JULY · 1948

electronics

A McGRAW-HILL PUBLICATION

NEW ANTI-CORONA HIGH VOLTAGE TUBE OPERATES IN OPEN TO 12-MILE ALTITUDES

AMPEREX RESEARCH TACKLED LONG PRESSING PROBLEM AND CAME THROUGH

As jet planes and guided missiles speed through diverse pressure and temperature changes into the thin air twelve miles above sea level, conventional high voltage tube performance drops far below minimum standards and becomes extremely erratic.

The importance of the problem can be seen in the fact that the dielectric strength of air at such altitudes permits standard tube designs to operate at less than *one-fifth* of their ratings.

Two years ago Amperex research teams tackled the problem of designing tubes that would insure sea-level performance, and the associated problem of developing the manufacturing techniques that would put them on a production basis.

The "specs" called for tubes to operate at full rating *in the open* at altitudes up to 60,000 feet where the barometer drops to the troposphere's 2" of mercury and the thermometer sinks to —55°C.

Not only would the tubes have to stand temperatures between the upper air's —55°C. and +250°C. but would have to stand up under a *rate of change* as high as 1°C. per second.

New standards of mechanical ruggedness were called for by hitherto unmet stresses of shock and vibration imposed by the tremendous rates of jet and rocket acceleration. Inevitable moisture and ice formation presented formidable hazards. Cosmic ray showers and other particles were additional challenges.

The first theoretical survey two years ago made it apparent that only a radically different approach could be successful. Amperex is proud to announce that all research and design problems have been surmounted and that the new tube combinations, after prolonged and rigorous testing, are now in production.

HAR-3 is only 4⅝" long and 2" in diameter. Of the total tube length approximately 3¼" protrudes above the top plane of the socket. An existing conventional-type tube having approximately the same electrical rating—but at sea level conditions only—is over 8" long and is 2-5/16" in diameter.

"SEALED" CONSTRUCTION SETS NEW STANDARDS FOR ALL EXTREME CONDITIONS

Problems presented by reliable and efficient operation of high voltage tubes in the open at full rating under extreme conditions of pressure, temperature and stress have been solved by a new Amperex development. Tubes incorporating the development are already in production.

Cumbersome containers, pressurized housings, oil baths and other devices which added heavily to weight, size, cost and operating complication are now eliminated. Tube replacement, often a major operation under old conditions, is now simple and speedy.

Basic to the advance is the conception of an all-in-one tube and socket combination and the use of the combination as a single operating unit with the complete exclusion of air. This, for the first time in practical fashion, eliminates the uncertainties of air as a dielectric and substitutes the advantage of solid dielectrics. The units are thus totally independent of outside influences which caused previous open designs to fail.

After the theoretical solution of the many problems involved and the making of scores of one-at-a-time prototypes for thorough testing, several novel manufacturing techniques were developed to place the new tube units on a production basis to insure extremely reasonable costs and fast delivery. These shop practices are a natural outgrowth of a quarter century of Amperex experience in electronic tube manufacture and the manipulation of materials to close tolerances.

IMMEDIATE USE SEEN IN INDUSTRIAL FIELDS

Industrial equipment designers and manufacturers are expressing "down-to-earth" interest in the new Amperex application developed for use at high altitudes.

Most frequently asked question is: "How about the general run of 'standard' tube types? Can they be produced with the advantages of this development?"

The answer is "Yes!"

And it is being done. The development can be applied to the major number of the 340 Amperex tubes now made and catalogued. Included are practically all wanted industrial types.

Many sea-level conditions such as dust, moisture, temperature and pressure limit full, safe and efficient tube operation. They shorten tube life and increase operating costs. The new Amperex application which makes the tube unit entirely independent of all significant external atmospheric and pressure conditions fills a broad need and furnishes the answer to many problems facing designing engineers. Inquiries on specific problems are solicited.

AMPEREX RECTIFIER HAR-3 GIVES UNVARYING SEA-LEVEL PERFORMANCE IN OPEN AT ALL PRESSURE, DUST, RADIATION, ICING AND TEMPERATURE EXTREMES TO 60,000 FOOT ALTITUDE

Challenging implications of the new Amperex application to equipment designers and engineers confronted with the necessity for utmost safety and feliability under extreme conditions of pressure, dust, cosmic ray bombardment, icing and temperature are illustrated in the Amperex HAR-3 now in production.

Characteristics apply to operation in the open at any altitude from sea level to 60,000 feet and to any rate of change in altitude.

The tube, a high vacuum, half-wave rectifier rated at 14,000 volts peak inverse, is fully able to handle voltages as high as 35,000 peak.

Average plate current delivery is 125 ma. Tube voltage drop at 100 ma. is 200 volts.

The molybdenum anode, coated with zirconium to provide substantial and continuous *additional* gettering, dissipates an average of 75 watts. The "hard" glass envelope is able to operate continuously at 204°C.

In excess of 2.0 amperes of useful peak emission is supplied by the thoriated tungsten filament when pulsed at 4.000 volts peak. It is rated at 5.0 volts and 10.0 amps.

Dimensions and other information are given under the photograph.

READY FOR YOU:

General technical bulletin on this new Amperex advance, technical rating and data sheets or individually prepared reports on specific industrial sea-level applications.

APPLICATION ENGINEERING DEPARTMENT

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

AMPEREX

electronics

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JULY • 1948

V-2 ELECTRONIC CONTROL ..... Cover
Servo-amplifier unit controls 300-lb nose section of giant rocket, orienting it in azimuth and elevating ultra-violet spectrograph so that missile always points toward the sun (U. S. Navy photos)

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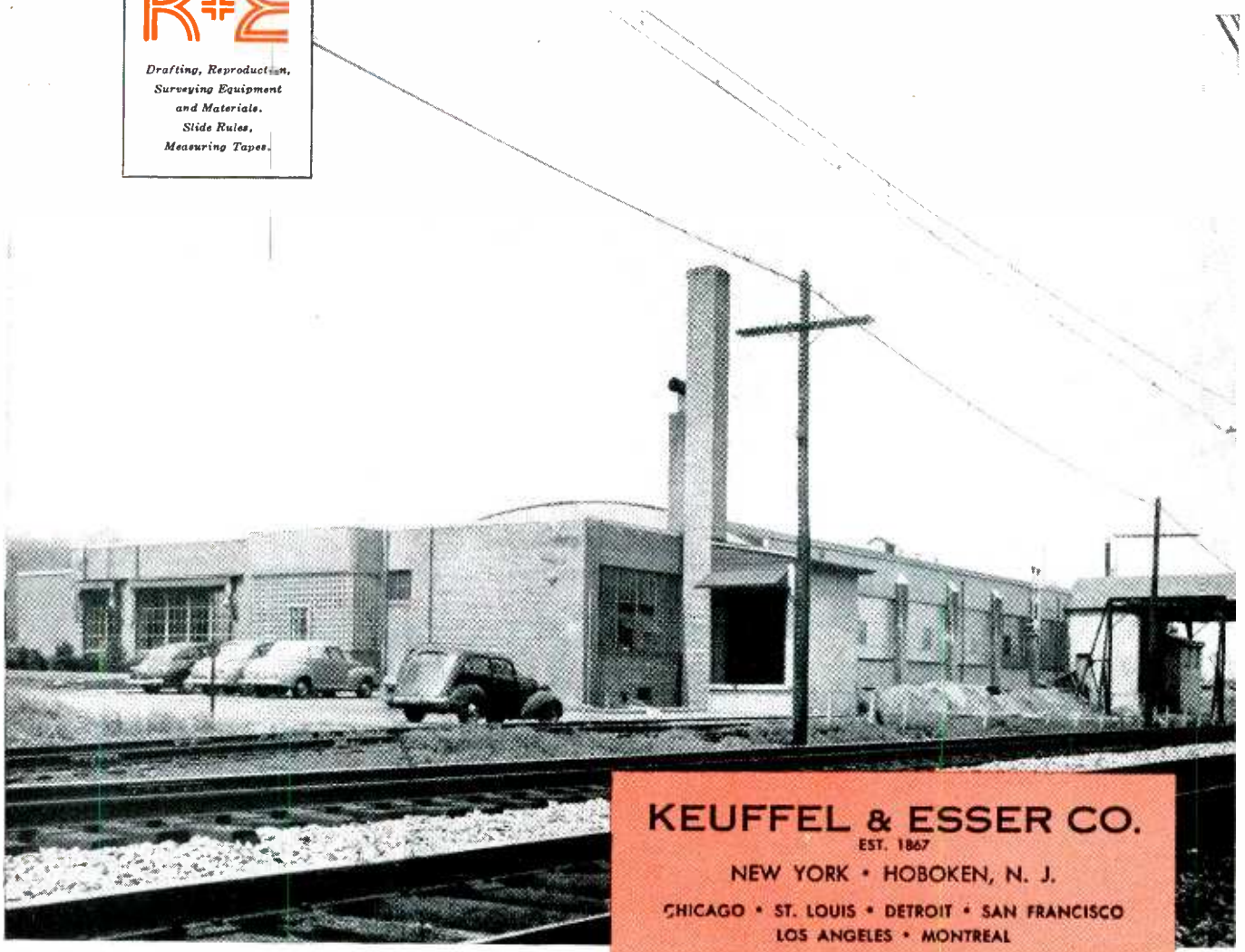
Drafting, Reproduction, Surveying Equipment and Materials. Slide Rules, Measuring Tapes.



