regulations provide 915 mc, 2,450 mc, and 5,850 mc in all countries of the Americas for this service.

In general, little or no modification is needed in equipment on which the FCC has already issued certificates of type approval, other than installation of new crystals or adjustment of selfexcited oscillators. Users are urged to make the slight change in frequency at the earliest possible date.

It is expected that a frequency in the 6-mc band will be made available in the future for diathermy and industrial heating equipment.

Research Positions Open

APPLICATIONS for Electronic Engineer and Physicist positions are being accepted by U. S. Civil Service Examiners at each of the following research laboratories: U. S. Navy Underwater Sound Laboratory, Fort Trumbull, New London, Conn.; Naval Research Laboratory Field Station, 470 Atlantic Avenue, Boston 10, Mass.; Cambridge Field Station, Watson Laboratories, Air Materiel Command, 230 Albany Street, Cambridge, Mass. The salaries for these positions range from \$3,397 to \$8,179 a year.

For the Electronic Engineer and Physicist positions, applicants must have completed (a) a full 4-year college course with major work in physics, mathematics, or engineering science, or (b) at least 4 years of progressive technical experience

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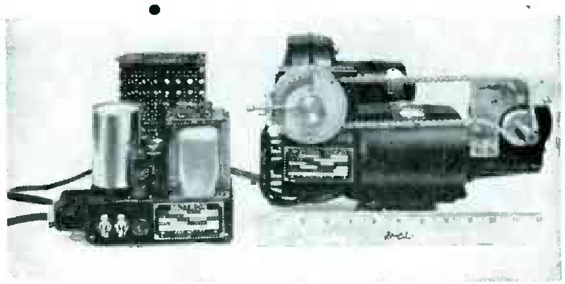

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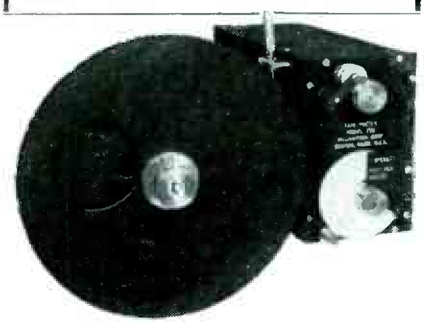

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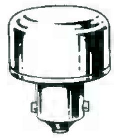

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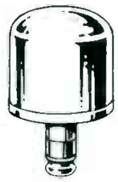

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in engineering or physics, or (c) any time equivalent combination of education and experience. In addition, applicants must have had from 1 to 4 years of progressive professional experience in the appropriate field. Graduate study may be substituted for experience up to a maximum of 2 years of experience. No written test is required.

Full information and Announcement 1-34 (47) application forms may be secured from the U. S. Civil Service Commission, Washington 25, D. C.

Transcontinental Racon System

A CHAIN OF 50 racon (radar beacon) stations providing transcontinental radar navigation facilities for both military and nonmilitary aircraft will soon be in operation. Manned jointly by the Navy, Air Force, and Coast Guard, the racon highway will extend down the East Coast, across the transcontinental southern ferry route, and up the West Coast. Already, all but one of the 22 stations assigned to the Navy are running on a 24-hour basis, and three Coast Guard and two Air stations are operating.

In using the racon system, pulses transmitted from a radar-equipped plane interrogate a ground station. The racon replies with coded identification pulses. The range and bearing of these pulses, indicated on the aircraft radar scope, show the location of the plane relative to the ground station. By checking his bearing and location, a pilot can carry out his intended flight path under any instrument flying conditions.

Infrared Communication

A NEWS STORY was dictated by a reporter to his office three-quarters of a mile away in Chicago recently by means of infrared beamcasting equipment of a type developed by Westinghouse lamp engineers during the war for secret two-way ship-to-ship or ship-to-shore conversations. Amplified microphone output current modulates the infrared light output of a special caesium-vapor lamp mounted in a reflector. A phototube in a similar reflector

Infrared transmitting tube in reflector, used in Chicago for transmitting a message three-quarters of a mile without resort to wires or radio

at the receiving point picks up the modulated invisible beam and feeds it to an amplifier and loudspeaker. The message can be picked up only from locations within the beam spread, which is five miles across at its widest point 10 miles away.

Telephone Recording is Legal

THE FCC on January 15, 1948 authorized use of recording devices in connection with interstate and foreign message toll telephone service, subject to an automatic tone warning which will notify all parties so engaged that their telephone conversation is being recorded.

The warning signal must be repeated at regular intervals during the conversation.

The recording device must be of the type which can be physically connected to and disconnected from the telephone line, or switched on and off, thereby enabling subscribers to limit the use of the device to the recording of interstate and foreign telephone calls where such use is prohibited in connection with intrastate telephone service. Further, the connecting equipment shall be provided, installed, and maintained by a company or other organization responsible for furnishing telephone service.

Radar Ignition of Flash Bulbs Creates Fire Hazards

IGNITION of wire- or foil-filled flash bulbs by radar beams can constitute a definite fire hazard, according to tests recently completed by engineers of the Photographic Laboratory and Electronic Subdivision of Air Materiel Command Headquarters at Wright Field.

More than 3,000 bulbs were exposed at distances of 80, 60, 40, and 20 yards to radio waves of various frequencies. No bulbs were fired at short-wave radio frequencies, but all bulbs eventually succumbed to high-frequency radar beams.

In making the tests, the bulbs were exposed to a radar beam, shaken and rotated slightly, and repeatedly exposed. An average of 4.75 percent were ignited by each single exposure to a standard radar transmitter. Forty percent of the bulbs were fired within the first 5 seconds of exposure at any given distance or angle. Only 12 percent were able to withstand exposure of more than one minute before being set off. The continued shaking and realignment eventually caused all of the bulbs to be ignited.

The research also revealed that some bulbs burst spontaneously when fired, and that even broken bulbs could be ignited by the radar beams. The latter were found to burn with a slow, hot flame which made the spreading of fire highly possible.

This high susceptibility to radar beams indicates that serious fire danger exists when such bulbs are exposed to airborne radar units or powerful ground transmitters located close to glide paths, runways, and taxi strips.

As a result of the tests special precautions are being taken to provide adequate protection against fire when flashlight bulbs are shipped or used in aircraft carrying radar. Directives have been issued to military installations ordering that no such bulbs be stored within 100 yards of radar transmitters and that individual bulbs or cartons of them be shielded with metal when it is necessary to place them within the 100-yard range for any period.

The only bulbs found to be naturally immune to radar were those having no foil or wire filling. At present such safe bulbs are only available in small sizes and are not in general use.

Plans for immunizing all bulbs against radar ignition are now

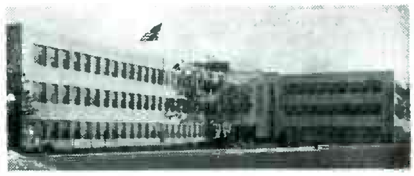
under consideration by engineers and photoflash bulb manufacturers. In the meantime, engineers are recommending precautionary measures against the fire menace.

BUSINESS NEWS

BUEHLER INC., wartime manufacturers of radar and electronic parts for Raytheon Mfg. Co. and others, are expanding services in that field and are now located at Route 17, Paramus, N. J.

ALLEN B. DUMONT LABORATORIES, INC. has added to its tube plant in Passaic, N. J., for the purpose of tripling production capacity of the popular 12-inch television tube.

WESTON ELECTRICAL INSTRUMENT CORP. now occupies its new 78,000-square-foot engineering and administration building on the plant grounds at Newark, N. J.



Weston's new engineering and administration building

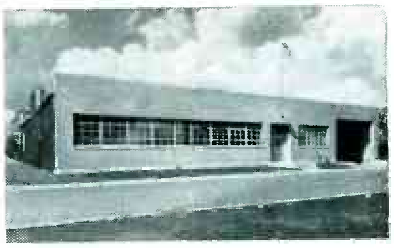
KAY ELECTRIC CO. purchased two acres of property incorporating facilities for the development and manufacture of several new products. The new address is Maple Ave., Pine Brook, N. J.

UNION PACIFIC R. R. is installing two-way radio in its yard offices and diesel switch engines in Los Angeles, Denver, Omaha, Salt Lake City, Portland, and Pocatello. Two-way radio-equipped engines and cabooses are operating between Kansas City and Marysville, Kansas, and fixed transmitters for communication with these trains are located at five Kansas stations.

LEEDS & NORTHRUP CO., manufacturers of electrical measuring instruments and automatic controls, has purchased an additional building in Germantown, Pa., one block from its main plant.

INTERNATIONAL RECTIFIER CORP., a new firm equipped for research and manufacture in the field of colorimetric equipment, photoelectric cells, and selenium rectifiers, has opened a plant at 6809 Victoria Ave., Los Angeles, Calif.

Bodine Electric Company, Chicago, Ill., is now operating a new plant to build the type U motor, a split-phase motor for office machines, coin-operated phonographs, circulating pumps, and other devices requiring fractional-horsepower motor drive.



New Bodine plant for midget motors

Sperry Gyroscope Company Ltd., Brentwood, Middlesex, England has added 20,000 sq ft of floor space, bringing the total to 150,000 sq ft. A large proportion of this additional space will be devoted to a new research laboratory.

Jefferson Electric Co., Bellwood, Ill., transformer, ballast, and fuse manufacturers, have bought the Capacitron Co., Inc. of Chicago to enlarge and improve facilities for capacitor production.

PERSONNEL

Dorman D. Israel, after 12 years as vice-president in charge of engineering and production at Emerson Radio and Phonograph Corp., was elected executive vice-president of the corporation.

Larry S. Cole was appointed head of the department of radio and electronics at Utah State Agricultural College. He had taught at the college in that field since 1939.

Lee A. DuBridge, president of the California Institute of Technology, received from the Research Corporation of New York their annual award of $2,500 in recognition of his scientific contributions in the field of radar and his outstanding administration of the MIT Radiation Laboratory during the war.

Frederick R. Lack, a director of Western Electric Co. and vice-president in charge of the radio division, received the Presidential Certificate of Merit "for outstanding fidelity and meritorious conduct in aid of the war effort against the common enemies of the United States and its Allies in World War II."

GEORGE W. LITTLE, chief of research and electronic development at the Maico Co., Inc. of Minneapolis, manufacturers of audiometers and hearing aids, has been elected vice-president of the company.


G. W. Little


L. B. Blaylock

L. B. BLAYLOCK has been appointed director of the Radio Division of Federal Telephone and Radio Corp., Clifton, N. J. He retired from the Navy with the rank of Captain in 1941 after 27 years of extensive Navy communications and design assignments.

PAUL J. LARSEN, for the last five years a member of the technical staff of the Applied Physics Laboratory of Johns Hopkins University, during which time he was actively engaged in the development of the radio proximity fuze, has been granted a leave of absence to serve as associate director of the Los Alamos Scientific Laboratory in New Mexico.


P. J. Larsen


J. B. Dow

JENNINGS B. DOW, wartime Chief of the Electronics Section of the Bureau of Ships in Washington, D. C. was recently elected to the board of directors of Hazeltine Corp.

NEW BOOKS

Elements of Acoustical Engineering

By Harry F. Olson, *Acoustical Research Director, RCA Laboratories, Princeton, N. J. D. Van Nostrand Company, Inc., New York, N. Y.*, 1947, 539 *pages*, $7.50.

This second edition of one of the outstanding books in this field is a very timely addition to the work of the author. Many advances have been made in acoustical engineering in the past few years, and a knowledge of them is of importance to those working in the field.

In preparing new and revising existing material, the same principles were followed as in the first edition. The author has attempted to bring up to date and amplify each chapter. A considerable amount of material in the first edition is now obsolete, and the book could have been of more value if he had given a new treatment of the up-to-date status of the field.

Material included on film, disc, and magnetic recording borders on the field of applied theory. Probably, for this reason, it has been restricted in scope.

The author has included many new valuable subjects in the revision, such as a complete list of definitions on dynamical analogies, more comprehensive charts on response of open, back, enclosed as well as reflex ported cabinets, additional information on diaphragm suspensions and voice coils, acoustical resistances of such materials as silk cloth used in microphones and loudspeakers, and a more thorough study of noise as generated in a sound pickup system.

The Acoustical Reciprocity Theorem of Helmholtz and Rayleigh is discussed in connection with the calibration of microphones. Free field sound room measurement technique is outlined, along with data on the absorption coefficient frequency characteristic of a typical room. A much needed discussion on the measurements of the response of phonograph records by the optical method has been included. Essential information required for the measurement of flow resistances is given. Considerable amplification is made in the chapter on dispersion of sound. A brief treatment of

polycylindrical surfaces as used for sound reinforcing and broadcasting as well as recording studios is presented. An expansion of the chapter on speech, music, and hearing includes new data and a discussion on the frequency range preference for live speech and music and for reproduced speech and music.

Two new chapters, on underwater sound and on supersonics and ultrasonics, have been added. There is a wide variety of material covered in the general field of acoustical engineering and its allied subject. As such, this is an excellent reference particularly for the designers of microphones, loudspeakers, and underwater signaling devices as well as for those who are interested in dynamical analogies and the general problems of speech, music, and hearing,—JOHN K. HILLIARD, *Chief Engineer, Altec Lansing Corp., Hollywood, Calif.*

Elements of Radio Servicing

By WILLIAM MARCUS and ALEX LEVY. *McGraw-Hill Book Company, Inc., New York*, 1947, 475 *pages*, $3.60.

THIS book is a welcome and much needed addition to the literature dealing with radio in general and home receivers in particular. While many fine books have been written to explain radio theory, there are very few that give any information of a practical nature concerning trouble shooting and repair techniques. The authors of this book have bridged this gap in the literature by telling the reader exactly what to do, why, and when to do it.

It is assumed that the reader has already acquired an elementary knowledge of basic radio theory. And to present a maximum of useful information, the scope of the book has been purposely restricted to the most widely used receiver—the superheterodyne. A circuit, typical of modern receiver design, has been selected and the discussions of basic service procedures for each of the various sections (power supply, audio, i-f, etc.) are centered on this model receiver, one or more chapters being devoted to each section of the receiver.