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NEW YORK • HOBOKEN, N. J.
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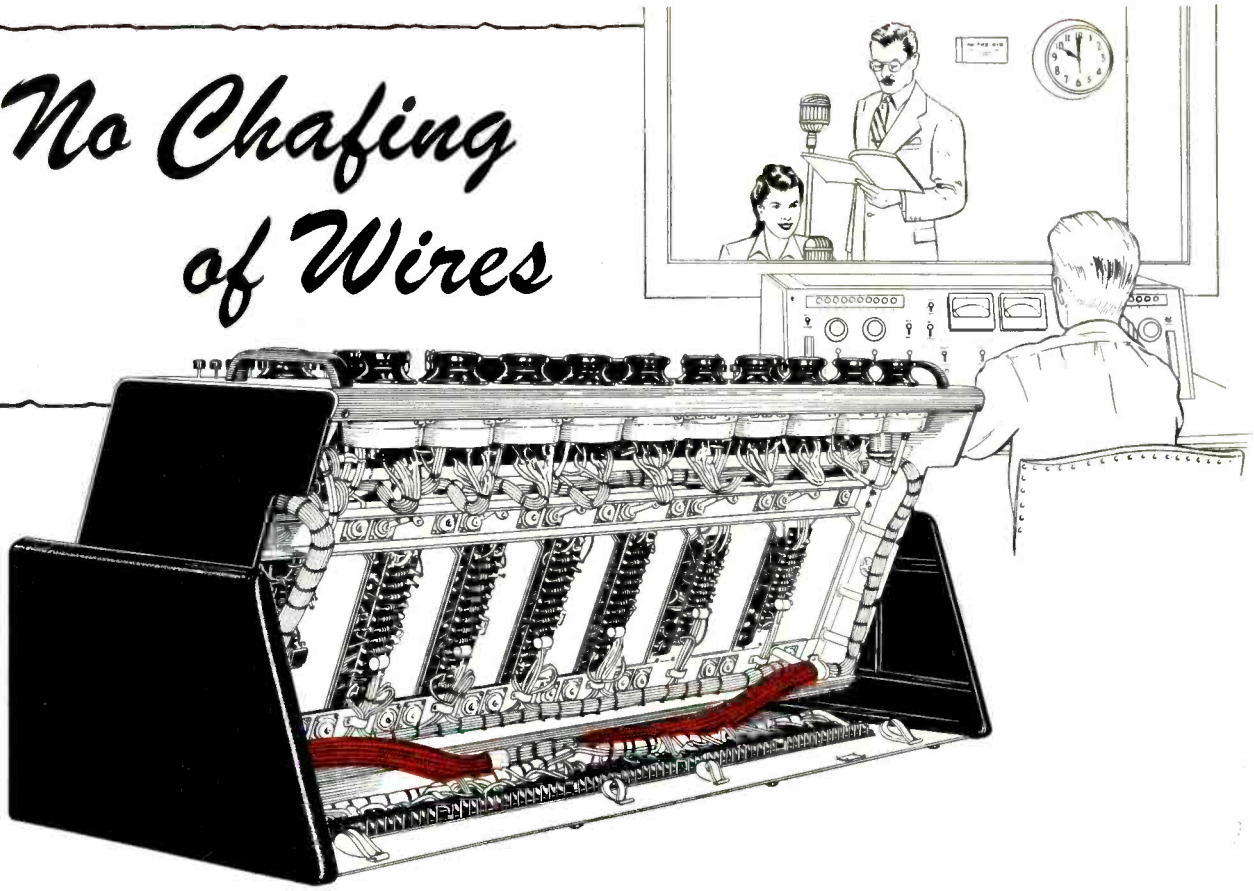
No Chafing of Wires



A tilting chassis is a unique feature of this broadcasting studio control made by Collins Radio Company. In rugged laboratory tests, Collins engineers found that the tilting of the chassis caused wires to be chafed. They knew the flexibility of BH Extra Flexible Fiberglas Sleeving from other applications . . . decided to try it in this console.

Here is what they found:

"BH Fiberglas Sleeving actually cables the wires together loosely, permitting greater flexibility than would be the case with tightly tied cable.

"When the chassis is tilted up for servicing, and tilted down again, BH Fiberglas Sleeving protects individual wires from abrasion. It actually takes the chafing strain upon itself."

If insulation breakdown is a problem in your plant or product, try this remarkable insulation — heat resistant to 1200°F. if required. Because no hardening varnish or lacquer is used in its manufacture, BH Fiberglas Sleeving stays flexible as string, cuts without fraying, does not deteriorate. Let us give you full details.

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-24, 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 _____

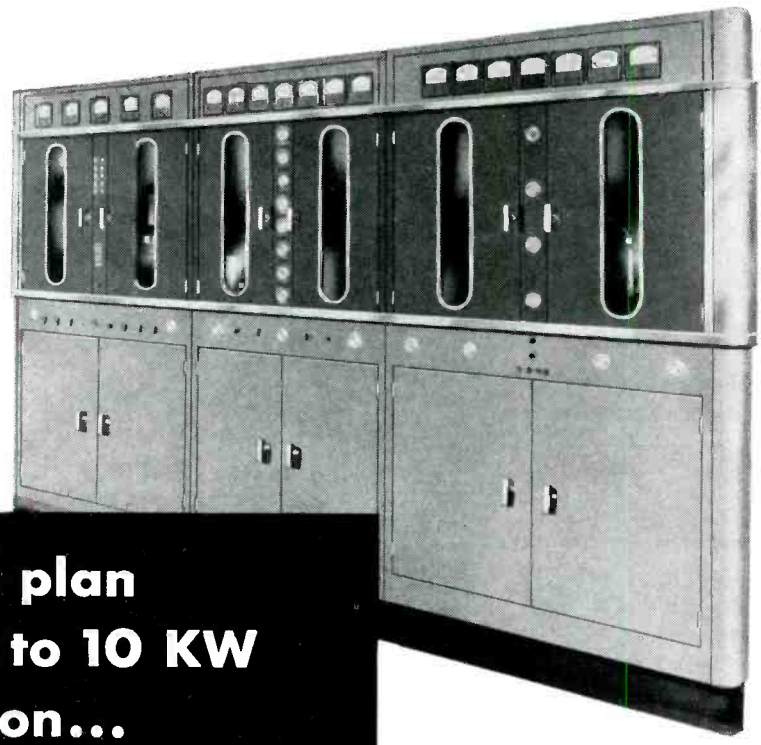
ADDRESS _____

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

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

If you want a 5 KW AM Transmitter right away...

. . . you can get immediate shipment from stock on the famous Western Electric 405B-2 utilizing the Doherty high-efficiency circuit.



If you plan to step up to 10 KW later on...

. . . you can order a complete conversion kit for change-over in the field. Kits are available also to present users of the 405B-1 and 405B-2.

AUXILIARY EQUIPMENT FOR USE WITH THE 405B-2 5 KW TRANSMITTER

33C ANTENNA CONTROL UNIT
Identical in styling with the 405B-2 Transmitter, the 33C controls, under power, the relative magnitude and phase relation of the element currents in a two-tower antenna system. 34A Antenna Phase Control Units may be added for control of a larger number of towers.

CONTROL DESK
Incorporates volume indicator panel, monitor amplifier, meter panel, audio line and announce control panel, power switch panels for controlling transmitter circuits.

When you buy a Western Electric 405B-2 5 kw AM Transmitter, you get these outstanding advantages:

The Doherty *high-efficiency* circuit permits attainment of *extremely low* noise, harmonic distortion and intermodulation distortion. The negligible carrier shift assures full utilization of assigned carrier power.

With low level modulation, no damage will result if the transmitter should be heavily overmodulated with either interrupted or continuous tone at any audio frequency, *even for extended periods.*

Compact design permits installation in relatively small space. Modern styling harmonizes with any architectural treatment.

You get these—and many other features—when you buy a 405B-2. And . . . you can get one *without waiting*—convert it later to 10 kw if you step up your power! For full information, call your local Graybar Broadcast Representative—or write Graybar Electric Company, 420 Lexington Ave., New York 17, N. Y.