The book opens with a discussion of service procedures and suitable test equipment, three chapters being devoted to signal generators as

the authors seem to prefer the signal substitution method of locating trouble. Then follows a thorough discussion which includes quick check procedures, normal test data, commonly encountered variations from the model circuit, information concerning the functioning of each part, and practical data concerning the procurement and installation of suitable replacement parts for each basic section of the model receiver. A summary and comprehensive list of questions designed to test the reader's grasp of the subject discussed closes each chapter.

There are certain basic procedures and circuits, however, that are conspicuous by their absence from this book. As an example, no attempt is made to explain how an ohmmeter or a voltmeter may be used to locate open, shorted, or grounded components in complex circuits. Neither is there any practical information on how to work without a circuit diagram, or how to use such a diagram to locate a given resistor, capacitor, or other component in the actual receiver chassis. Step-by-step procedures of this sort are invaluable to the beginner.

There is a definite need for more photographs. In the example given above, a photograph of the underside of a receiver chassis, together with its circuit diagram and a clear-cut explanation telling how to locate parts, would add greatly to the value of this book. Unfortunate also is the lack of any discussion of the voltage-doubler circuits commonly encountered in transformerless receivers, and the unexpectedly brief section on receiver alignment with no mention of a cathode-ray oscilloscope.

There are other points that make the book less than ideal but they are of too minor a nature to detract from the total value of the book. The authors are to be complimented for bringing professional servicing techniques into the prominence they deserve now that radio has come of age.—RAY SCHAAF, *National Radio Institute, Washington, D. C.*

In 1917, the Marconi Company experimented with spark transmitters on 60 to 70 mc and in 1920 a rotating radio beacon in Great Britain used a frequency of 50 mc.

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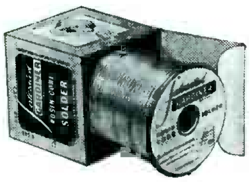

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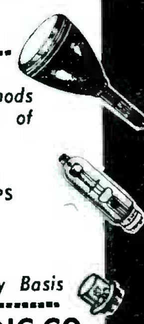

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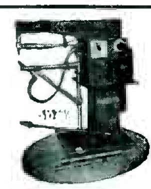

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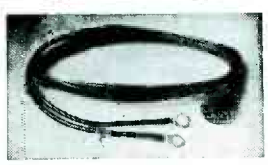

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SALARIED POSITIONS $3,500 and up. If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (38 years recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. For identity covered and present position protected. Particulars on request. R. W. Bixby Inc., 278 Dun Bldg., Buffalo 2, N. Y.

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Navy project for Guidance and Control of Missiles requires Senior Engineers for responsible positions in analysis, development and test of radar equipment, electro-mechanical servomechanisms, electronic timing and control circuits, and other associated equipment. Bachelor's Degree in Electrical Engineering or Physics required, with Master's Degree or equivalent study of Mathematics, Electronics and Applied Physics desirable. Salary to $7500.00 depending upon qualifications.

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Fairchild Engine and Airplane Corporation
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Wanted For Pilotless Aircraft, and Guided Missile Development

Must be graduate Engineers with design and development experience in one or more of the following: Miniature or Sub-Miniature circuits and assemblies, Sensing and End-Instruments, FM, AM, and Pulse Transmitters. Organizing & Supervising ability required. Employment on west coast.

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WANTED
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LOCATION: New York City.

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SENIOR—Fine opportunity with a large mid-western radio corporation. Must have a minimum of three years' experience in loud-speaker design and materials used in manufacturing. College education in electronics or equivalent. In replying state age, education, experience, and salary requirements.

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Capable of taking full charge electrolytic production and design. Chicago Company. Excellent salary.

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Transformers-Amplifiers-assembly.

Real bargain for quick sale.

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BRITISH MANUFACTURERS OFFER

Substantial and regular supplies in round and rectangular sections. Some additional capacity available for processed tubes but principally for plain tubes in lengths up to 40". Enquiries are invited from actual users who purchase for their own account.

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15 KW output with working frequencies up to 6000 Kilocycles. Unit used in research. Practically new. Full description on request.

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Substantial Quantities Nearly All Types Selsyn Motors 60 and 400 Cycle AC Control Motors and Inverters

Advise nameplate data, quantity and price. Samples must be approved before purchase.

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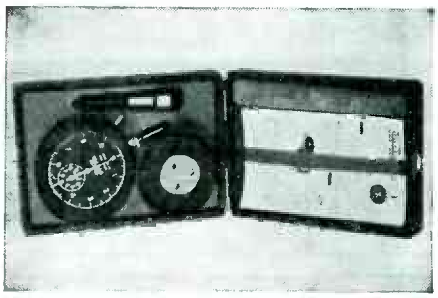
PORTABLE CHRONOMETRIC TACHOMETER

$24.50



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CAN BE USED FOR SPEEDS UP TO 20,000 R.P.M.

CAN BE USED FOR LINEAL SPEED MEASUREMENTS TO 10,000 F.P.M.

IDEALLY SUITED FOR TESTING THE SPEEDS OF MOTORS, PARTICULARLY OF FRACTIONAL HORSE POWER, GENERATORS, TURBINES, CENTRIFUGALS, FANS, ETC.

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GREATEST ACCURACY — Meets Navy Specifications — Guaranteed to be within ½ of 1%.

RESULTS OF TEST READING REMAIN ON DIAL UNTIL NEXT TEST IS TAKEN.

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1—LARGE POINTED RUBBER TIP
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1—6" CIRCUMFERENCE WHEEL TIP
1—OPERATING INSTRUCTIONS
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The combination of the above features will give accurately, within a few seconds, by direct reading, the R.P.M. of shafts or the lineal speeds of surfaces without any accessories or timing of any kind. Each unit comes complete in a red velvet lined carrying case 5" x 3½" x 1½". NET LIST PRICE $75.00—SURPLUS—NEW—GUARANTEED.

YOUR COST $24.50 FOB, NEW YORK

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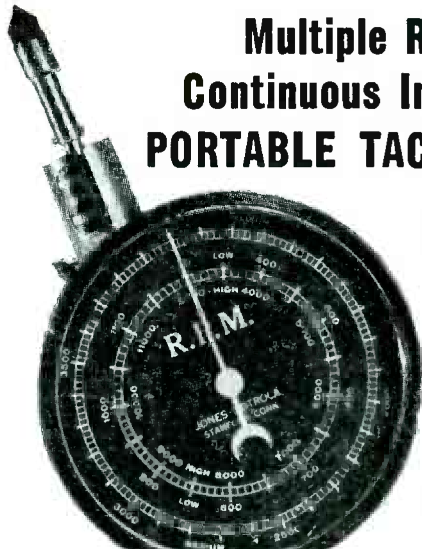
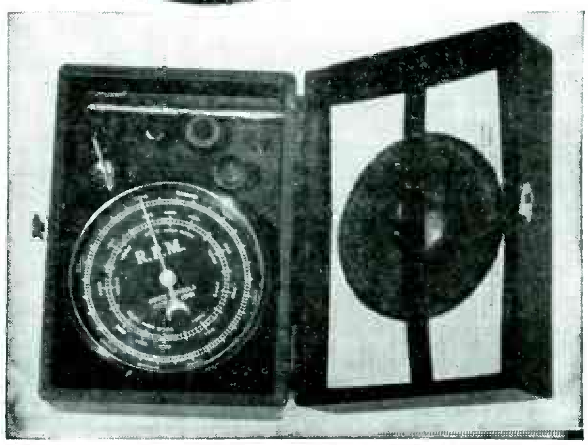
$24.50



2/3 Actual Size



This unit is of the centrifugal mechanical type and is designed to show instantaneously and continuously the speed or change in speed of any revolving shaft or surface. No stop watch or other mechanism required.

Three Ranges in R.P.M. and Three Ranges in F.P.M.

LOW RANGE 300- 1,200
(Each Division Equals 10 R.P.M.)
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RUGGEDLY CONSTRUCTED For Heavy Duty Service.

BALL BEARING AND OILLESS BEARINGS — Require No Lubrication Whatsoever.

READILY PORTABLE — Fits Neatly Into Palm of Hand.

GEAR SHIFT FOR SELECTING LOW, Medium and High Ranges.

GREATEST ACCURACY — Meets Navy Specifications 18-T-22, Type B, Class A.

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1—STEEL TIP
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1—EXTENSION ROD
1—SMALL SIZE CONVEX RUBBER TIP, Metal Mounted
1—OPERATING INSTRUCTIONS

MADE BY JONES MOTROLA, STAMFORD, CONNECTICUT. Comes Complete in Blue Velvet Lined Carrying Case: 7⅛" L x 4" H x 5" W. LIST PRICE $75.00—SURPLUS—NEW—GUARANTEED.

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SPECIAL $15.95

Immediate Delivery

Blows 200 CFM; 110 Volt AC, 60 Cycles; overall length 10¾"; overall width 6¾"; each blower opening 2" in diameter; intake opening 2⅝" in diameter. Unit has DELCO sealed in motor requiring no lubrication—built-in mounting brackets; ideal unit for cooling large tubes or exhaust for laboratory use—also perfect for Photo Darkroom application.

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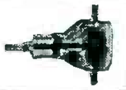
Blower 6 v. AC or DC hi speed blower made by John Oster. Rated at 5000 RPM—1.8 AMP—made for continuous duty—1½" overall diameter—1" blower output—1¼" blower intake **$5.95**

Sperti RF Vacuum switch used as antenna switch in the ART 13—9200 v. peak 8 amps... **$1.95**



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Perfect for bias application—Use your DC relays from an AC source. Only requires 3" x ½" mounting space Rectifier for input up to 300 V at 40 ma output.

$.89 or 5 for $4.00

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Synchronous Type

Pair in Series for 110 v. AC.

Type I—5¼" long, 3" dia.—50 v. AC. 50 cy.—4 lbs.....................$ 9.95 pr

Type II—6¼" long, 4¼" dia.—115 v. AC. 50 cy. 11 oz...................12.95 pr

SYNCHRO—DIFFERENTIAL

Model #1943 — C78249-CAL-11280 Bendix Aviation 115 v.—60 cy. 6" length to end of shaft x 4¼" diameter ....$ 9.95

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FOR ALL APPLICATIONS

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0-18 V.A.C.	0-14 V.D.C.	10 AMP	7.95
0-18 V.A.C.	0-14 V.D.C.	15 AMP	10.95
0-18 V.A.C.	0-14 V.D.C.	20 AMP	13.95
0-18 V.A.C.	0-14 V.D.C.	25 AMP	16.95
0-18 V.A.C.	0-14 V.D.C.	30 AMP	19.95

Input *From	Output From	Current	Price
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0-36 V.A.C.	0-28 V.D.C.	5 AMP	7.95
0-36 V.A.C.	0-28 V.D.C.	10 AMP	13.95
0-36 V.A.C.	0-28 V.D.C.	15 AMP	19.95
0-36 V.A.C.	0-28 V.D.C.	20 AMP	25.95
0-120 V.A.C.	0-100 V.D.C.	2 AMP	14.95
0-120 V.A.C.	0-100 V.D.C.	5 AMP	19.95

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0-18 V.A.C.	0-7 V.D.C.	10 AMP	4.95
0-18 V.A.C.	0-7 V.D.C.	15 AMP	6.95
0-18 V.A.C.	0-7 V.D.C.	20 AMP	8.95
0-18 V.A.C.	0-7 V.D.C.	25 AMP	10.95

Input From	Output From	Current	Price
0-36 V.A.C.	0-14 V.D.C.	3 AMP	$2.95
0-36 V.A.C.	0-14 V.D.C.	5 AMP	4.95
0-36 V.A.C.	0-14 V.D.C.	10 AMP	7.95
0-36 V.A.C.	0-14 V.D.C.	15 AMP	10.95
0-36 V.A.C.	0-14 V.D.C.	20 AMP	13.95
0-36 V.A.C.	0-14 V.D.C.	25 AMP	16.95

* USE with capacitor to obtain any voltage up to twice rated output.

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TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
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1A7GT	1.10	6SN7GT	.69	394A	4.50
1B24	4.50	6SQ7	.89	417A	19.95
1G4	.98	6SR7	.89	446A	2.60
1G6	.98	6SS7	.75	703A	7.50
1H4G	.98	6U5	.98	705A	4.95
1L4	1.10	6V6GT	.99	713A	1.65
1R4/1294	1.29	6Y6G	.89	715B	4.95
1T4	1.10	6X4	.98	717A	.75
1H5	.99	6X5	.89	723A/B	9.95
1N5GT	1.10	7AE7	.75	800	2.25
1LN5	1.92	7C4	1.50	801A	.75
1R5	1.10	7C5	.89	802/RK25	1.40
1S5	1.10	7F7	1.25	803	8.95
2A3	1.39	7L7GT	1.39	805	3.75
2C22	.98	10Y	1.50	807	1.25
2C26A	.59	12A6	.89	808	2.95
2C34	1.15	12AH7	1.10	809	1.50
2C40	2.60	12AT6	1.10	810	5.95
2C44	1.75	12BA6	.89	811	1.95
2D21	.75	12BE6	.89	812	3.25
2E22	1.50	12C8	.89	812H	6.90
2E25	3.95	12J5	.69	813	8.95
2E30	2.25	12K8	1.25	814	4.49
2J32	20.00	12SA7GT	.99	815	2.25
2J33	20.00	12SG7	.89	826	1.75
2JB51	4.95	12SH7	.89	829B	3.95
2X2	.84	12SJ7	.79	830B	5.25
3A4	.49	12SK7	.89	832A	2.25
3B7	.98	12SL7	1.10	833A	34.50
3B22	4.95	12SN7GT	.79	836	1.15
3B24	1.95	12SQ7GT	.99	837	2.50
3D6/1299	.89	12SR7	.79	838	3.75
3E29	2.95	12X3	.98	841	1.20
3Q4	1.10	14A7	1.10	845	3.75
3Q5GT	1.10	14B7	1.10	860	3.00
3S4	1.10	14H7	1.25	861	50.00
4C35	7.95	14J7	1.25	866A	.75
5R4GY	1.15	14R7	1.10	872A	2.25
5T4	1.25	15E	1.50	874	1.95
5U4	.98	23D4	.49	884	.75
5V4G	.98	23D6	.98	923	.49
5W4	.98	24G	1.35	954	.75
5Y3	.60	25A6GT	.75	955	.75
5Y4G	.59	25L6GT	.75	956	.75
5Z3	.89	25Z5	.75	957	.75
5Z4	.89	25Z6	.98	958A	.75
6AB7/1853	.99	28D7	.75	959	.75
6AC7	.99	30	.78	991	.50
6AG5	.99	32L7	1.50	1005	.39
6AG7	.99	34	.98	1006	.39
6AK5	.99	35L6GT	.75	1613	.95
6AL5	.99	35Y4	1.10	1614	1.75
6AQ5	.98	35W4	.69	1616	2.95
6AT6	.75	35Z3	.99	1619	.98
6AU6	.89	35Z5	.69	1624	.98
6B4	1.29	36	1.10	1625	.98
6B6G	.89	37	.69	1851	1.25
6B8	.99	38	.89	2050	.90
6C4	.64	39/44	.59	2051	.90
6C5	.81	41	.69	5514	3.95
6C6	.75	45	.64	7193	.49
6C21	12.95	46	.65	8005	3.25
6D6	.75	47	.90	8011	4.95
6F4	1.35	50B5	1.89	8012	4.95
6F5	.51	50L6GT	.75	8016	1.49
6F6	.95	70L7	.89	8020	5.95
6F6G	.80	71A	.69	9001	1.15
6F7	1.25	75	.69	9002	.98
6F8	1.10	75T	2.95	9003	.98
6G6	1.10	76	.75	9004	.98
6H6	.69	77	.75	9005	.98
6J4	1.50	78	.75	9006	.69
6J5	.59	79	1.10	HF100	6.95
6J6	.89	80	.53	HY75	1.25
6J7	.89	82	.98	HY615	1.25
6K6	.69	83V	.98	OZ4	1.25
6K7	.79	84	.75	RK60	1.25
6K8	1.25	85	.89	RK72	3.50
6L6	1.25	100TS	3.00	T20	1.95
6L6G	1.20	117L7	1.89	TZ40	2.95
6L7	.98	117Z3	.89	V70D	6.90
6N7	1.25	117Z6GT	1.10	VR78	.75
6Q5	.98	121A	2.65	VR90	.75
6Q5G	.98	205B	4.50	VR105	.75
6Q7	.89	211	1.25	VR150	.75
6R7	.98	215A	3.00	Z225	1.95
6SA7	.90	217C	7.50	902	2.95
6SC7	.85	250R	3.95	2AP1	2.25
6SF5	.79	250TH	12.95	3AP1	3.45
6SG7	.89	274B	1.50	3BP1	2.95
6SH7	.65	304TH	9.85	5CP1	3.95
6SJ7GT	.69	304TL	3.75	5FP7	4.50
6SK7	.79	307A	6.25	7BP7	7.95
		371A	3.00	7BP4	14.95