Western Electric

—QUALITY COUNTS—

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1 Beautiful Streamlined Instrument.

2 Large 5½" Meter In Special Molded Case Under Panel.

3 Resistance Scale Markings From .2 Ohm To 100 Megohms . . . Zero Ohms Control Flush With Panel.

4 Only one Switch . . . Has Extra Large Knob 2½" Long . . . Easy To Turn . . . Flush With Panel Surface.

Precision first . . . to Last

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IN V.O.M. HISTORY

IMPROVEMENTS

MODEL 630

$37.50 U.S.A. Dealer Net

Leather Carrying Case $5.75
ADAPTER PROD FOR TV
HIGH VOLTAGE TESTS EXTRA

5 **New Molded Selector Switch** . . . Contacts Are Fully Enclosed.

6 **Unit Construction** . . . Resistors, Shunts, Rectifier, Batteries All Are Housed In A Molded Base Built Right Over The Switch . . . Provides Direct Connections Without Cabling . . . No Change For Shorts.

7 **All Resistors** Are Precision Film Or Wire Wound Types . . . For Permanent Accuracy.

8 **Batteries** Easily Replaced . . . New Double Suspended Contacts.

New Selector Switch Assembly

Note entire enclosed contacts . . . for the first time in any radio service test equipment . . . will retain lubrication without dust contamination.

5

TECH DATA

D.C. VOLTS: 0-3-12-60-300-1200-6000, at 20,000 Ohms/Volt

A.C. VOLTS: 0-3-12-60-300-1200-6000, at 5,000 Ohms/Volt

D.C. MICROAMPERES: 0-60, at 250 Millivolts

D.C. MILLIAMPERES: 0-1.2-12-120, at 250 Millivolts

D.C. AMPERES: 0-12, at 250 Millivolts

OHMS: 0-1000-10,000; 4.4 Ohms at center scale on 1000 scale; 44 Ohms center scale on 10,000 range.

MEGOHMS: 0-1-100 (4400-440,000 at center scale)

DECIBELS: —30 to +4, +16, +30, +44, +56, +70

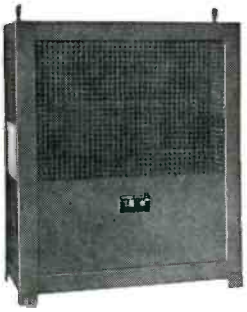
OUTPUT: Condenser in series with A.C. Volt ranges

BLUFFTON, OHIO

3-Phase Regulation

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

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



Extra Heavy Loads

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

General Application

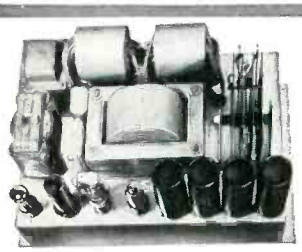
MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
150	25 - 150	0.5%
250	25 - 250	0.2%
500	50 - 500	0.5%
1000	100-1000	0.2%
2000	200-2000	0.2%

400-800 Cycle Line

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

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

Other capacities also available



The NOBATRON Line

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

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

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The First Line of standard electronic AC Voltage Regulators and Nobatrons

GENERAL SPECIFICATIONS:

- Harmonic distortion max. 5% basic, 2% "S" models
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- Output adjustable bet. 110-120: 220-240 (—2 models)
- Recovery time: 6 cycles: ± (9 cycles)
- Input frequency range: 50 to 65 cycles
- Power factor range: down to 0.7 P.F.
- Ambient temperature range: —50°C to +50°C

All AC Regulators & Nobatrons may be used with no load.

*Models available with increased regulation accuracy.

Special Models designed to meet your unusual applications.

Write for the new Sorensen catalog. It contains complete specifications on standard Voltage Regulators, Nobatrons, Increvolts, Transformers, DC Power Supplies, Saturable Core Reactors and Meter Calibrators.

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Represented in all principal cities.

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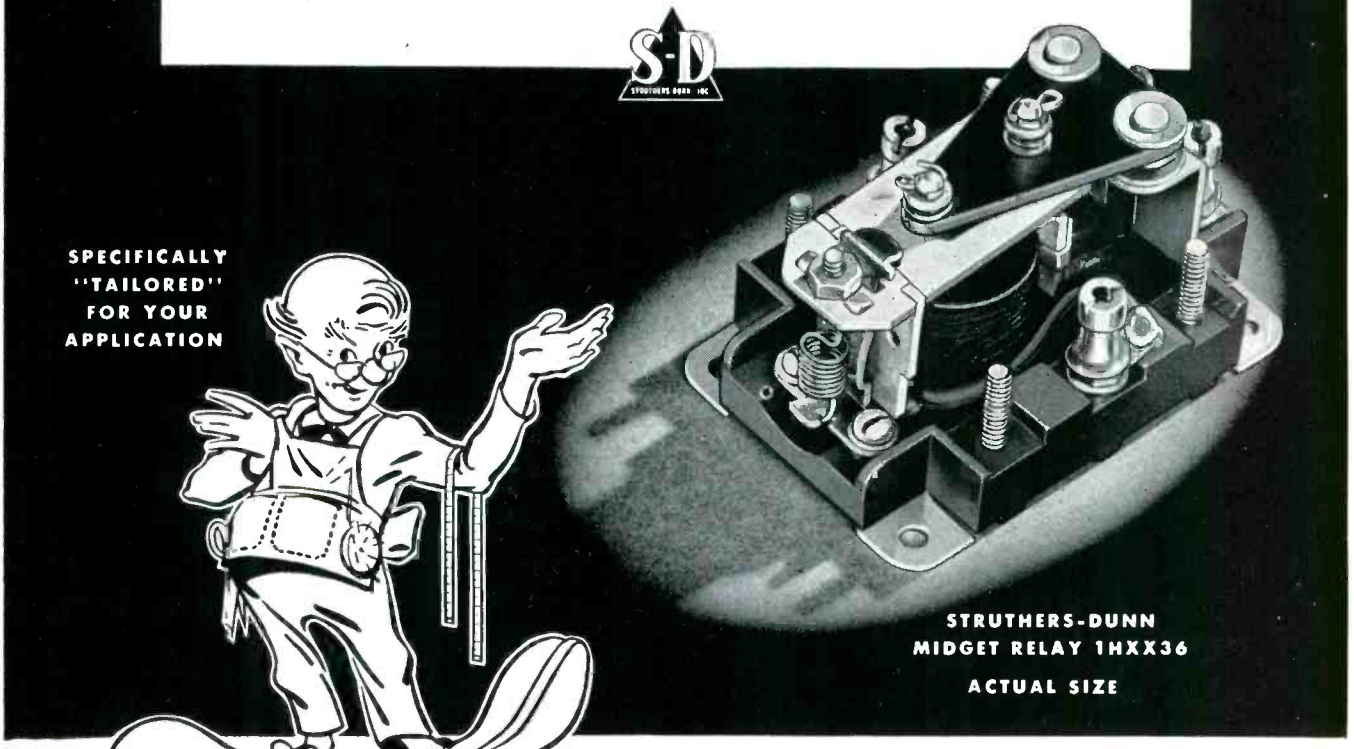
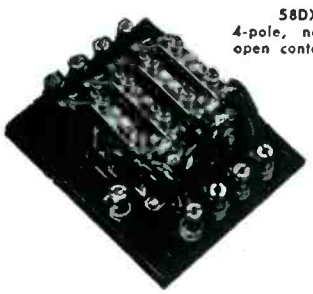


CONSERVATIVELY RATED AT 15 AMPERES, 115 VOLT AC.

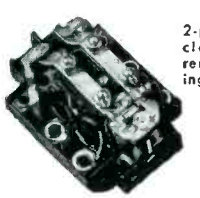
This little relay, only 1⅞" x 2¾" x 2" is made for trouble-free performance on a long list of heavy-duty control applications. Single-pole, single-throw, double-break ⅜" diameter fine silver contacts. Underwriters approved.

Hundreds of other Struthers-Dunn Midget Relays in both AC and DC types are available for practically any control need. Small as they are, however, in no case have dependability and durability been sacrificed merely to obtain compactness.

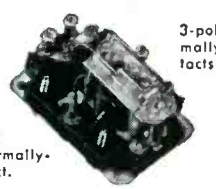
OTHER POPULAR STRUTHERS-DUNN MIDGET RELAY TYPES



58DXX
4-pole, normally-open contacts.

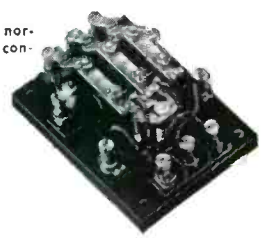


1XXB12
2-pole, normally-closed contacts, removable mounting.



1HXX
1-pole, normally-open contact.

1XBA
3-pole, DT, normally-closed contacts.



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Multicore

is worth "more" because it speeds up your assembly line. Multicore melts rapidly; wets metals faster; makes perfect joints possible on difficult metals and alloys, even if oxidized or corroded . . . Cuts down rejects on the production line!

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is worth "more" because it helps to insure the good name of your product. Continuity of the flux stream is guaranteed; prevents "dry" high resistance joints, reducing incidents of set failure.

Soldered joints made with Multicore do not corrode, even after prolonged exposure to varying temperatures and humidities.

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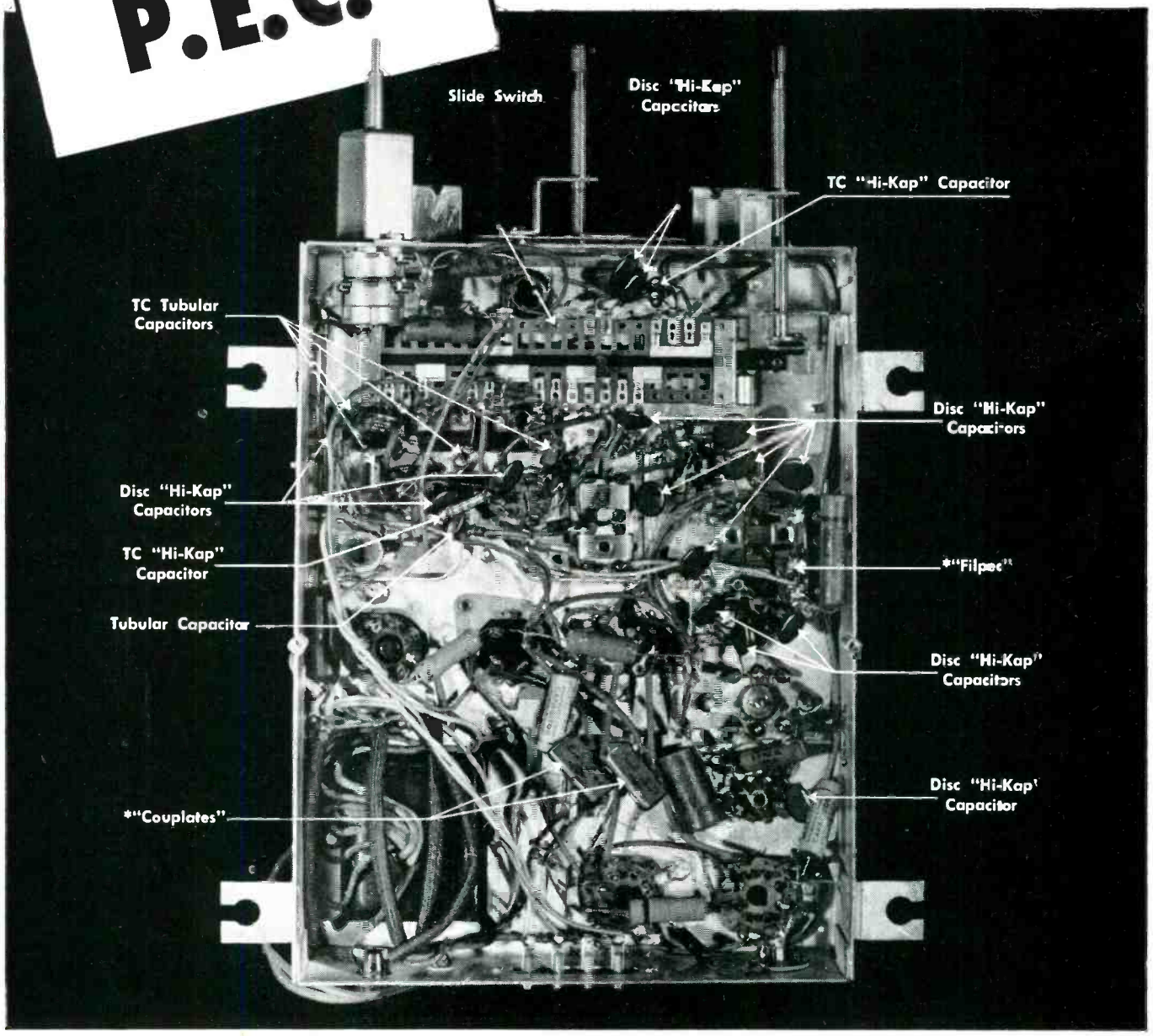
PROGRESS REPORT ON P.E.C.*

How Stewart-Warner uses two "Couplates", one "Filpec" plus other Centralab components in compact chassis design.



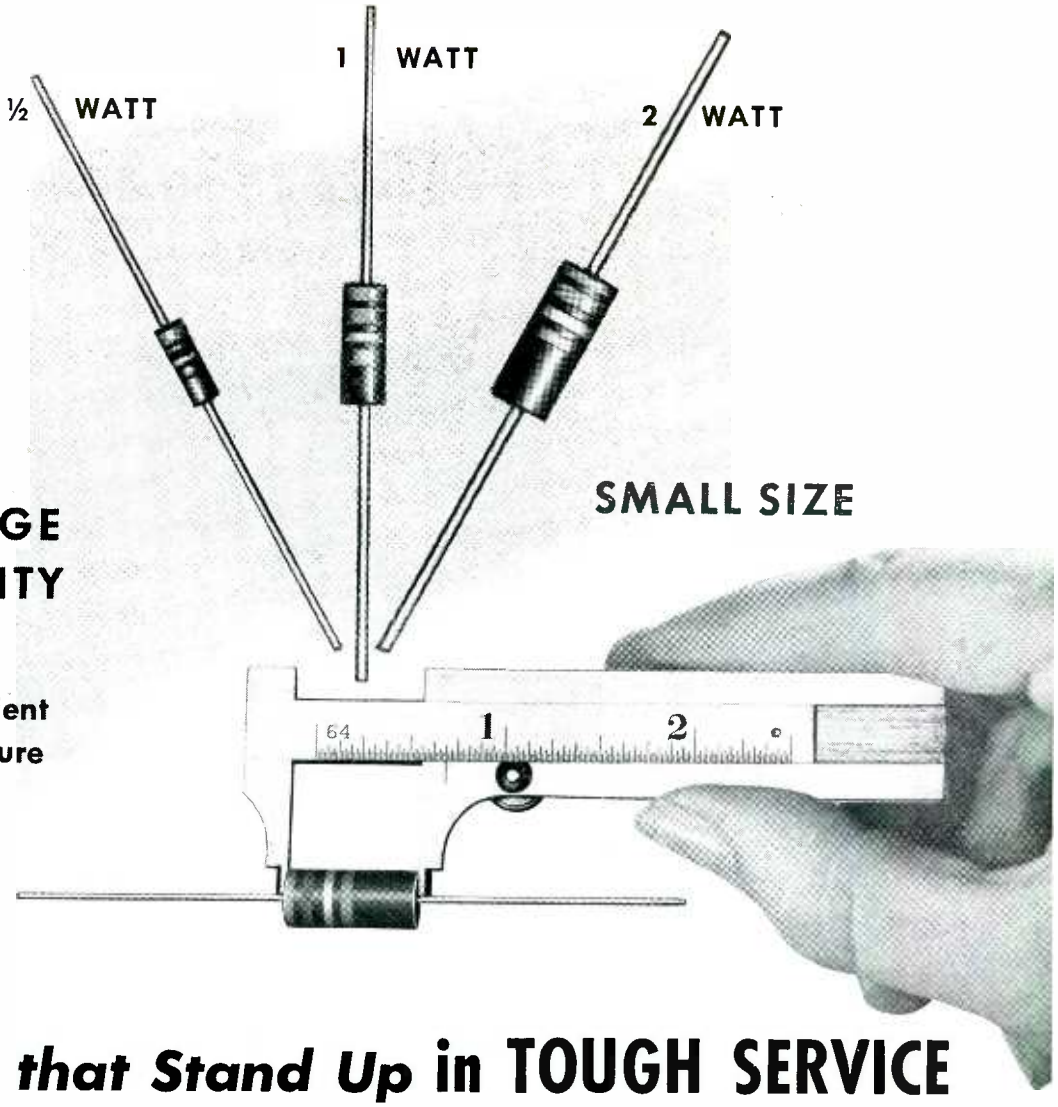
Chassis Courtesy Stewart-Warner Corp.