NO MAIL ORDERS FOR LESS THAN $5.00

AMPHENOL COAX CONNECTORS

83-1SPN $0.45
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UG-12/U .... .50
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83-1AP .... .79
UG-28-U 1.49
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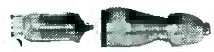
AMERTRAN VOLTAGE REGULATOR

(TRANSTAT)

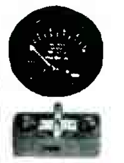
17.4 amps. maximum output 2 KVA single phase 115 v. 50 to 60 cy. 90 to 130 v. shipping weight 20 lbs.—a marvelous buy—First come first served **$24.95**

MINIATURE TUBE PULLER



Niagara solves your miniature tube breakage problem with this new sensational invention. Tubes may now be easily extracted or placed into those hard-to-reach places, without the fear of breakage or burning of hands. This new invention incorporates a heat resistant rubber cap with aluminum body and handy thumb-operated plunger release. Be sure to get yours today. Money back guarantee. **Only 88c**

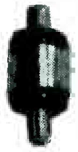
METER SPECIAL



Here is a natural for reading ant. current, neutralizing your final, checking your beam, or wherever a good R.F. Thermocouple Meter is needed—full scale —.750 ma. Complete with thermocouple General Electric type DW-52—2" round.

A steal at.......... **$2.98**

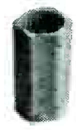
PLUG-IN VACUUM CAPACITOR



50 mmf, designed to work with voltages up to 5000 volts. Will handle 5 amps. made by General Electric—don't change the final when switching bands just plug in condenser—size 1¾ x 1½.................. **$2.98**

55 mmf with 20,000 V. peak **$4.95**

COIL FORM



Made of very high grade ceramic—grooved for easy winding, can be used for a multitude of purposes—size 2½ long x 1-5/16 wide

.29 ea. or 2 for .50

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KR-4—Allied—115 v. AC—DPDT—B.O. type.$2.50

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KR-12—Struther Dunn—115 v. AC—2 relays on one mount SPDT & EPST 10 A. cont.... 3.95

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KR-26—G.E. Instantaneous over current relay—Type PBC 3 amps at 115 v...............24.95

G. E. INTERLOCK SWITCH

Hi-voltage is lethal—protect yourself and family—this switch automatically shuts off Hi-volt. circuits while adjustments are being made—low pressure—hi current capacity positive action. Silver plated contacts. Pr.... **$1.00**

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We can supply power xtals of any frequency ground to .02 tolerance in any type of holder for any surplus or standard transmitters or test equipment as well as any receiver IF frequency. Prices on request—write to our engineering department.

ROTARY SWITCH—3 deck 9 position non-shortening ceramic wafers. Each.. **$1.25**

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MM 4-0-100MA Model 301 Weston 3½"....$3.95
MM 10-0-1 amp DC-Model 301 Weston 3½". 3.95
MM 14-0-150 MA NX 35 Westinghouse 3½". 3.95
MM 19-0-800MA Weston Model 301MA..... 3.35
MM 33-0-1MA-MD-300 I K-McClintock 3½". 3.95
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MV 8-0-4 K.V. DC—Roller Smith 3½"..... 2.95

All Prices f.o.b. N. Y. C.

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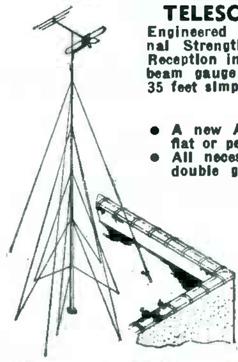
CREDIT EXTENDED TO RATED ACCT'S.

FOR THE FINEST IN TELEVISION SEE NIAGARA FIRST



TELESCOPING ANTENNA MAST

Engineered for Television and FM. Increases Signal Strength. Reduces Interference & Improves Reception in Remote Areas. This unit is made of beam gauge steel and Telescopes from 6 feet to 35 feet simply and easily.

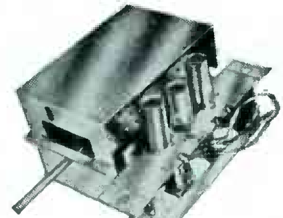
Features

- A new ALL ANGLE foot bracket for use on flat or peaked roof to 90 degrees.
- All necessary parts such as screw eyes, bolts, double galvanized guy wires (360 ft.) cut to length.
- New NUT-LOCK guy wire clamps (vibration proof).
- GRIP-TITE tube clamp, eye bolts serving a TWO-FOLD purpose interlocking tube section that are overlapped 6 inches for rigidity and an ideal staggered method for attaching guy wires to mast.
- All Parts Protected From Weather.

Priced at only $32.25

ALL CHANNEL R. F. UNIT

FOR USE IN BUILDING YOUR OWN CUSTOM-MADE TELEVISION RECEIVER—ANY SIZE or TYPE



This all-channel R.F. unit is factory pre-wired and tuned for 7 channels* (covers all channels in lower and higher bands in any single area operating presently or in the future). Average sensitivity 20 microvolts; has R.F. stage before oscillator: complete with 3 tubes; 1—6AK5, 1—6AK6, 1—6C4; input impedance 300 ohms, balanced to ground. Size 9½" deep, 4½" high, 6⅜" wide.

NOTE: No single area is scheduled for more than 7 channels. However, 6 more channels can be added to this unit, if desired, at nominal factory cost. It is not expected that these additional 6 channels will be required for several years **$31.95**

YOUR TELEVISION HEADQUARTERS

TRANSVISION TELEVISION KITS

15" Kit—Complete with FM Radio, all tubes, antenna, etc.	$372.95
12" Kit—Complete with all tubes —a real honey	$289.50
7" Kit—Thousands of satisfied users	$159.50

RAY-ELECTRON COIL KIT

INCLUDES:
1 Oscillator Tank Coil, 1 Antenna Coil, 6 RF Tuning Coils, all mounted on Switch Assembly Plate; 5 Video IF Coils, Shielded, Permeability Tuned; 1 Shielded Discriminator Coil; 3 Video Peaking Coils, and Instruction Manual containing Circuit Diagram for 20 Tube Seven Inch Picture Tube Set, together with detailed Assembly Instructions, and Parts list.

The design of these Coils makes it possible to obtain satisfactory operation within the ENTIRE service range of ANY Television Station. Complete.... **$23.50**

NIAGARA COMPONENTS CONDENSERS

CF 45 1 mfd—3500 volt DC..............	$ 1.98
CF 48—.05 mfd—2500 volt DC............	1.09
CB 18—.25 mfd—4000 volt DC............	2.95
ER25AD—dual 25 mmf per sect. variable condenser	2.04

SOCKETS

11 prong Isolant scope socket.................	$ 0.39
Octal socket	.12

TRANSFORMERS

TS.6—Scope transformer—2500 v. @ .4 a., 2.5 v. @ 1.75 a., 6.3 v. @ .6 a..........	$ 9.95
TS.5—Western Electric—D303184—hi. volt 4200 v. @ 9 ma lo. volt. 640 v. @ 200 ma—fil. 6.4 v. @ 5 a., 5.4 v. @ 3 a., 5.1 v. @ 3 a., 2.5 v. @ 1.75 a.—complete television hi. & lo. volt. trans. in one compact oil filled unit—will handle any television tube	12.95
TCH 2—Scope transformer 1750 v. @ 4 ma and matching fil. trans. 6.3 v. @ .8 a., 2.5 v. @ 1.75 a..........................	7.95
HF 16—Filter choke 10 hy @ 150 ma......	1.95
LC 2—25 ma R.F. choke.................	.59

MISCELLANEOUS

Pots—all sizes less switch................	$0.69
Pots—all sizes with switch................	1.09
Trimmers—single 3—30 mmf	.20
dual 5—50 mmf	.35
High voltage wire—50 ft. roll..............	1.00
Peaking coil	.45

Complete Line of Television Components in Stock

Write for Free Listing

5TP4 PROJECTION TUBE

Perfectly operating condition but with very slight imperfection. Ideal for engineers, experimenters, inventors, or school instructors. Regular price of these tubes is $65.00—
Special Bargain **$20.00**

POWER! POWER! POWER!

Hi & Low Voltage Rectifier Power Supply Model C F T—20169 formerly used with the DAQ Direction Finder. This power supply contains 2500 v. at 3 mils—325 v. at 100 mils. Also contains a sweep amplifier, voltage regulated. 110V 60 Cy Primary. Power Supply can be used to power a television receiver or perfect power supply for an Oscilloscope, or General Lab. use. Unit is mounted in a cabinet with all controls including pilot lights & switches on front panel. Wt. approx. 40 pounds—

LIMITED QUANTITY $29.95

CATHODE RAY

5BP1	3.95	9AP4	50.00
5BP4	4.95	10BP4	29.95
7EP4	18.95	10FP4	42.20
7DP4 (RCA Replacement)	21.60	12AP4	60.00
5TP4 Projection	54.00	15AP4	110.00
7GP4	19.40	20AP4	270.00

SCOOP! ANOTHER NIAGARA FIRST

McMurdo Silver Co., Model 909 FM and Television Sweep Signal Generator with a frequency range of 2 mc. thru 226 mcs. with true electronic FM sweep variable from 40 kc. to 9 mc.

Power required is 105/125 v., 50/60 cycles a.c. at 35 watts. With this new unit one can visually align FM and TV receivers quickly and perfectly with simple but complete instructions supplied for FM and TV servicing.

Priced at Only $48.50

NEW TELEVISION COIL KIT

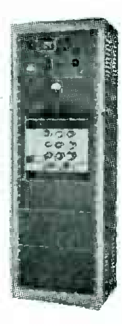
This Coil Kit obtains a four megacycle band width for the picture circuit from 22 to 26 Mc. The coils for the audio section are designed to secure high fidelity F.M. sound at 21.25 Mc. All transformers are permeability tuned for high gain and utmost stability.

Coils included in Kit: 1 Antenna Coil—Channels 1 to 6, 1 Oscillator Coil Channels 1 to 6, 1 Converter Transformer, 4 Video IF Transformers with traps for sound and adjacent channel, 1 Sound IF Transformer, 1 Sound Discriminator, 1 180 uh Peaking Coil, 1 120 uh Peaking Coil, 1 36 uh Peaking Coil.

Complete $8.95

MASTER OSCILLATOR MI-19427-B

This unit was built for R.C.A. Add a final—becomes a complete transmitter with signal shifter. Perfect for Television sweep circuits for field or station use or wherever 300 v. must be maintained under varying load conditions—
COMPLETE (less tubes).................................... **$225.00**



TECHNICAL SUMMARY

ELECTRICAL CHARACTERISTICS

Output Frequency	2 to 20 megacycles
Output Level, Buffer-Amplifier	Sufficient to drive an RCA-807
Modulation Frequency	650 cycles ± 150 cycles
Frequency Deviation (maximum)	± 500 cycles
Power Consumption	200 watts
Power Supply	115 230 volts, 50/60 cycles
Oscillator Filament Current	0.05 ampere d-c
Amplifier and Tone Generator Filament Voltage	6.3 volts a-c

TUBE COMPLEMENT

Electron-Coupled Oscillator	2 RCA-3Q5-GT
Buffer-Amplifier	1 RCA-807
Tone Generator	1 RCA-6AB7, 1 RCA-6F6
Regulated Power Supply	2 RCA-5U4-G, 5 RCA-6Y6-G; 1 RCA-1852, 2 RCA-VR-150 30

MECHANICAL SPECIFICATIONS

Dimensions	Height, 66 9/10 in.; Width, 22 in.; Depth, 17⅛ in.
Weight	275 pounds

TYPICAL PERFORMANCE DATA

	Frequency Change
Line voltage change, ± 10 per cent	0.0005 per cent
Temperature change, per degree Fahrenheit	0.0007 per cent
Relative humidity change of 1 per cent over the range of 30 to 95 at a dry bulb temperature of 110 degrees F.	0.0003 per cent

Drift from cold start, first reading taken within 1 minute after applying power:
Frequency deviation at the end of the first hour a negative drift of 100-400 cycles (measured at 7 mc)

All Prices f.o.b. N. Y. C.

NIAGARA RADIO SUPPLY CORP.

160 GREENWICH STREET, NEW YORK 6, N. Y.

CREDIT EXTENDED TO RATED ACCT'S

RELAYS

Clare SPST normally open miniature type #A-20545 45 ohms, 6 Volts D.C. .... $.95

Clare #A-30262 D.P.D.T. 3300 ohms, 20,900 Turns .... .95

RBM Telephone Type #556-881 D.P.D.T. 14,000 ohms Double contacts .... .95

RBM Telephone Type #556-882 D.P.D.T. plus SPST normally open. Dual windings—180 ohms each winding. Double contacts. .95

RBM Telephone Type #556-883 4 Pole S.T. normally open. Dual windings 180 ohms each winding. Double contacts .... .95

RBM Telephone Type #556-884 D.P.S.T.—one open, one closed. Dual windings. 180 ohms each winding. Double contacts ..... .95

G.E. 2 circuit; coil 10 volts DC contacts 50/20 amps 115 vlots AC .... .85

Oak Rotary type 8-28 volts DC 3 single break, 3 make—1 break and make .... .85

G.E. #D106F3, coil 180 ohm, 24 volts DC Double Pole, Double throw .... .65

Allied #B012D 180 ohm coil, 20 volts DC 4 Pole double Throw.. .65

Allied #73B60, miniature type 26 volts Double Pole, Double throw, isolantite spacer ......

Clare #814680—Miniature, 300 ohms, 24 volts DC Four Pole—two throws .... .95

Leach #1054, coil 260 ohms, 24 volts DC Heavy contacts, two pole single throw + Holding contact .... .95

RCA Vacuum Relay, Relay contacts will break 3000 volts and carry 10 amperes Solenoid resistance 200 ohms, 24 volts DC —Excellent as R.F. antenna relay .... .95

Clare #818062—2 Pole single throw. Miniature type. Resistance 140 ohms. Will operate from 10 volts DC or 20 Volts AC .95

TIME DELAY RELAY

Thermal vacuum type
S. P. S. T. 100 ohm coil
24 Volts AC/DC
90 second delay .... .95

Nationally Advertised Precision Resistors

Tolerance 1% or better—$.35 each

WW—1

Resistance

4500 ohms, 8000 ", 95000 ", 20520 ohms, 26500 ", 40000 ", 41808 ", 46000 ", 54500 ", 66000 ", 92000 ", 109000 ", 120000 "

WW—3

4.4 ohms, 4.35 ", 13.52 ", 20 ", 30 ", 70 ", 105.8 ", 125 ", 130 ", 147.5 ", 220.4 ", 366.6 ", 414.3 ", 750 ", 1000 ", 2200 ", 2230 ", 2500 ", 4000 ", 5000 ", 7500 ", 10000 ", 14460 ", 15000 ", 17000 ", 17300 ", 20000 "

WW—4

1.123 ohms, 1.563 ", 4.3 ", 5.1 ", 12.0 ", 13.333 ", 14 ", 20 ", 22 ", 23.29 ", 33.22 ", 53.32 ", 53.96 ", 208 ", 988 ", 1200 ", 4000 ", 11000 ", 20000 ", 30000 ", 82000 ", 400000 ", 600000 "

WW—5

1500 ohms, 4000 ", 100000 ", 125000 ", 268000 ", 700000 ", 750000 ", 800000 ", 1 megohm

WW—7

100

WW—13

100, 40000

Nationally Advertised Precision Resistors

Tolerance 3% or better—$.25

WW—3

235, 4000, 4300, 12000, 33000, 6.0, 10.0, 10.2, 4000, 84000, 250000, 290000

WW—4

1.0, 3.94

WW—5

84000, 220000

Nationally Advertised Precision Resistors

Tolerance 5% or better—$.19

WW—3

30, 35, 40, 50, 70, 100, 110, 2500

WW—4

250000

WW—13

15000, 22000, 100000, 110000

TUBES

BRAND NEW

surplus priced for quick sale.

RK60	$1.95
23D4	.35
VR78	.45
HY114B	.45
394A	2.95
705A	1.95
954	.45
957	.45
1629	.25
9002	.40
9003	.35
9006	.45
3B24	.50
3B25	.55
RK72	1.95

TUBES

BRAND NEW

surplus priced for quick sale.

RK73	$.45
ELC5B	.95
1632	.45
33	.45
46	.55
30	.45
VR90	.45
724B	.19
12SN7	.45
12K8	.45
6X5	.45
1626	.45
VR65	.45
7193	.45

EDLIE ELECTRONIC INC.

135 LIBERTY ST. *BArclay-7-4763* NEW YORK 6, N. Y.

SURPLUS BARGAINS!

TRANSTATS—3 K. V. A.

Type RH Input: 115 V 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-36 Volts at 30 Amps. No Knob.

A Real Buy at $18.00

(same type, but .25 KVA. Input: 103-126 V. Output: 115 V.-2.17 A.)

Price $6.50

STEPDOWN TRANSFORMER

Made by General Electric. Heavy duty stepdown transformer, with considerable overdesign. Ideal for rectifier applications, low voltage heating, general laboratory use, etc. Open frame type.

Input: 115 Volts—60 Cycles
Output: 15 Volts (at full load)
Capacity: 180 V.A.
Size: 3½" x 3½" x 4".

Your Cost $3.75

Quantity prices available

HEAVY DUTY STEPDOWN TRANSFORMERS

Input: 115 V. (with 8 taps in primary).
Output: from 16 to 10.5 V. (in 8 steps).
Capacity: 1.25 KVA—Sec. Amps: 100.
Size: 13"x10"x5". Approx. Weight: 30 Lbs.
Open Frame Construction.

Your Cost $12.50
10 for $100.00

PORTABLE A.C. AMMETER
WESTON #528

Double range ammeter. 0—3 Amps and 0—15 Amps. Two of the very useful ranges for your Lab. or shop. Complete in genuine leather case with test leads.

Your Price $12.25

SELENIUM RECTIFIERS
Full Wave Bridge
Approximate Rating

Federal Type #	Input Max.	Output Max.	Amps.	Price
10B1CV1	18 V.	14 V.	.5	$ .98
10B2CV1	36 V.	28 V.	.5	1.50
4B3CV2	48 V.	36 V.	.5	2.75
5B2AV1	36 V.	28 V.	1.6	4.25
5B2AV5	36 V.	28 V.	8	11.75
11BA6AM1	120 V.	100 V.	1.6	11.95
9DO612R	150 V.	115 V.	1.6	14.50

G. E. PYRANOL CAPACITORS

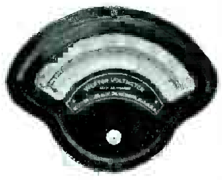
Cap. Mfd.	Volts D.C.	Height Weight Length	Price
10	1000	5-7/8 x 1-3/4 x 3-7/8"	$1.85
4	1000	5-7/8 x 2-3/4 x 1-1/4"	.85
1	1000	3-5/7 x 2 x 1-1/16"	.50
1	500	2" x 1-1/4" x 1-1/16"	.25
.25	1000	1-1/2 x 1" x 3/4"	.25

G.E. H. V. PYRANOL CAPACITORS

.001 Mfd.—50 K.V. DC.—5⅛"x7¾"x4" $12.50
Insulators 4" Dia. x 7" High.
.1 Mfd—25 K.V. DC.—13"x7"x4" $9.85

All meters are white scale flush bakelite case unless otherwise specified.

WESTON MODEL 271
Large Fan Shaped Microammeter



Another of the famous Weston fan shaped line. Very large scale 5.8" long. These meters were made by Weston to General Radio specifications, with special mirrored scale and knife edge pointer. Accuracy 1%.

0—600 Microamps
170 M.V.
Coil Res: 250 Ohms

Your Price $12.50
10 for $100.00

D. C. MICROAMPS

0-100 Microamps, res. 100 Ohms
3" Rd. Westinghouse NX/35
$7.95

0-150 Microamps—2" rd. G.E.—DW51 or Whse NX33. Res: 500 Ohms.
Your Cost $3.75

RECTIFIER TUBES

6 Amp. (Tungar type) for battery chargers, rectifiers, etc.

Your Cost $1.50
(minimum order of 10 tubes)

D.C. AMPS & MILLS

0-1 Ma 2" G.E. DW41 (special scale)	$2.95
0-1 Ma 2" Weston 506	3.75
0-2 Ma 2" Sun 1AP525-5	2.25
0-2 Ma 3" Weston 301	4.95
0-3 Ma 2" Weston 506 with metal case	1.85
0-5 Ma 2" Dejur S-210	1.95
0-25 Ma 2" G.E. DW41	2.95
0-30 Ma 2" G.E. DW41	2.95
0-100 Ma 2" sq. Simpson 127	2.95
0-100 Ma 3" Weston 301	4.95
0-500 Ma 2" G.E. DB41	3.25
0-1 Ma 3" sq. Westhe RX-35 (Scale: 1.5 KV)	4.25
0-1 Ma G.E. DO-41-Black Scale 3" (Scale: 3 KV)	3.85
0-1 Ma G.E. DO53-3"	4.75
0-15 Ma 3" Westhse NX-35 (scale: 15/150/300)	2.95
0-30 Ma 3" Weston 301 (Metal)	3.75
0-1 A. 3" sq. Weston 301	5.50
0-10 A. 3" sq. Triplett	2.50
0-10 A. 3" Simpson #25	4.50
30-0-30 A. 3" Simpson 25	4.50
0-30/120/600 Ma Weston Portable-Model 280—Precision Type	5.95
0-300 A. 3" Roller-Smith (fl. bake. Type TD-50 MV) (with ext. shunt)	4.95
0-300 A. same as above (without shunt)	2.25
0-300 A. 4" Weston #643 (fl. metal—black scale—ext. Shunt)	8.50
0-300 A. 4" same as above (without shunt)	5.50

D.C. VOLTS

0-15 V. 2" Westhse BX-33 (Black scale)	2.75
0-15 V. 2" Simpson #125	2.95
0-20 V. 2" Weston 506 (1000 Ohms per Volt)	2.95
0-15 V. 3" Westhse. NX-35	3.95
0-40 V. 2" Weston 506	2.95
0-150 V. Weston 301 (Black scale-metal case)	4.50
0-150 V. 3" G.E. DO-41	4.75
0-150 V. 4" Weston 643 (Black scale—flush—metal)	6.75

A.C. VOLTS

0-10 V. 2" G.E. AW-42	$2.95
0-10 V. 3" G.E. AO-41	3.75
0-150 V. 2" Simpson 155 (metal case)	2.95
0-150 3" G.E. AO-41	4.50
0-150 V. 3" Simpson 55	5.95
0-75 V. 4" Weston 642 (Surface Metal Case)	6.75
0-300 V. 4" sq. Triplett (431A 300/600 V. scale)	3.25

TOTAL HOUR METER

Westinghouse elapsed time meter. Type RH-35; 120 Volts, 60 Cycles. Six counter units, the sixth counter indicates 1/10th hour steps.

Your Cost . . $4.95

HEAVY DUTY RHEOSTAT
WARD LEONARD

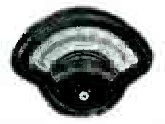
10 ohms — 9.2 Amps —9.2 Amps (Not tapered). 14" Dia. Complete with handle and legs for rear of panel mounting.

Your Cost . $5.95

A.C. VOLT-AMMETER SET

Westinghouse RA-37—4" Sq. 0-300 Volts AC Scale: 300/600 Volts A.C.
With Potential Transformer for 600 Volt Range **$10.00**
Westinghouse RA-37—4" Sq. 0-5 Amps AC. Scale: 75/150 Amps A.C.
With Donut Current Transformer for Double Range 75/150 to 5 . . . . **$10.00**
Price, for ALL 4 PIECES **$17.50**

WESTON MODEL 269 FAN SHAPED METER



One of the Weston popular fan shaped line. Exceptionally long scale for size of instrument. Accuracy — within 1%. Scale length—4". Spade pointer. Here is a good movement for special purpose instruments. Comes with blank scale with arc drawn in. Ready for plotting calibration points. Can be used to make up any range of volts, amps, MA., etc. Full scale deflection—5 M.A.—40 M.V.

List $29.83
Your Cost $8.95
10 for $75.00

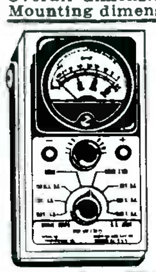
H. V. Plate & Fil. TRANSFORMER

Westghse Encased Oil Filled
Plate: Pri-108-122V, 60 Cy. Sec—15 KV @ .020 A, 18 KV @ .015 A. Fil: Pri—105/115/125 Sec—2.5 V @ 5 A Overall Dimen: 13½"W x 14¼"L x 7" D. Weight: Approx 50 lbs.
Price **$22.50**

POWER TRANSFORMER

Pri—440/220 V 60 Cy Sec—125/115/105 V Rating .8 KVA RCA Open construction, Bracket mounted, pri & sec terminal boards. Overall dimensions: 5¾"H x 7½"W x 8" D. Mounting dimensions: 6⅞"x5⅞". Price **$12.50**

VOLT—OHM—MILLIAMMETER



Made by Triumph Mfg. Co. to Signal Corps Specs—Test Set 1-77-H.

Ranges:
Volts DC—0-30/300/1500
Volts AC—0-15/150
Ohms—0-1000
0-300,000
M.A., DC—0-150

Equipped with snap-on carrying handle—size 5¼"x 3½"x2⅝". Your Price **$8.50**

A.C. AMPS

0-1.5 A. 2" Weston 507 (RF)	$3.50
0-2 A. 3" Westhse RT-35 (RF)	3.95
0-3 A 3" Westhse NA-35 (scale: 120 A.)	3.95
0-30 A. 3" Triplett (metal)	2.95
0-5 A. 4" Weston 642 (surf.) (surface-metal)	7.95
0-5 A. 4" sq. Triplett 431A (scale: 150/300)	2.95

All meters are white scale flush brakelite case unless otherwise specified.

POWERTRON Electrical Equipment Co.