***Centralab's "Printed Electronic Circuit" — Industry's newest method for improving design and manufacturing efficiency!**

SIMPLIFIED wiring and assembly . . . fewer individual components . . . fewer leads to be soldered—these are just a few of the advantages you get when you use CRL's *Printed Electronic Circuits*. That's why Stewart-Warner has turned to CRL's *Couplate* (printed interstage coupling plate) and *Filpec* (printed electronic circuit filter). And that's why you will want to see and test this amazing new electronic development. But that's not all! For quality performance, dependability and long life, Stewart-Warner uses Centralab's *Slide Switch*, Ceramic Disc and Tubular *Hi-Kap* Capacitors. For all the facts about Centralab's advanced line of components, see your nearest CRL Representative, or write direct.

LOOK TO **Centralab** IN 1948

Division of GLOBE-UNION, INC., *Milwaukee*



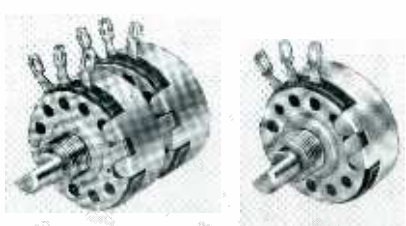
BIG WATTAGE CAPACITY

at

70C Ambient Temperature

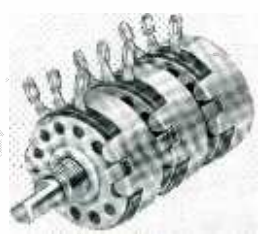
SMALL SIZE

RESISTORS *that Stand Up* in TOUGH SERVICE



TYPE J BRADLEYOMETERS
in 1, 2, and 3 section types

For continuously adjustable resistors—in 1, 2, or 3 section types—specify Type J Bradleyometers. They meet any resistance-rotation curve specification... and, being solid-molded, there is no change due to age or use. Furnished with line switch if desired.



Fixed resistors are usually rated at ambient temperatures of 40C. But Bradleyunit resistors are rated at 70C ambient temperature. At this high temperature, Bradleyunits . . . in ½-watt, 1-watt, and 2-watt ratings . . . operate at full rating for 1000 hours with less than 5% resistance change.

Bradleyunits require no wax impregnation to pass salt water immersion tests, and have high mechanical strength and permanent electrical characteristics.

Available in all standard R.M.A. values as follows: ½-watt and 2-watt sizes from 10 ohms to 22 megohms; 1-watt size from 2.7 ohms to 22 megohms. We shall be glad to send you an A-B resistor chart.

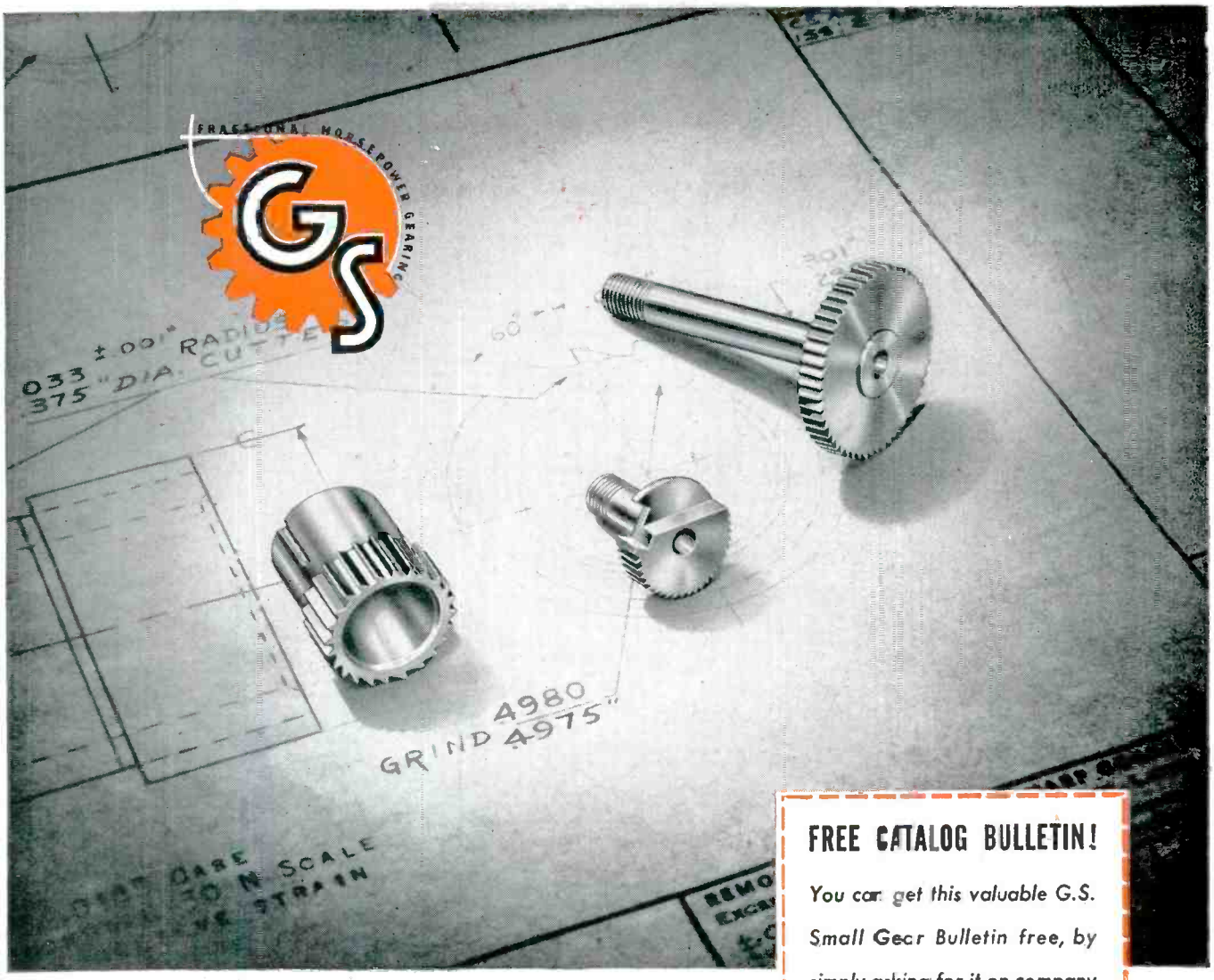
Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis.

A-B Quality

ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY



GET THE ADVANTAGE OF *SPECIAL* FACILITIES

AS our company name implies, we *SPECIALIZE* in the manufacture of small Gears. This has been a basic policy of ours for more than *thirty years!* During that long period of time, every conceivable effort has been made to produce the *world's finest* Fractional Horsepower Gears. Men and methods and machinery have been developed and co-ordinated to a degree of perfection unequalled, we believe, in the history of the industry. All these extensive, highly specialized facilities are available to those who need Small Gears of finer, *more uniform* quality in economical "production runs". More and more of our country's most particular buyers are specifying "G. S. Small Gears" exclusively. May we serve you too . . real soon?

FREE CATALOG BULLETIN!

You can get this valuable G.S. Small Gear Bulletin free, by simply asking for it on company stationery. Send for a copy now, and discuss your needs with our skilled engineers.

GEAR Specialties

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

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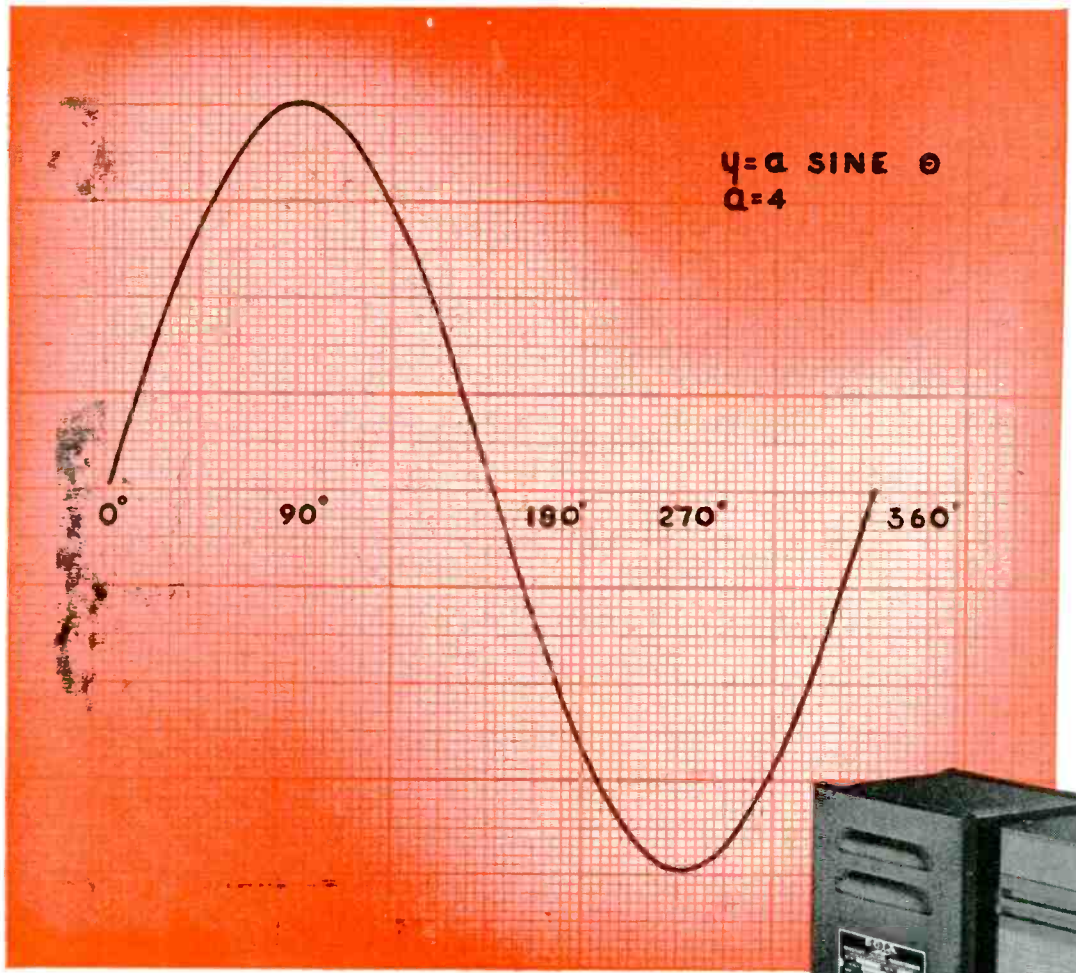
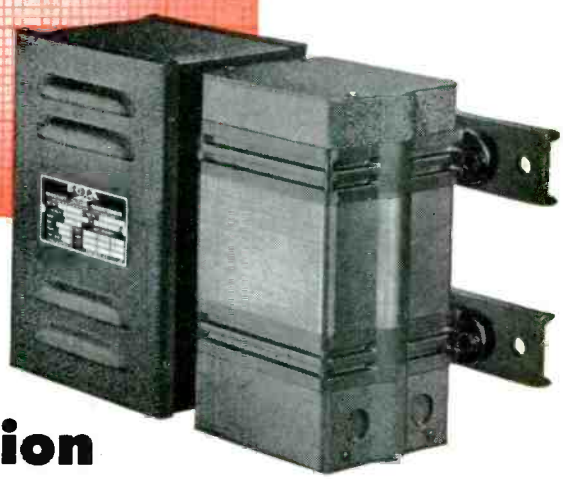
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS





CONSTANT VOLTAGE
with low harmonic distortion

TYPE CVH, an important newcomer in a famous line —a SOLA CONSTANT VOLTAGE Transformer designed for use with equipment that requires a source of undistorted voltage. These new transformers, available in 250, 500 and 1,000 VA capacities, provide all of the voltage stabilizing characteristics of the standard SOLA Constant Voltage Transformer, with less than 3% harmonic distortion of the output voltage wave.

Since the output voltage wave is essentially sinusoidal, these transformers may be used for the most exacting applications such as general laboratory work, instrument calibration, precision electronic equipment or other equipment having elements which are sensitive to power frequencies harmonically related to the fundamental.

As in all SOLA Constant Voltage Transformers the regulation is automatic and instantaneous. There are no moving parts, no manual adjustments and every unit is self-protecting against short circuit.

Type CVH represents an outstanding advance in automatic voltage regulation and an important contribution to precise electronic equipment.

WRITE FOR THESE BULLETINS

DCVH-136—*complete electrical and mechanical characteristics of the new Type CVH Constant Voltage Transformers.*

DCV-102 — *complete engineering handbook and catalog of standard Constant Voltage Transformers available for remedial or built-in applications.*

SOLA *Constant Voltage* **TRANSFORMERS**

Transformers for: Constant Voltage • Cold Cathode Lighting • Airport Lighting • Series Lighting • Fluorescent Lighting • Luminous Tube Signs Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • **SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois**

Manufactured under license by: ENDURANCE ELECTRIC CO., Concord West, N. S. W., Australia • ADVANCE COMPONENTS LTD., Walthamstow, E., England UCOA RADIO S.A., Buenos Aires, Argentina • M. C. B. & VERITABLE ALTER, Courbevoie (Seine), France

IN THE BATTLE FOR THE LISTENER'S EAR...

Here's increased coverage for your station!

with the new

LIMITING AMPLIFIER

FITS neatly into your audio cabinet—attractive, sturdy, quiet. But what a *wallop* it packs when you want attention from Mr. Big—the listener!

Based on engineering developments by CBS engineers, the Limiting Amplifier has been designed by General Electric to give you greater coverage and more potential listeners without changing your present transmitter or antenna.

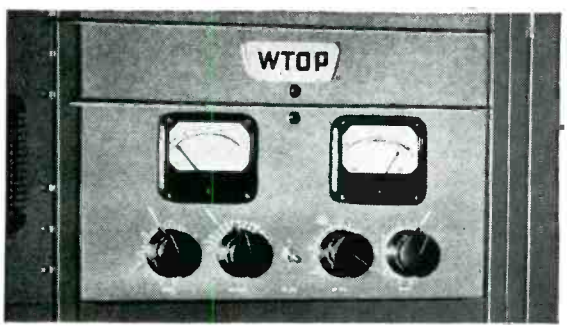
For more information, call your nearest G-E broadcast equipment representative, or write us. *General Electric Company, Transmitter Division, Electronics Park, Syracuse, New York.*

MEMO TO STATION MANAGERS:

- Increases modulation and thus makes signal reach farther, sound clearer.
- Raises effective signal strength—this means increased coverage.
- Low installation cost—quickly, easily mounted in G-E Audio Cabinet Rack.
- In FM, too—protect your listeners against receiver distortion caused by transmitter overswing. Dynamic range, so important in FM, is maintained.

MEMO TO ENGINEERS:

- Increases average level of modulation as much as 8 to 10 db.
- Anticipatory circuit prevents overmodulation—even on the first half cycle of the overmodulation peak. Automatic recovery time improves program fidelity!
- Prevents distortion and adjacent channel splatter.
- G-E popular hinged panel construction—easy to get at.
- Vertical mounted for better ventilation.



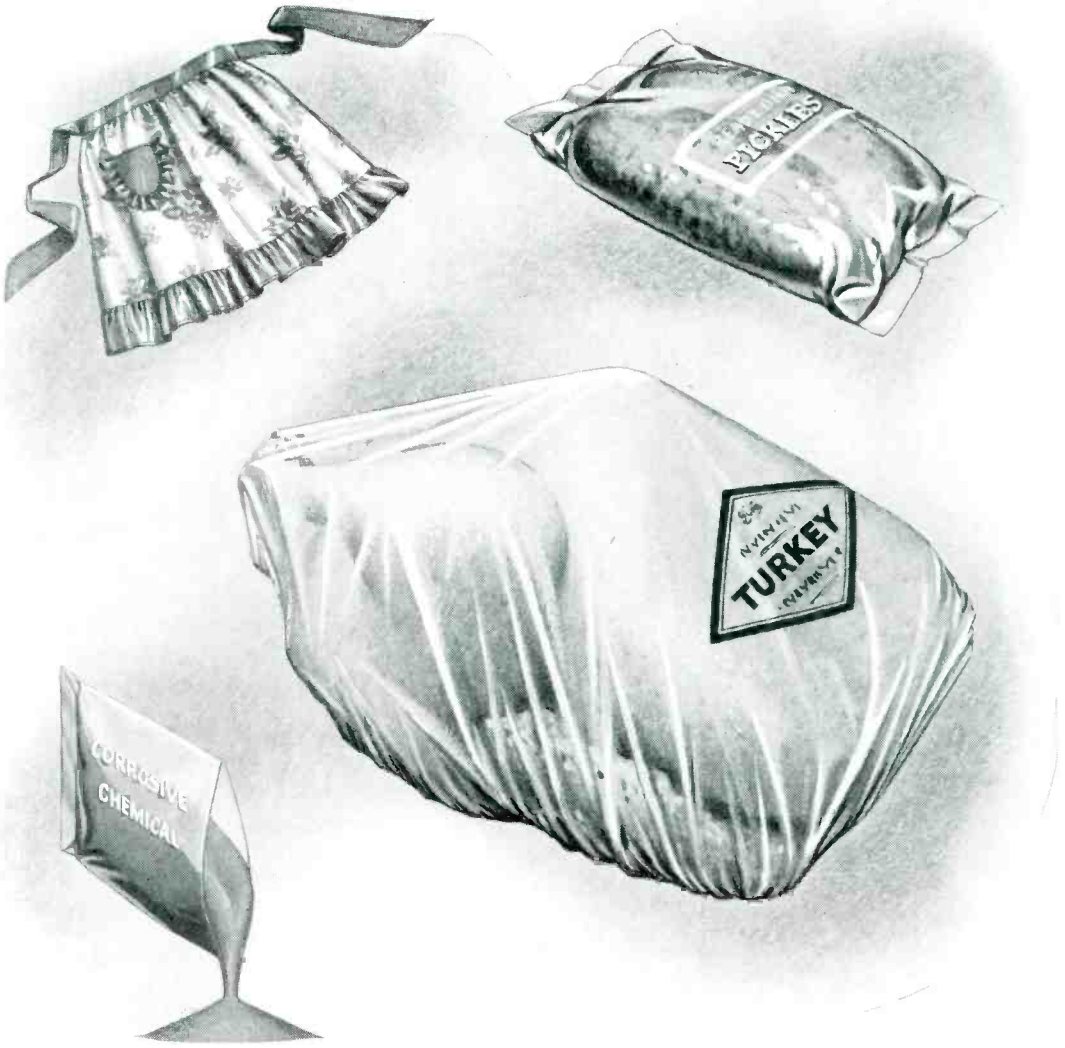
G-E Limiting Amplifier at the 50,000 watt transmitter of WTOP, Washington, D. C.