119 LAFAYETTE STREET ***Phone:*** **WOrth 4-8610** **NEW YORK 13, N. Y.**

"TAB" That's A Buy

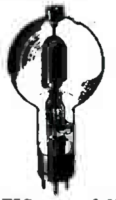
• NEW GUARANTEED ELECTRONIC PARTS •

CHOKES

15-29hy/150ma Swinging Cased........... $2.95
12hy/30ma$2.95; 12hy/500ma/95ohm..... 9.95
15hy/400 ma or 20hy/300ma/15KVins.... 7.95
3hy/40ma/3for$1; 0.5hy/100ma ......4for .98
3hy/400ma/15KV $2.75; 8hy/200ma...2for 2.89
8hy/150ma new UTC Cracked Bklte T'Bd...... .89

HEINEMAN CIRCUIT BREAKERS

10ma, 2, 3, 10, 15, 20, 30, 35, 40 & 50, 80, 100AMP NEW EACH............ 1.25
DUAL 10Amp $2.95; KLIXON 60Amp..... .89
SQUARE D 25Amp BKR&TOGGLE SW..... .69
VIBROPLEX KEY NEW................ 5.75
WIRE AN insltd #10Std flexible 1000ft... 12.95
WIRE AN insltd #18Std flexible 1000ft..... 4.50
WIRE 3Cond Tel or Mike flexible 100ft..... 1.95
BENDIX GYROSERVO UNIT NEW........ 2.95
FOXBORO GRAPHIC RECORDER 115V/60cys 39.95



		12A6	.29	1622/6L6M	1.24
		12AH7 ...	1.00	1624	.69
		12K8 ...	.84	1625	.15
		12SA7 ...	.58	1635	.98
		12SG7 ...	.82	1641	.89
		12SH7 ...	.87	2050	.89
		12SK7 ...	.79	2051	.88
		12SL7 ...	.98	8005	3.15
		12SN7 ...	.75	8012	1.95
		12SR7 ...	.75	8013	2.00
		12SQ7 ...	.75	8020	3.95
		28D7	.70	9001	.30
		35L6	.62	9002	.40
		35Z5	.52	9003	.30
1E7G	$.89	50L6	.64	9004	.30
1L4	.98	30	.74	9006	.30
1P5G	.59	80	.39	2AP1	1.95
2A5	.60	0C3/VR105	.74	3AP1	2.90
2X2	.49	0D3/VR150	.74	3BP1	1.95
2V3G	.89	211	.59	3FP7	1.90
3A4	.61	250TH ...	13.95	3GP1	2.90
3B7/1291..	.79	2C26	.39	3JP12 ...	2.00
3D6/1299..	.79	2C34/RK34	.49	5AP1	2.25
3S4	.90	2C40/446A	.88	5BP1	2.25
5R4GY ..	.90	2D21	.98	5BP4	2.25
5T4	1.49	3B24	.74	5CP1	2.25
5U4G	.69	304TL ...	3.75	5FP7	2.60
5W4	.98	307A	3.25	5HP1	2.95
5Y3G	.44	450TH ...	18.00	7BP7/1813	2.90
5V4G	.98	450TL ...	29.95	9JP1	2.95
5Z3	.70	WL531 ...	18.00	12DP7 ...	4.50
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6AG5	.97	717A	.89	2K29	4.95
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6AJ5	.98	725	2.95	100TS ..	2.95
6AK5	.59	803	9.00	2E22	1.50
6AL5	.88	804	8.95	631P1/SN4	3.75
6B4G	1.29	805	4.95	CK1005 ..	.30
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6C4	.20	808	1.95	TUBES	
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6F6/1613.	.69	836	1.10	2RA6 ...	3.95
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6J4	1.98	865	1.00	4E24.257B.	8.00
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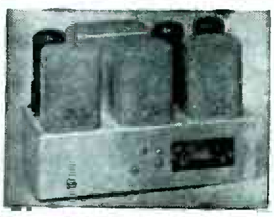

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1.3	113.1	750	2485	9445
1.75	120	800	2490	9710
2	121.2	806	2500	10,000
3	125	900	2580	10,500
4	150	910	2600	12,000
4.35	160	917	2635	14,460
5	165	1000	2700	14,600
5.025	170	1030	2850	15,000
6	182.4	1056	2860	17,000
7	200	1100	2900	18,000
7.5	209.4	1110	3000	19,000
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.1	.175	.254	.402	.654
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.135	.22	.294	.478	.7613
.14	.229	.314	.5	.8
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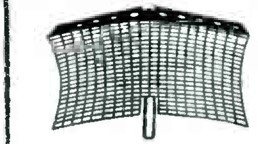

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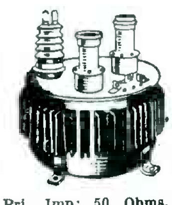

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AN/TPS-3 Parabolic reflector, approx. 10 ft. diam. Extremely lightweight construction, New, in portable carrying case $35.00
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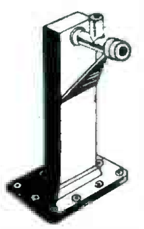

10 Cm McNally cavity. Silver Plated. Type SG ....$3.00 Ea.
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10 CM Dipole and Reflector with type "N" Fitting........$2.75
Waveguide to flexible coax coupler (RG 18 U), with flange. Gold plated. App 10" high....$17.50
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Per section $12.00
Per set of 4 sections....$45.00
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⅞" rigid coax, Rt. angle bend 15" long, overall.$2.00

3 Centimeter

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H plane $5.50
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1.25 Centimeter

Wave Guide Section 1" cover to cover....$2.00
T Section choke to cover....$4.50
Mitred Elbow cover to cover....$3.00
Mitred Elbow and "S" sections choke to cover.$3.50
Flexible Section 1" long choke to choke....$3.00
Tunable Cavity with Coax input and output....$6.00

Connectors

UG 21/U, Type "N". Male.... $.65
UG 86/U, Gold Plated.... $.85

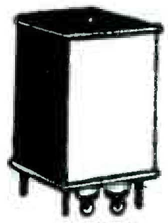
DYNA-MOTORS

PE 73 CM. Power supply for BC 375 input: 28 V DC. Output 1000 VDC @ 350 Ma. Starting relay, filter, etc..$4.95
Mfrs: write for quantity, prices and discounts on above item.
BD 77KM, Power supply for BC 191. Input: 14V DC. Output 1000 VDC @ 350 Ma. New. with spare fuse links, etc....$5.95
PE 101C. Input: 13/26 VDC @ 12.6/6.3 A. Output: 400 VDC @ 135 Ma., 800 VDC @ 20 Ma. (9VAC @ 1.12 A.)....$3.40
PE 86 N. Input: 28 VDC. Output: 250 VDC @ 60 Ma. Westinghouse w/Filter....$1.95
Without Filter 1.60
PC 77. Input: 12 VDC. Output 275 VDC @ 110 Ma. 500 VDC @ 50 Ma....$3.25
DAG 33 A. Input: 18 VDC @ 3.2 A. Output: 450 VDC @ 60 Ma....$2.45
DM 32 A. Input: 28 VDC @ 7 A. Output: 540 VDC @ 250 MA. Power supply for modulator for SCR 274 N....$3.99
Dyn. Model 23350. Input 27 VDC @ 1.75 A. Output: 285 VDC @ 75 Ma....$1.79
DM-21: In 14VDC 3.3A Out 235VDC 90 ma with filter $2.59
DM-25: In 12VDC 2.3A Out 250VDC 50 ma..$2.49
DM-34: In 14VDC 2.8A Out 220VDC 80 ma..$2.49
DM-42: In 14VDC. Out 515/1030 VDC 215/260 ma and 2/8VDC....$3.95
BD-77 input 14VDC output 1000V 350ma DC..$5.95
PE 55. Input: 12 vdc @ 25 amp. Output: 500 vdc @ 400 ma. (slightly used, excellent condition).$4.95
MP 10-G. Power supply using 2 dynamotors. Input: 24-28 vdc. Output: 1000 vdc @ 400 ma. New. complete with enclosed starting relays, filters, etc. Bendix....$20.00
MK 11 dynamotor. Input: 12 vdc @ 9.4 amp. Output: 275 vdc @ 110 ma, 500 vdc @ 50 ma. New. complete with connecting cable and plugs $4.75

INVERTERS

PE 206-A. Input: 28 v.d.c. @ 38 amp. Output: 80 volts at 500 volt-amps. 800 cycle. Leland Electric. New, complete, with enclosed relay, filter, instruction book....$12.50
PE 218. Input: 25-28 v.d.c. @ 92 amp. Output: 115 volts, 1500 volt-amps, 380-500 cycle. Leland Electric. New....$15.00

TRANSFORMERS



Power xfmr. Pri: 117v. 60 cy. Sec: 330-0-330 v. @ 85 ma. 5v @ 2 amp. 6.3 v. @ .3 amp., 6.3 v. @ 7.5 amp.$1.95
Power Pair: Xfmr 470 v.c.t. @ 60 ma. 6.3 v. @ 1.65. 5v. @ 2 amp. PLUS a 6hy 50 ma. choke. Both for only $1.75

Filament Transformers (RAYTHEON)
(All primaries 117v., 60 cy.)
#5126: 5v. @ 3 amp., 5v. @ 3 amp., 5v. @ 6 amp. (All center tapped) $2.25
#5100: 6.3 v. ct @ 1.2 amp....$1.35
#5085: 6.3 v. @ 6 amp. 6.3 v. @ 1.5 amp..$1.40
UX 6899: 5 v. @ 5.5 amp. 5 v. @ 5.5 amp. 29,000 volt test $24.50
Doughnut fil. xfmr: Input: 117 v, 60 cy. Output: 2/WOGS. 5.1 v. @ 5 amp. 15000 volt insulation. Electrostatic shielding. 7" x 5" x 7½". Amertran $7.50

CHOKES
6 Hy @ 150 Ma....$1.59
6 Hy @ 300 Ma....$3.25
1 Hy @ 800 Ma. 7.5 ohms....$8.95
Dual choke, 2 Hy @ 100 ma....$ .90
Dual choke, 7 Hy @ 75 Ma, 11 Hy @ 60 Ma.$1.50
8.5 h. @ 150 ma....$1.50
25 h. @ 65 ma....$1.10

24-VOLT FILAMENT TRANSFORMERS

(All primaries 117 volts, 60 cycles)
#2Z17: Output: 24 volts @ 3 amp....$1.50
#517: Output: 24 volts @ 5 amp. or 12 volts @ 3 amps. Size: 4½" x 4½" x 5¼"....$2.75

CATHODE RAY TUBES

3BP1	$1.25	3FP7	$1.20
5BP1	$1.20	5FP7	$1.75
5BP4	$1.60	5JP2	$4.00

RECTIFIER TUBES

872A	$1.00	705A	$1.25

PULSE TRANSFORMERS

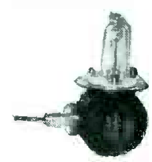
All Standard Name Items

GE # K 2731
Repetition Rate: 635 PPS, Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms, Pulse Width: 1 Microsec. Pri. Input: 9.5 KV. PK. Sec. Output: 28 KV. PK. Peak Output: 800 KW., Bifilar: 2.75 Amp..$19.50
Type K2450A. Will receive 13 KV, 4 micro-second pulse on pri., secondary delivers 14 KV Peak power out 100 KW GE....$15.00
HI Volt. Magnetron Input transformer W.E. # D-166173 with cooling fins....$12.00
U 4298E—Pri. 4 KV. 1 microsecond Sec. 16 KV. 16 amps. Fil. pri. 115v. 400 Cycle Raytheon.$15.00
HI Volt input pulse Transformer W.E. #D169271 $9.95
Pulse: Input, line to magnetron K2748A....$12.00
Utah Pulse or Blocking Oscillator Transformer: Freq. limits 790-810 cy-3 windings turns ration 1:1:1. Dimensions 1 13/16 x 1⅛ x 19/32....$.75

MICROWAVE TEST EQUIPMENT

Wave guide experimental kit. Consists of: One direct-reading wavemeter, app 2600-3400 mc. (cavity type); One dummy load w/crystal probe. One line stretcher full wave; two wave guide to RG 18/U coax couples; two 1' sections w/flanges. Complete $250.00
10 CM ECHO BOX, complete with micrometer adjust cavity & resonance indicator. Type TS 238/GP. With calibration chart....$105.00
10 CM WAVEMETER. Model "SL". Micrometer adjust cavity with microammeter resonance indicator. Includes 115 VAC operation converter section. In grey metal carrying case, complete with cables & spares. Made by Western Electric $135.00
W.E. 1138 A. Signal generator, 2700-2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram....$50.00

MICROWAVE TUBES (Magnetrons)



2J22 (10 CM)....$15.00
2J21 ....$15.00
2J21A $15.00
2J26 ....$15.00
2J27 ....$15.00
2J31 ....$15.00
2J32 ....$15.00
Magnet for 2J32....$8.00
2J38 with magnet..$25.00
2J55 with magnet 10 CM. $25.00
3J31 ....$17.50
Magnet for 3J31....$8.00
W.E. 700-A (L band)....$45.00
W.E. 720-BY (S band) 1000 KW....$25.00
QK 59, QK 60, QK 62, tunable, packaged magnetrons, 10 CM. Each....$45.00
Klystron, 2K25-723 AB....$3.50

SPECIALS

10 CM, RF Package. Consists of: SO Xmtr.-receiver using 2127 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer....$150.00
Modulator-motor-alternater unit for above...$75.00
Receiver rectifier power unit for above....$25.00
Rotating antenna using dipole feed and parabolic reflector. New less hood....$75.00
Used $45.00
RT39APG15 Transmitter-receiver, Lighthouse tube oscillator. .5 KW. App. 2700 Mc. operation. With lighthouse and TR tubes....$100.00

CERAMICON CAPACITORS (Erie, Centralab) $7.50/100

3 mmf	±5%	67 mmf	±20%
5 mmf	±5%	100 mmf	±5%
4 mmf	±.5 mmf	115 mmf	±2%
8.5 mmf	±.5 mmf	120 mmf	±5%
11 mmf	±5%	240 mmf	±3%
15 mmf	±2.5 mmf	250 mmf	—
48 mmf	±2%	500 mmf	+15 —30%
50 mmf	±20%	1000 mmf	±5%
60 mmf	±3%		

Silver-Mica BUTTON CAPACITORS (Erie, Centralab) $9.50/100

185 mmf ....±2.5 mmf
175 mmf ....±2.5 mmf
500 mmf ....±10%

OIL CONDENSERS

.25 mf @ 20000 VDC Aerovox....$17.50
1.5 mf @ 6000 VDC Aerovox....$12.50
1 mf @ 25 KV....$60.00
.5 mf @ 25 KV....$40.00

MICA

.08 mf @ 1500 VDC, Sprague MX60....$11.50
.03 mf @ 2000 VDC, CD 551A-50....$12.75
.045 mf @ 2000 VDC, Sangamo, G1....$12.75
.00015 mf @ 20 KV, Aerovox 1970-404....$25.00
.0001 mf @ 20 KV, Sangamo G3....$25.00
.002 mf @ 15 KV, Sangamo....$20.00
Isolating Capacitor. Cornell-Dubilier PL 1417. 106-110 mmf @ 10 KV AC (peak). Each....$3.50
MFRS.: Send your requirements for bathtubs, Micas, Hardware, resistors, & connectors.

Varistors $.95 Ea.
(Western Electric)
D-167176
D-170225
D-162356

Thermistors $.95 Ea.
(Western Electric)
D-167332 Bead
D-170396 Bead
D-163392 Button

Mail orders promptly filled. All prices: F. O. B. New York City
Send Money Order or Check. Rated firms send P. O. Shipping charges only sent C.O.D.
Send for our latest microwave flyer, also our complete parts catalog.

COMMUNICATIONS EQUIPMENT CO.
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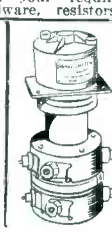


MOTOR DRIVEN SWITCH. Switch operates at 1800 rpm. using internal 24 VDC motor. Switch is DPDT, and was originally designed for automatic switching of YAGI radar antennae $2.00

Finest of surplus at a fraction of cost

PEAK ELECTRONICS CO.

Industrials Schools - Labs

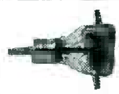
AMERTRAN TRANSTAT

110/220 volts 60 cycle input. Output variable plus or minus 10% of 115 volts at 8.5 amps. Also can be connected to give different voltage combinations. Brand new ......only $22.50

AMERTRAN VOLTAGE REGULATOR

130/230 volts 50/60 cycles input. Output variable from 0—260 volts. 1.3 KVA, single phase. Like new $29.50

SPERTI RF VACUUM SWITCH



9200 volts peak, 8 amps. Used as antenna switch in Collins ART 13. BRAND new $1.95

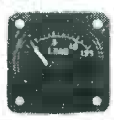
GENERAL RADIO TYPE LR FREQUENCY METER AND INTERPOLATION OSCILLATOR

160 to 30,000 KC. input 110 V. 60 cycles, excellent condition $575.00

OIL CONDENSERS
CD, GE, Aerovox, etc.

2mfd 600 vdc....$ .39
4mfd 600 vdc.... .59
3/3 mfd 600 vdc.. .79
4/4/4 mfd 600 vdc .95
14 mfd 600 vdc.. 1.35
20 mfd 600 vdc.. 1.85
2 mfd 1000 vdc.. .79
4 mfd 1000 vdc.. .95
2 mfd 1500 vdc.. 1.25
1 mfd 2000 vdc.. 1.15
3 mfd 3000 vdc..$3.95
1 mfd 4000 vdc.. 3.75
1 mfd 5000 vdc.. 4.50
.1 mfd 7500 vdc.. 1.95
.1/.1 mfd 7500 vdc 2.45
.01/.01 12 KV dc 5.75
.005/.01 12 KV dc 5.50
.65 mfd 12500 vdc 12.95
.75/.35 mfd (dual)
8/16 KV dc......14.95

WHERE SPACE IS LIMITED



This tiny GE motor only 1½ inches square. Basic movement 0—1 ma. Ideal as "S" meter for BC348, etc. Only.......$3.95 ea.

METERS (brand new)

2" GE 0—5 ma (amp scale)........$1.95
2" GE 0—1.2 (0-100 scale)......... 2.49
2" GE 0—1 amp R.F. (internal thermo) 3.49
2" Weston 150-0-150 microamps. Model 506 (Sperry scale)....... 3.49
2" McClintoch 0-50 microamps. (square) 7.50
2" Weston type 507 0-120 Ma RF.. 4.95
2" Gruen 0-1 MA Basic (0-3V Scale) 2.95
3" W. E. 500-0-500 microamps. (Blank scale) 3.95
3" Westinghouse 0-50 amps. A.C... 4.95
3" Westinghouse 0-2 ma D.C....... 3.95
3" Westinghouse 0-20 ma D.C....... 3.95
3" G.E. 0-15 ma D.C. (square)...... 3.95
3" Westinghouse 0-150 volts A.C.... 3.95
3" G.E. 0-200 microamps (volt-scale) 6.95
3" G.E. Running Time Meter....... 7.95
4" G.E. 1-0-1 ma D.C. (Blank scale) 3.95

FEDERAL TELEGRAPH TRANSMITTER

B.C. 325-B—Phone-CW. 110V 60V cycle Input—400 watts output CW. Crystal and Variable Frequency Control — Has Blower Motor, Crystal Oven, Transtat, Modulation Oscilloscope, 11 Panel Meters, etc. Perfect condition....$575.00

WIRE WOUND RESISTORS
Standard Make

5 watt type AA, 20-25-50-200-470-2500-4000 ohms .... .09 ea.
10 watt type AB, 25-40-84-400-470-1325-1980-2000-4000 ohms .... .15 ea.
20 watt type DG, 50-70-100-150-300-750-1000-1500-2500-2700-5000-7500 10000-16000-20000-30000 ohms .... .20 ea.
30 watt type DI, 100-150-2500-3000-4500-5300-7500-18000-40000 ohms .... .24 ea.

1% PRECISION RESISTORS—
Standard Make

2000-2500-5000-8500-10000 ohms .... .39 ea.
50000-95000 ohms .... .40 ea.
100000-750000-1 meg .... .89 ea.

AMERTRAN STEPDOWN TRANSFORMER

7½ KVA, 50 cycles, 3 phase. Primary 208 volts. Delta secondary 106-144 volts in 3½ volt steps. 10¼x18¼x10 5/16.
Brand new $59.50

MEGOHM METER

Industrial Instruments Model L2AU 110/220 volts 60 cycle input. Direct reading from 0-100000 megohms on 4" meter. Can be extended to 500000 megohms with external supply. Sloping hardwood cabinet 15"x8"x10". Brand new with tubes plus running spare parts including extra tubes. Great value only $69.95

G.E. 2" SCOPE

This compact unit only 4½" x4"x6¾". Ideal for modulation indicator, etc. Has focus, intensity and reticle brilliance controls. Uses 2AP1 C.R.T. and 9006 rectifier. We supply instructions with each scope. Rectifier built in. Need only 500-600 volts A.C. plus 6.3 volts. Changes very simple with cable and 9006 but less 2AP1 ....$4.95
2AP1 C.R.T. 2.50

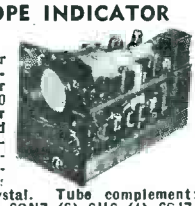
FEDERAL SELENIUM RECTIFIER

Full wave. 36 volts input. 28 volts output at 6.1 amps. Brand new $7.95

ELECTROLYTIC CONDENSER BARGAINS

(Cornell Dubilier, Aerovox, W. E. only)
25 mfd 25 w.v. tubular C.D.................$ .25
50 mfd 50 w.v. tubular Aerovox.............. .29
4 mfd 150 w.v. tubular C.D.................. .18
8 mfd 450 w.v. tubular C.D.................. .37
12 mfd 450 w.v. tubular C.D................. .44
500 mfd 15 w.v. tubular C.D................. .49
10 mfd 450 w.v. can C.D..................... .45
16 mfd 450 w.v. can C.D..................... .69
20x20 mfd 450 w.v. can Aerovox.............. 1.05
80 mfd 200 w.v. can W.E..................... .69
200 mfd 200 w.v. can W.E.................... .98
1000 mfd 25 w.v. can Aerovox................ .95

APN 4, 5" SCOPE INDICATOR
(25 tubes)



Makes an ideal basis for 5" scope. Also can be converted into Panadaptor with marker pips at 100 KC - 20KC - 2 KC., for measuring drift and width of F.M. Has electronic switch for observing 2 frequencies simultaneously. Unit contains an accurate 100KC crystal. Tube complement: (1) 5CP1 (3) 6SL7 (14) 6SN7 (6) 6H6 (1) 6SJ7. Complete with tubes and 100KC crystal. Marvelous buy at $24.95

POWER PLANT (PE 197)

4 cylinder Hercules Gas driven engine. Output 110 volts 60 cycles, voltage regulated, 5KW-6.3KVA at 80% Pwr. Ftr. Single phase, complete with running spare parts, meter panel, battery, tools, remote cable, etc.
Weight 1200 lbs. Export Packed. Excellent for emergency power. Brand new.............$575.00

MISCELLANEOUS SPECIALS

2-11 mmf. Butterfly with ball bearings.....$ .59
G.E. S.P.D.T. Relay 10000 ohm coil........ .59
Heineman Circuit Breaker 5 amp. 110V. A.C. .89
G.E. Solenoid W/Microswitches 24 V. D.C... .69
Ohmite 25 ohm 25 watt Rheostat............ .39
Microswitch 10 amp. (interlock)............ .59
C.H. Bat Handle Switch—D.P.S.T. ½ H.P. .95
Bendix Synchro Motor 115V. A.C. 400 cycle 1.95
Weston 663 Analyzer 19.50
Weston 665 Analyzer 29.50
Veeder Root Counter .... .95
Single Plate to P.P. Input 3:1 ratio trans... .49

Tremendous stocks on hand. Please send requests for quotes. Special quantity discounts. Prices f.o.b. N. Y. 20% with order unless rated, balance COD. Minimum order $3.00.

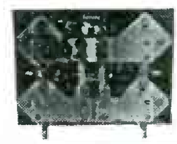
DAVEN AUDIO FREQUENCY METER Model 837E

Direct reading from 0-30 KC in 4 separate ranges on 6" Weston Model 271 Fan Meter. Built-in voltage regulated power supply operates from 115 volts 60 cycles, has high input impedance. With pick-up can be used to determine frequency in vibration tester. With suitable mixer can check deviation of R.F. carrier from standard. Mounts on 8¾"x19" rack panel. Complete with tubes. Slightly used but perfect. Only..........$59.50

S.C. TEST SET—1-114

In portable wood case 6" x 6" x 10" (including cover not shown). Has Weston 0-150 volt A.C. meter 60 cycle, 2 switching circuits. Complete with line and test cables. A bargain at only $3.95.

HIGH WATTAGE ANTENNA RELAY



110/220 volt 60 cycle coil. D.P.D.T. rated at 5000 volts. Heavy duty paralleled contacts. Sturdy construction. Isolantite insulation. Base 8" x 10½". Brand new...$7.95

CHOKE BARGAINS

WE 4.3 henry 620 ma. 40 ohms............$4.95
N.Y.T. 8 henry 160 ma. 140 ohms D.C....... 1.39
C.T.C. 1.5 henry 250 ma. 72 ohms........... .60
R.C.A. 50 henry 680 amps. high voltage.....19.50
Fed. Tel 6 henry 1.8 amps. high volt.......29.50

R.C.A. POWER TRANSFORMER

770 V.C.T. 100 ma., 6.3 volts—2.5 amp. 5 volts—2 amps.—3½" x 4" x 4½"........$2.75

AMERTRAN STEPDOWN TRANSFORMER

220-110 100 watts, shielded................$2.49

MIDGET VARIABLE BARGAINS

Hammarlund MC 250S 250 mmf............$ .69
Hammarlund MC 320S 320 mmf............ .79
Hammarlund APC 100 100 mmf............ .39
Hammarlund APC 50 50 mmf.............. .29
Hammarlund HFD 30X Dual 30 mmf. D.S... 1.10
Bud MC 913 Dual 35 mmf. D.S............ 1.25

LINK BC 438 FREQUENCY METER

195-215 mcs. Built in 110 volt 60 cycle power supply. Complete with tubes and crystal. Slightly used. Limited quantity............$9.95

TRANSMITTING VARIABLES

Cardwell XD160 XD. Split stator. 160 mmf./section .125 spacing $7.95
Hammarlund MTC 150 to 150 mmf. .07 spacing (easy to split)...................... 1.49

HANDY LAB KITS

25 Popular silver micas $1.95
50 Popular pigtail micas.................... 2.39
25 Popular ceramicons 1.50
25 Wirewound resistors 5 to 30 watt......... 2.50
15 Bathtub condensers 1.95

HIGH VOLTAGE MICAS

C.D. .002 2500 W.V. 5000 V.T. type 9......$ .49
C.D. .002 3500 W.V. 7500 V.T. type 9........ .69
Micamold .005 2500 W.V. type 4.............. .69
Solar .005 10 KV. D.C. 11 amp. 3000 K.C.... 7.95
C.D. .006 6 KV. D.C. 20 amp. 400 K.C....... 5.95
C.D. .004 3KV. D.C. 20 amp. 18000 K.C.... 2.50
Sprague .08 1500V. D.C. 20 amp. 3000 K.C... 1.95
R.C.A. .02 2000V. D.C. 10 amp. 300 K.C..... 1.75
Sangamo (F2L) .015 2000V. D.C.............. 1.50
C.D. (6H) .0013 5000V. D.C.................. 1.00
C.D. (6H) .005 5000V. D.C. 11 amp. 1000 K.C. 2.50
R.C.A. .0002 2500 W.V. 5000 V.T............ .39

U.H.F. COAX. CONNECTORS

UG12U—831R—831J—UG21U—831AP—831SP .39 ea.

Large stocks of Coax. and A/N connectors.

Phone: Cortlandt 7-6443

PEAK ELECTRONICS CO.
188 Washington St., New York 7, N.Y.

DEPARTMENT EA
SEND FOR BULLETIN

TRANSFORMERS
110 V. 60 CYC.
6.3 VOLTS CT. @ 1 AMP....
8 VOLTS CT. @ 1 AMP....
98c EA.

R-H-S
SPECIALS OF THE MONTH

VIBRATORS
6 VOLTS—4 PRONG....
2 VOLTS—7 PRONG....
98c EA.