LEADER IN RADIO TELEVISION AND ELECTRONICS

GENERAL ELECTRIC

160-G2A-6914

FOOD . . . CHEMICALS . . . CONSUMERS . . .



EVEN WHEN STRETCHED several hundred per cent, Plax Polyethylene sheet is tough, moisture-proof, odorless, tasteless, and pleasing to touch.

An ideal material for food packaging, it protects goodness without hiding it. Chemical inertness makes it an effective wrapper for everything from food to corrosive chemicals. These qualities, plus color, have led to its wide use in the home—as aprons, clothes bags, bowl covers, etc.

Plax also supplies Polyflex* Sheet and Film, and cellulose acetate, cellulose acetate butyrate and ethyl cellulose sheet and film. To be sure you have the complete story about Plax products, please write for details.

*T.M. reg. U. S. Pat. Off.

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NOT SUBSTITUTES···IMPROVEMENTS

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In Canada – Canadian Industries, Ltd., Montreal

Specify HI-Q COMPONENTS for UNIFORMITY . . .

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

HI-Q DISK CAPACITORS

BPD Where space is a factor and the physical shape is more adaptable than tubular unit try these **HI-Q** Disk Capacitors. Another example of accurate dependable miniaturization, this high dielectric by-pass, blocking or coupling **HI-Q** Disk Capacitor has many applications. Available in three standard capacities. Type BPD-5: .005 mfd. guar. min. Type BPD-10: .01 mfd. guar. min. Type BPD-1.5: .0015 mfd. guar. min.

Illustration at right is actual size.

HI-Q MINIATURE G. P. TUBULARS

G.P. By the use of our new Body 41, 5 mmf to 33,000 mmf capacity ranges are now available which will cover the majority of your by-passing problems. These **HI-Q** Miniature G. P. Tubulars also provide closer coupling of leads thus insuring minimum inductance and highest self resonant frequencies.

Illustration at left is actual size.

HI-Q COMPONENTS BETTER 4 WAYS

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

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

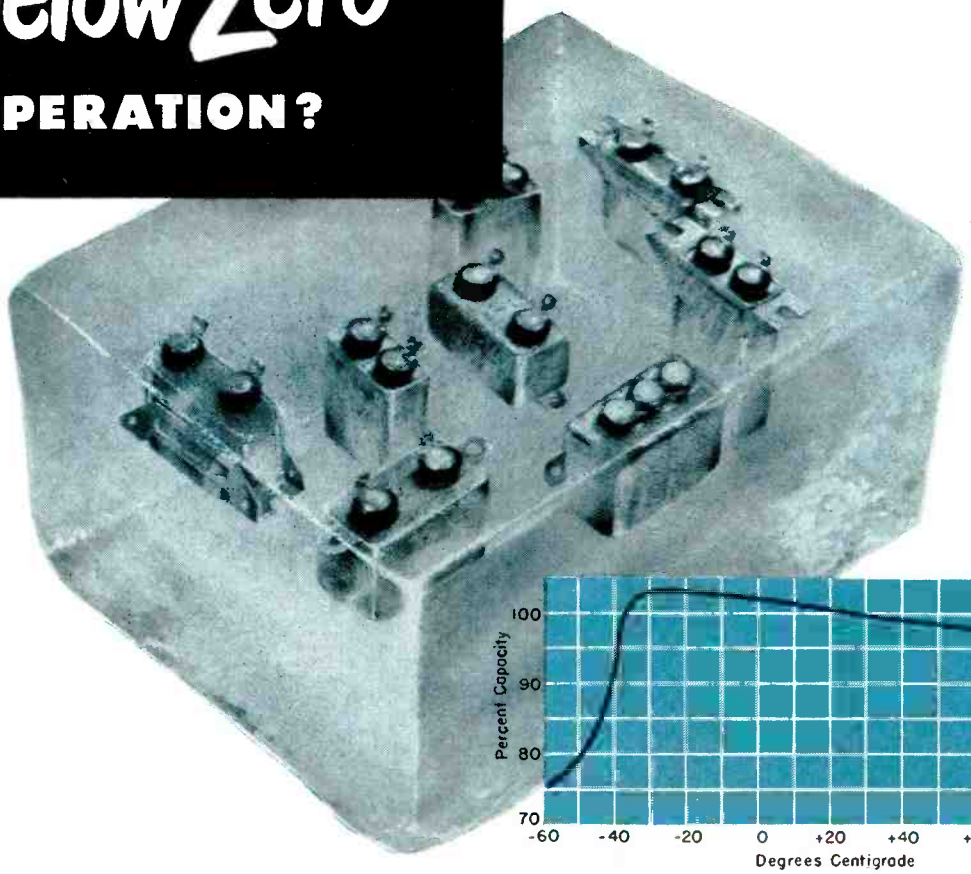
DEPENDABILITY Interpret this factor in terms of your customers' satisfaction . . . Year after year of trouble-free performance. Our Hi-Q makes your product better.

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

HI-Q Electrical Reactance Corp.
FRANKLINVILLE, N. Y.

Plants: FRANKLINVILLE, N. Y. — JESSUP, PA.
Sales Offices: NEW YORK, PHILADELPHIA, DETROIT, CHICAGO, LOS ANGELES

D-C CAPACITORS FOR Below Zero OPERATION?



Take advantage of the small size and light weight of Pyranol® d-c capacitors for those applications in freezing temperatures and below. No need to penalize your designs with oversize capacitors resulting from the use of other dielectrics.

Pyranol capacitors, as improved in recent years, are not only suitable for operation at temperatures up to 85C, but can also be operated at temperatures down to —40C. Throughout this wide temperature range, the capacitance remains within plus or minus 5% of its 25C value.

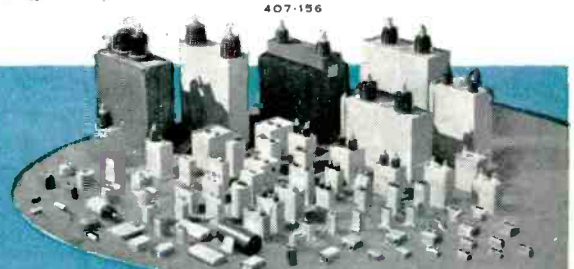
Here are some of the advantages you'll secure by using Pyranol capacitors—styles 50 through 69 like those pictured above—built to commercial standards:

- Size is smaller.
- Most commercial standard ratings can be shipped from stock.
- Pyranol is non-flammable.
- Like other G-E small capacitors, Pyranol commercial-standard capacitors are hermetically sealed in drawn cases—hot tinned for resistance to corrosion. They use the new silicone-gasketed bushing as insurance against leaks. They are all *individually* tested.