GENERAL RADIO 566A WAVEMETER

.5 mc to 150 mc

5 Plug In Coils, Reg. Price.. $69.50
Brand New **$39.50**

SELENIUM RECTIFIERS

Full Wave Bridge Type

INPUT	OUTPUT		
up to 18v A.C.	up to 12v D.C.	1 Amp.	$1.95
up to 18v A.C.	up to 12v D.C.	5 Amp.	4.45
up to 18v A.C.	up to 12v D.C.	10 Amp.	7.45
up to 18v A.C.	up to 12v D.C.	15 Amp.	9.95
up to 18v A.C.	up to 12v D.C.	30 Amp.	14.95
up to 36v A.C.	up to 28v D.C.	1 Amp.	3.45
up to 36v A.C.	up to 28v D.C.	5 Amp.	7.45
up to 36v A.C.	up to 28v D.C.	10 Amp.	12.45
up to 36v A.C.	up to 28v D.C.	15 Amp.	18.95
up to 54v A.C.	up to 36v D.C.	.25 Amp.	.98
up to 115v A.C.	up to 100v D.C.	.25 Amp.	2.95
up to 115v A.C.	up to 100v D.C.	.6 Amp.	6.95
up to 115v A.C.	up to 100v D.C.	5 Amp.	19.95

OIL CONDENSERS:

G. E.: AEROVOX, CD., ETC.
All Ratings, D.C.

1mfd.	600v..	$0.35	2mfd.	2000v..	$1.75
2mfd.	600v..	.35	3mfd.	2000v..	2.75
4mfd.	600v..	.60	4mfd.	2000v..	3.75
8mfd.	600v..	1.10	15mfd.	2000v..	4.95
10mfd.	600v..	1.15	.1mfd.	2500v..	1.25
1mfd.	1000v..	.60	.25mfd.	2500v..	1.45
2mfd.	1000v..	.70	.5mfd.	2500v..	1.75
4mfd.	1000v..	.95	.05mfd.	3000v..	1.95
8mfd.	1000v..	1.95	.1mfd.	3000v..	2.25
10mfd.	1000v..	2.10	.25mfd.	3000v..	2.65
15mfd.	1000v..	2.25	.5mfd.	3000v..	2.85
20mfd.	1000v..	2.95	1mfd.	3000v..	3.50
24mfd.	1500v..	6.95	12mfd.	3000v..	6.95
.25mfd.	2000v..	1.05	2mfd.	4000v..	5.95
.5mfd.	2000v..	1.15	.1mfd.	5000v..	4.95
1mfd.	2000v..	.95	1mfd.	7000v..	2.95

SPECIAL 2 mfd. 3000 v. **$4.45**

HIGH CAPACITY CONDENSERS

2x3500 mfd.—25WVDC $3.45
4000 mfd.—30WVDC 2.95
1000 mfd.—15WVDC .... .99
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BC-314 RECEIVER

Used but in perfect condition. Two stages RF, separate local and beat oscillators. For 12-volt DC operation but easily converted to 110-volt AC. Frequency range 150-1500 KC, continuous in 6 bands. This unit is ideal as an airport or marine low frequency receiver, also a very excellent BC receiver. Complete with tubes, specially priced at.......... **$29.50**

BC-375-E TRANSMITTER

Operates from 200 kc—12.5 mc complete with all tubes, dynamotor, six tuning units and one antenna tuning unit.
Like New **$39.50**

SOLA

Constant Voltage Transformer

Pri.: 190 to 260v 60 cyc.
Sec.: 115 volts @ 1.74 amps.
Rated 250 V. A.

Brand New **$29.95**

PERMALLOY SHIELDS

for CATHODE RAY TUBES

3" Shield $1.49
5" Shield 1.98

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Army-Navy Inspected

1N21	$ .39	371B	$5.95
2AP1	2.25	450TH	39.95
2C40	1.19	703A	7.95
2D21	.89	705A	3.95
2V3G	1.25	715B	7.95
2X2	.84	721A	4.35
3AP1	3.00	726/AC	7.50
3BP1	2.95	801	1.49
3E29	2.95	802	1.98
3GP1	3.95	803	8.95
5BP4	4.95	804	9.95
5CP1	3.95	805	4.95
5JP1	11.95	806	14.95
5LP1	8.95	807	.95
5R4GY	.98	808	2.95
5Y3	.41	809	1.50
6AB7	.99	810	5.95
6AC7	.99	811	1.95
6AG5	.99	812	3.15
6AG7	.99	813	8.95
6AJ5	.99	814	4.45
6AK5	.90	815	3.95
6AL5	.99	829-A-B	3.00
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6B4G	1.29	833A	39.50
6C4	.69	836	1.75
6C5	.49	837	2.50
6D4	.99	838	3.95
6F6	.89	861	69.50
6F6G	.59	866	.75
6J4	1.50	872A	2.50
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6J6	.89	885	.98
6L6	1.23	954	.75
6L7	.98	955	.75
6N7	1.02	956	.75
6SH7	.59	957	.75
6SL7	.89	958	.75
6SN7	.69	959	.75
6SR7	.89	1005	.69
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7L7	1.59	1620	1.98
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12X3	1.50	1624	.90
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28D7	.98	8001	6.49
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35T/TG	3.50	8005	4.95
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211	1.25	9002	.98
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250TH	14.95	9004	.98
257B	6.49	9005	.98
304TH	9.95	9006	.98

GLIDE PATH RECEIVER R-89/ARN-5

Glide Path Receiver used in the Instrument Landing System covering the frequency range 332 to 335 mc; complete with the following tubes: 7—6AJ5, 1—12SR7, 2—12SN7, 1—28D7, and including three crystals 6497KC, 6522K.
Brand New **$12.95**

TRANSFORMERS—115 V 60 CYC.

HI-VOLTAGE INSULATION

3710v @ 10 ma.; 2x2½v @ 3A	$9.95
2500v @ 10 ma	6.50
2500v @ 15 ma	6.50
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2100v @ 10 ma	6.50
1750v @ 4 ma.; 6.3v @ 3A	7.50
1700v @ 4 ma.; 6.3v @ .6A; 2½v @ 1.75A	8.50
1600v @ 4 ma.; 700v CT @ 150 ma.; 6.3v @ 9A	8.50
1600v @ 2 ma.; 6.3v @ 6A; 2½v @ 1.75A	8.50
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550-0-550 @ 150 ma.; 5v @ 3A; 2x6.3v @ 5A C.T.	7.95
525-0-525v @ 60 ma.; 925v @ 10 ma.; 2x5v @ 3A; 6.3v @ 3.6A; 6.3v @ 2A; 6.3v @ 1A	8.95
525v @ 35 ma.; 5v @ 35 ma.; 2½v @ 1.75A	1.98
520-0-520v @ 120 ma.; 5v @2A; 6.3v CT @5A	5.95
500-0-500v @ 25 ma.; 262-0-262v @ 55 ma.; 6.3v @ 1A; 2x5v @ 2A	4.49
500-0-500v @ 100 ma.; 5v CT @ 3A	4.95
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400-230-0-230-400v @ 250 ma.; 3x5v @ 3A; 6.3v @ 5A; 6.3v @ 3A; 6.3v @ 1A	7.95
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400-315-0-100-315v @ 200 ma.; 2.5v @ 2A; 6.3v @ 1A; 5v @ 3A; 6.3v @ 9A	7.50
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350-0-350v @ 45 ma.; 675v @ 5 ma.; 2½v @ 2A; 2x6.3v @ 1A; 6.3v @ 2½A	4.95
350-0-350v @ 80 ma.; 6.3v @ .6A; 6.3v @ 3.75A; 2x5v @ 3A	3.98
350-0-350v @ 120 ma.; 5v CT @ 3A; 6.3v CT @ 4.7A	3.95
350-0-350v @ 70 ma.; 400v @ 10 ma.; 65v 6.3v @ 6A; 6.3v @ 4A; 5v @ 2A	2.49
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340-0-340v @ 300 ma.; 1540v @ 5 ma	7.50
325-0-325v @ 120 ma.; 10v @ 5A; 5v @ 7A.	3.49
300-0-300v @ 65 ma.; 2x5v @ 2A; 6.3v @ 2½A; 6.3v @ 1A	3.49
250-0-250v @ 100 ma.; 2x6.3v @ 4A; 6.3v @ 5A; 6.3v @ 1A	4.95
200-0-200v A 140 ma ; 6.3v @ 4A; 5v @ 2A	1.98
120-0-120v @ 50 ma	.98
24v @ 6A	3.50
6.3v @ 10A; 6.3v @ 1A	3.50
6.3v @ 1A; 2½v @ 2A	3.95
6.3v @ 21½A; 6.3v @ 2A; 2½v @ 2A	6.95
6.3v @ .25A; 6.3v @ 3A; 5v @ 12A; 6.3v CT @ 9A	4.95
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10v @ 5A	1.49

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10 hy @ 400ma..	$4.95	4 hy @ 600ma...	$5.95
8 hy @ 300ma...	3.95	10 hy @ 250ma..	2.49
8/30 hy @ 250ma	3.50	10 hy @ 200ma..	1.98
25 hy @ 160ma..	3.49	10/20 @ 85ma...	1.59
12 hy @ 150ma..	2.25	15 hy @ 125ma..	1.49
12 hy @ 100ma..	1.39	15 hy @ 100ma..	1.39
30 hy @ 70ma...	1.39	3 hy @ 50ma....	.29
20 hy @ 30ma...	1.49	30 hy Dual @ 20ma	1.49
120 hy Dual @ 17ma	1.39	200 hy @ 12ma..	1.39
.1 hy @ 5 amps..	6.95		

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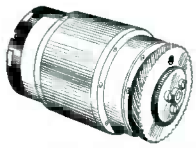
RG 8/U • 3000 to 5000 ft **$27.50** per m •

3c per foot 500-2500 ft.

52 ohm. • 5500 to 10,000 ft **$22.50** per m •

Over 10,000 ft. $20 per m



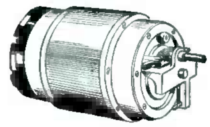
ONLY $6.75 pair

115 v, 60 cy—3¼" dia x 4½" body

SELSYN #C78248

Used in pairs for remote control.

ONLY $1.75 ea.



DIFFERENTIAL #C78249

Used between two #C78248 as dampener. Can be converted to a 3600 RPM MOTOR in 10 minutes conversion sheet supplied.

BC 1072A *Maple Chest*

IFF X'MITTER 150 to 200 Mcs 115 v, 60 cy

POWER SUPPLY gives:

0-5000 VDC (variac control) 312 VDC, 700 VDC, 6.3 vac. Also contains:

11 tubes (6J5, 826, 6SN7, 5U4G, etc.) 0-5 KV meter, Blower, Condensers, and many other useful parts too numerous to list. Of course, at this price it is used. Shp. Wt. 245 lbs.

All This for ONLY . . $22.50

AIRCRAFT GALLEY KIT from B-29. Contains 2 ½-gal. food warmers with stainless lids. Operating on either 115 V 60 cy. or 24 V D.C.; grill and chrome plated soup warmer 24 V D.C.; salt and pepper shakers; sugar dispenser; A.C. & D.C. line cords and canvas cover. $15.00

HI VOLT DUAL X'FMR

18 KV 15 mg can be varied separately

$30

2½ x @ 5 A *built in rectifier socket*

#CAY 30741-A

115 v, 60 cy

Sealed in Oil

STEP DOWN TRANSFORMERS

440/220 to 230/115, 600VA............ $12.50
440/220 to 105/115/125, 800VA........ $11.75
440/220 to 230/115 1.15 KVA........... $17.00

PYRANOL CAPACITORS — *BEAUTIFUL NEW* — *APPROX. 10% OF LIST PRICE*

.2 mfd	10,000 V.D.C.	$2.95
.1-.1 mfd	7,000 V.D.C.	1.85
2 mfd	4,000 V.D.C.	4.65
4 mfd	3,000 V.D.C.	3.25
.1 mfd	3,000 V.D.C.	1.70
4 mfd	2,500 V.D.C.	2.65
.2 mfd	750 V.A.C. 2200 V.D.C.	.40
4 mfd	2,000 V.D.C.	2.00
.1 mfd 4 mfd	1,000 V.D.C.	1.00
3 mfd	1,000 V.D.C.	.90
14 mfd	600 V.D.C.	1.70
10 mfd	600 V.D.C. (Solar)	1.35
4. mfd	600 V.D.C.	.70
1 mfd	600 V.D.C.	.29
1.75 mfd	330 V.A.C.	.39

ALLEN SET SCREWS & WRENCHES

2-56x1/16, 4-40x⅛, 4-40x3/16, 4-40x¼, 6-32x⅛, 6-32x3/16, 8-32x⅛, 3-32x3/16

Screws—$1.50 per C. Wrenches—2c

BALL BEARING 3/16" hole x ½"OD ..25c

BALL BEARING ¼" hole x ⅝" O.D. ..35c

GEAR REDUCTION UNIT—16½ to 1 ratio. Aluminum housing 5¼" x 2¾" plus extensions for couplings & base flange x 6¼" $5.00

4.5 MD. CONTROLS 10 AMP!

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2A—30c 3A—35c 5A—45c 6A—55c 15A—85c

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OSCILLATOR UNIT—from T.B.K. Transmitter. 2000 to 18,000 KCS. Temperature controlled heavy duty blower included. 21"x16½"x25"............ $40.00

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VIBROTEST Resistance Tester Associated Research, Inc. #204 0-200 Megohms (1000V potential, 0-2000 ohms AC & DC volts 150, 300 & 600 Self Contained #6 bat........ **$37.50**

UTAH PULSE Transformer #9280 Hypersil Core—Makes blocking oscillator with pulses 1 microsecond wide............ 75c

PRECISION Wire Wound SHALLCROSS 1% RESISTORS

1 WATT 40c			½ WATT 30c	
700,000	100,000	150,000	8500	400
600,000	70,000	40,000	8000	270
522,000	65,000	30,000	7500	260
470,000	55,000	25,000	6500	235
250,000	50,000	20,000	5000	210
180,000	30,000	17,000	4000	180
160,000	20,000	15,000	2500	125
125,000	18,000	10,000	1500	100

1 Megohm 1% 1 Watt 65¢

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1R5	.59c	12SG7	.49c	1E36	.19c
2x2/879	.39c	12SK7	.47c	1H20	.19c
3Q4	.72c	12SQ7	.47c	2C26	.49c
3Q5GT	.69c	12SQ7GT	.47c	3BP1	$1.00
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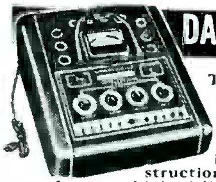
6AG5	.69c	28D7	.79c	3D21A	$1.00
6H6	.49c	35L6GT	.47c	15E	$1.95
6J6	.59c	35W4	.45c	15R	$1.95
6SA7	.47c	50A5	.65c	RK34/2C34	.79c
6SA7GT	.47c	50B5	.47c	HY114B	.79c
6SH7	.34c	117Z3	.79c	HY615	.79c
6SK7GT	.47c	954	.39c	801A	.99c
6SQ7	.45c	955	.39c	803	$3.75
6V6GT/G	.47c	1613	.25c	807	.90c
6X5GT	.45c	1619	.13c	830B	$1.95
7C4	.59c	1624	.25c	1005	.49c
7E5	.59c	1625	.25c	1960	$1.00
7Y4	.59c	1632	.25c	VR90	.79c
7Z4	.59c	1633	.25c	VR150	.79c



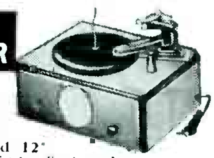
DACO Tube Tester

Tests performance, leakage and shorts in ALL receiving tubes, even sub-miniature and acorn. PLUS provision for tubes that may be invented. Durable construction is fully shielded; dust-proof case, high-visibility meter, illuminated chart; no books or charts to be misplaced. Simple, fast operation with positive contact slide-switches; tests EVERY tube element. 110 volt AC. 16½" x 14½". MA-2193 .... **$29.50**

PORTABLE DACO TUBE TESTER

Same construction and operating features as counter model. Enclosed in sturdy case with durable black leatherette covering. 12¾" x 12½". MA-2194 .... **$32.50**

PHONO AMP and RECORD CHANGER



Inexpensive phono amplifier and record changer with "big set" features. Positive-action Crescent changer handles 10" and 12" records without jamming; finger-tip reject button. Lightweight counter-balanced pickup arm with Shure crystal and lifetime floating sapphire needle. 78 RPM constant-speed motor. 5" PM speaker and high-quality amplifier complete with tubes. Base measures 15½" x 12¾" x 6". MA21 .... **$23.95**
Base with motor, turntable and record changer. MA-2192 .... **$14.95**

15" HIGH-FIDELITY DYNAMIC SPEAKER

Husky 25-watt dynamic speaker for use where perfect reproduction is desired. Ideal for both indoor and outdoor installations. 12,500 ohm field, 16 ohm voice coil. Regular $40.00 list. MA-2190 .... **$18.95**

FM and HAM ANTENNA

AN-104-B. ¼-wave at 100-156 MC; formerly used with SCR-522, 274-N, ARC-5. A pair make an excellent broad-band dipole for FM reception. Coaxial connector in base. Very sturdy; use anywhere. MA-2153 .... **39c**

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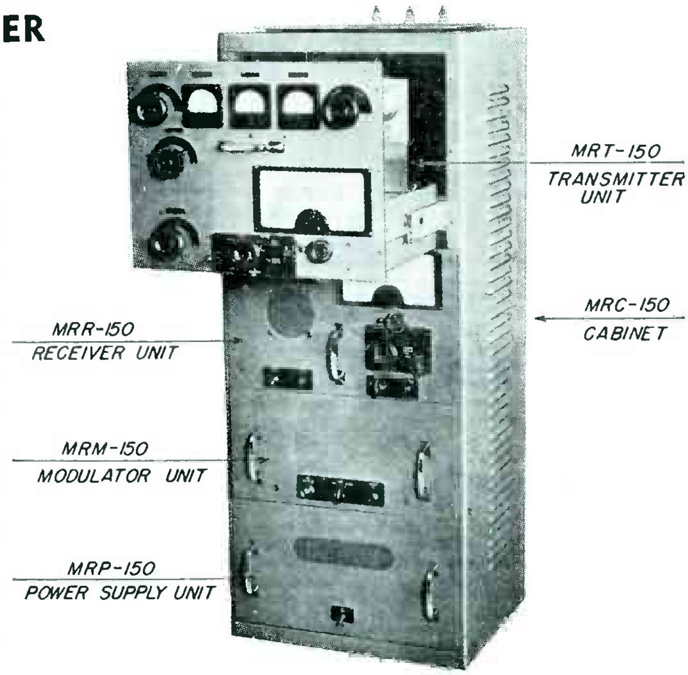
New

GOVERNMENT SURPLUS UNITS

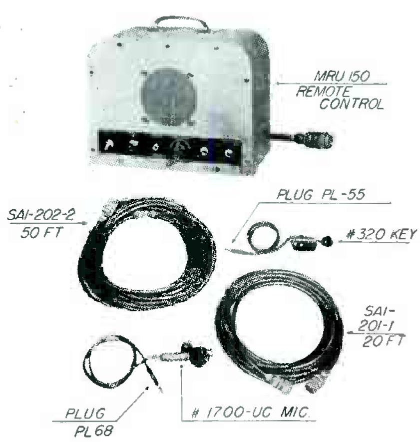
TYPE AN/FRC-1 *(export packed)*

TRANSMITTER AND RECEIVER



GENERAL. Designed for portability, Model AN/FRC-1 Radio Transmitter and Receiver operates from either 90-120 volt or 200-230 volt 50/60 cycle a-c power sources, correct transformer primary being selected by means of a tapped switch upon initial installation of the equipment. When used with an adequate antenna and ground, the equipment comprises a complete radio installation for airport traffic control. Where advantageous, provision has been made for semi-remote control of the transmitter and receiver at an operating position which may be removed from the main equipment by a distance up to 70 feet. Transmitting and receiving components are contained within a medium-sized cabinet fabricated from sheet steel finished in light gray wrinkle. The cabinet houses four decks, and incorporates roller devices similar to those used in filing cabinets, enabling each of the decks to be withdrawn separately. These decks contain the power supply, the modulator, the superheterodyne receiver and the transmitter respectively. For general size, view of components and cabinet arrangement, refer to Figure 1. Model AN/FRC-1 Radio Transmitter and Receiver covers a frequency range of from 1.5 mc to 12.5 mc. The transmitter requires five bands for this coverage. The receiver covers the frequency range in four bands.

LIST OF COMPONENTS. MRC-150 Cabinet—MRP-150 Power Supply Unit—MRM-150 Modulator Unit—MRR-150 Receiver Unit—MRT-150 Transmitter Unit—MRU-150 Remote Control Unit—SAI-202-1 20 ft. Interconnecting Cable—SAI-202-2 50 ft. Interconnecting Cable—Speedex #320 Transmitting Key—Universal #1700 UC Single Button, Press-to-Talk Microphone.



POWER. Power requirements for Model AN/FRC-1 Radio Transmitter and Receiver under full load will approximate 800 watts. The minimum power requirement for adequate airport traffic control will be 500 watts. This power represents the maximum required, or the minimum permissible, for the operation of all equipment comprising Model AN/FRC-1 Transmitter and Receiver. Normally, when working into a suitable antenna, the r-f power output with full power input will exceed 250 watts.

MODES OF TRANSMISSION. Model AN/FRC-1 Radio Transmitter and Receiver, through MRM-150 Modulator Unit and MRT-150 Transmitter Unit, permits three types of emission: (1) C.W., (2) M.C.W., (3) Phone. A function selector switch on the front panel of the modulator deck provides for this selection of emission.

MODES OF RECEPTION. A toggle switch on the front of MRR-150 Receiver Unit provides AVC (Automatic Volume Control) for radio telephone reception or BFO (Beat Frequency Oscillator) for heterodyning during the reception of telegraph signals.

Also available 150 Army Units, Type SCR-284-A, Brand New in Export Cases

Contact us for price information. All units subject to prior sale

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FOR ALL APPLICATIONS

FULL WAVE BRIDGE TYPES

Input From	Output From	Current	Price
0-18 V.A.C.	0-14 V.D.C.	1 AMP.	$2.49
0-18 V.A.C.	0-14 V.D.C.	3 AMP.	3.49
0-18 V.A.C.	0-14 V.D.C.	5 AMP.	4.95
0-18 V.A.C.	0-14 V.D.C.	10 AMP.	7.95
0-18 V.A.C.	0-14 V.D.C.	15 AMP.	10.95
0-18 V.A.C.	0-14 V.D.C.	20 AMP.	13.95
0-18 V.A.C.	0-14 V.D.C.	25 AMP.	16.95
0-18 V.A.C.	0-14 V.D.C.	30 AMP.	19.95

Input From	Output From	Current	Price
0-36 V.A.C.	0-28 V.D.C.	2 AMP.	$4.95
0-36 V.A.C.	0-28 V.D.C.	3 AMP.	5.95
0-36 V.A.C.	0-28 V.D.C.	5 AMP.	7.95
0-36 V.A.C.	0-28 V.D.C.	10 AMP.	13.95
0-36 V.A.C.	0-28 V.D.C.	15 AMP.	19.95
0-36 V.A.C.	0-28 V.D.C.	20 AMP.	25.95
From 0-120 V.A.C.	From 0-100 V.D.C.	2 AMP.	14.95
0-120 V.A.C.	0-100 V.D.C.	5 AMP.	19.95

HALF WAVE TYPES*

Input From	Output From	Current	Price
0-18 V.A.C.	0-7 V.D.C.	3 AMP.	$2.25
0-18 V.A.C.	0-7 V.D.C.	5 AMP.	2.95
0-18 V.A.C.	0-7 V.D.C.	10 AMP.	4.95
0-18 V.A.C.	0-7 V.D.C.	15 AMP.	6.95
0-18 V.A.C.	0-7 V.D.C.	20 AMP.	8.95
0-18 V.A.C.	0-7 V.D.C.	25 AMP.	10.95

Input From	Output From	Current	Price
0-36 V.A.C.	0-14 V.D.C.	3 AMP.	$2.95
0-36 V.A.C.	0-14 V.D.C.	5 AMP.	4.95
0-36 V.A.C.	0-14 V.D.C.	10 AMP.	7.95
0-36 V.A.C.	0-14 V.D.C.	15 AMP.	10.95
0-36 V.A.C.	0-14 V.D.C.	20 AMP.	13.95
0-36 V.A.C.	0-14 V.D.C.	25 AMP.	16.95

*Use with capacitor to obtain any voltage up to twice rated output.

FULL WAVE CENTER TAP

Input	Output	Current	Price
400-0-400 V.A.C.	0-450 V.D.C.	600 Mils	$5.95
9-0-9 V.A.C.	0-7 V.D.C.	22 Amps.	9.95

CAPACITORS

1000 MFD., 15 V.D.C.	$0.98
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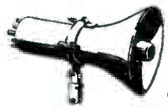

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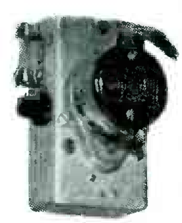

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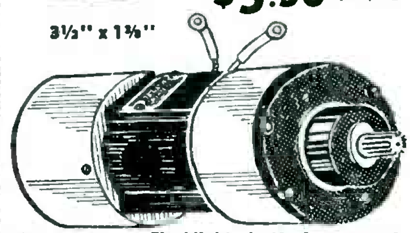

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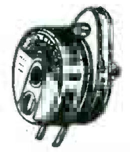

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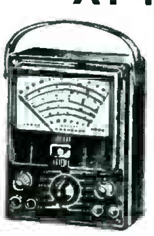

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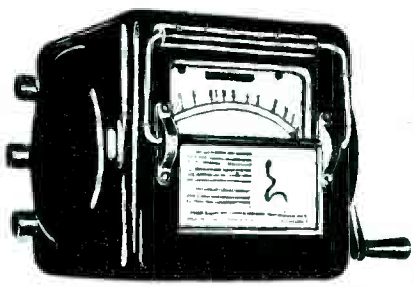

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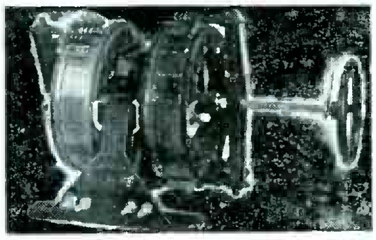

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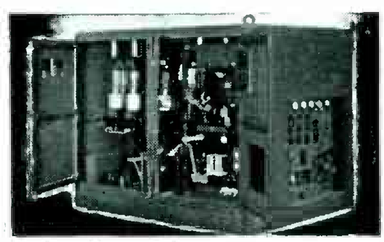

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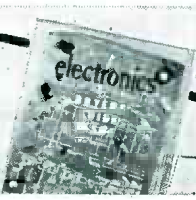

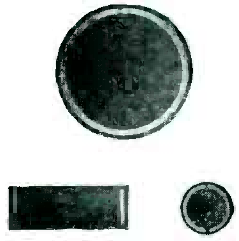

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136- AM radio with metalized-path circuitry

automatic manufacture

• These new RCA Special Red Tubes are specifically designed for those industrial and commercial applications using small-type tubes but having rigid requirements for reliability and long tube life.

As contrasted with their receiving-tube counterparts, RCA Special Red Tubes feature vastly improved life, stability, uniformity, and resistance to vibration and impact. Their unique structural design makes them capable of withstanding shocks of 100 g for extended periods. Rigid processing and inspection controls provide these tubes with a minimum life of 10,000 hours when they are operated within their specified ratings. Extreme care in manufacturing combined with precision designs account for their unusually close electrical tolerances.

RCA Application Engineers will be pleased to cooperate with you in adapting RCA Special Red Tubes to your equipment. Write RCA, Commercial Engineering, Section BR40, Harrison, New Jersey.

TABLE OF RECEIVING-TYPE COUNTERPARTS

5691 (0.6 A. heater)	6SL7GT (0.3 A. heater)
5692	6SN7GT
5693	6SJ7

RCA Special Red Tubes can be used as replacements for their counterparts in equipment where long life, rigid construction, extreme uniformity, and exceptional stability are needed.

SEND FOR FREE BULLETIN—Booklet SRT-1001 provides complete data on RCA Special Red Tubes. For your copy write to RCA, Commercial Engineering, Section BR40, Harrison, N. J.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.