For specifications and details, ask for GEA-2621. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

407-156



Specialty Capacitors FOR

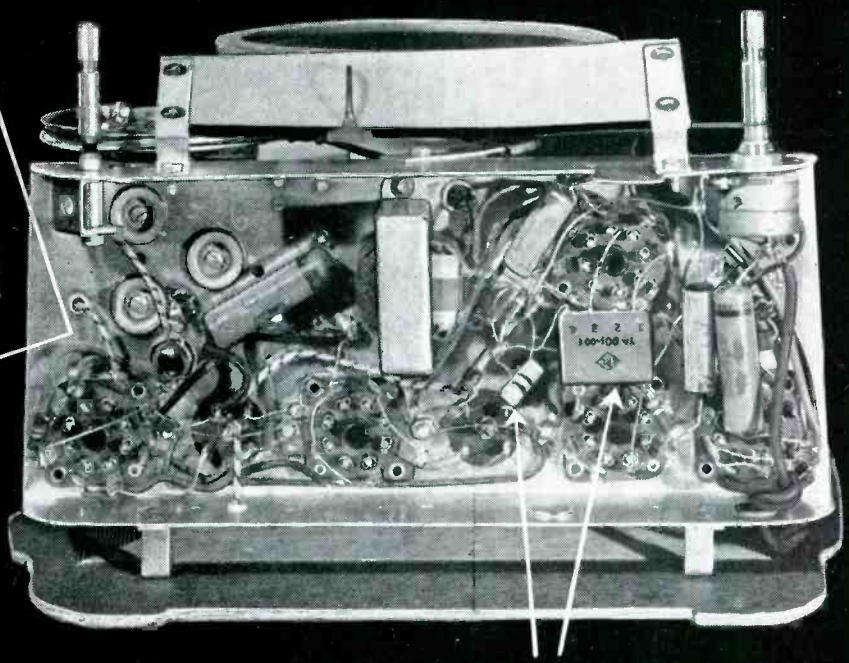
- Motors
- Luminous-tube transformers
- Fluorescent lamp ballasts
- Industrial control
- Radio filters
- Radar
- Electronic equipment
- Communication systems
- Capacitor discharge welding
- Flash photography
- Stroboscopic equipment
- Television
- Dust precipitators
- Radio interference suppression
- Impulse generators

AND MANY OTHER APPLICATIONS

Centralab reports to

JULY 1948

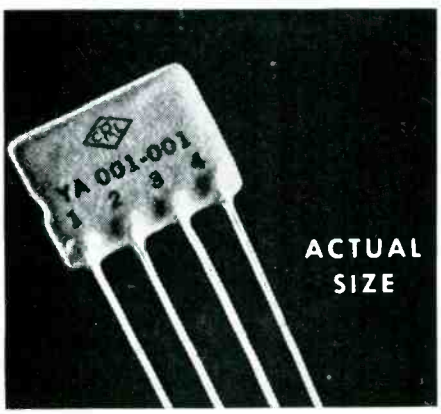
How Sentinel uses two "Printed Electronic Circuit" units to simplify production!



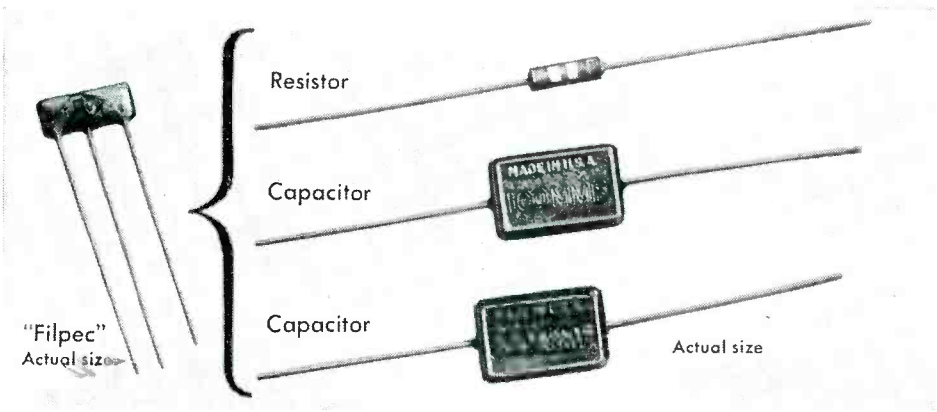
Look closely and you'll see where Sentinel engineers have applied Centralab's "Couplate" and "Filpec" in this special small receiver circuit. Result: important savings in production and space.

Chassis courtesy of Sentinel Radio Corp., Evanston, Ill.

1 Yes, here is a typical illustration of how CRL'S *Printed Electronic Circuits* have simplified wiring and assembly by (1) reducing number of components required, and (2) reducing number of leads to be soldered! That's why Sentinel Radio Corp. has adopted CRL'S *Couplate* (printed interstage coupling plate) and CRL'S *Filpec* (printed electronic circuit filter) — and that's why you'll want to see and test these exciting, new electronic developments.

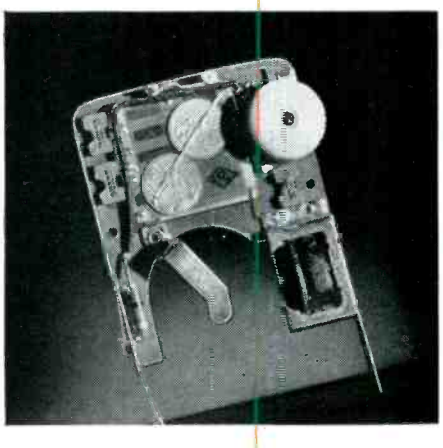


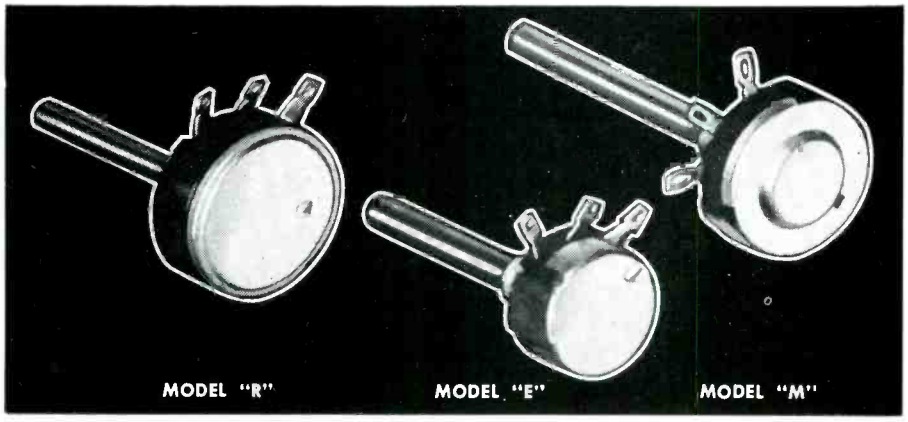
2 CRL'S *Couplate* consists of a plate load resistor, grid resistor, plate by-pass capacitor and coupling capacitor. Write for Bulletin 943.



3 Centralab's *Filpec* is for use as a balanced diode load filter. It combines up to three major components into one tiny filter unit, lighter and smaller than one ordinary capacitor. Also available for other applications. Write for complete information about *Filpec*, as well as other *Printed Electronic Circuits*.

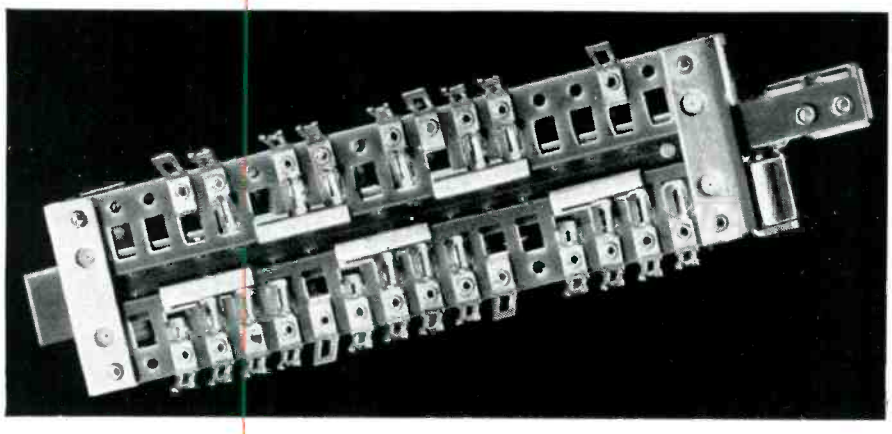
Electronic Industry

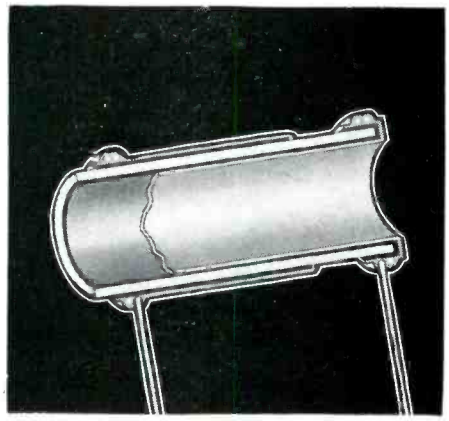




4 Using *PEC*, new Beltone Hearing Aid is smaller, lighter, combines 45 parts, including capacitors and resistors into one compact chassis.

5 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 ¼ watt. Direct contact, 6 resistance tapers. *Model "M"* — composition type, ½ watt. For complete information, write for Bulletin 697.





6 Centralab's revolutionary, new *Slide Switch* offers 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.

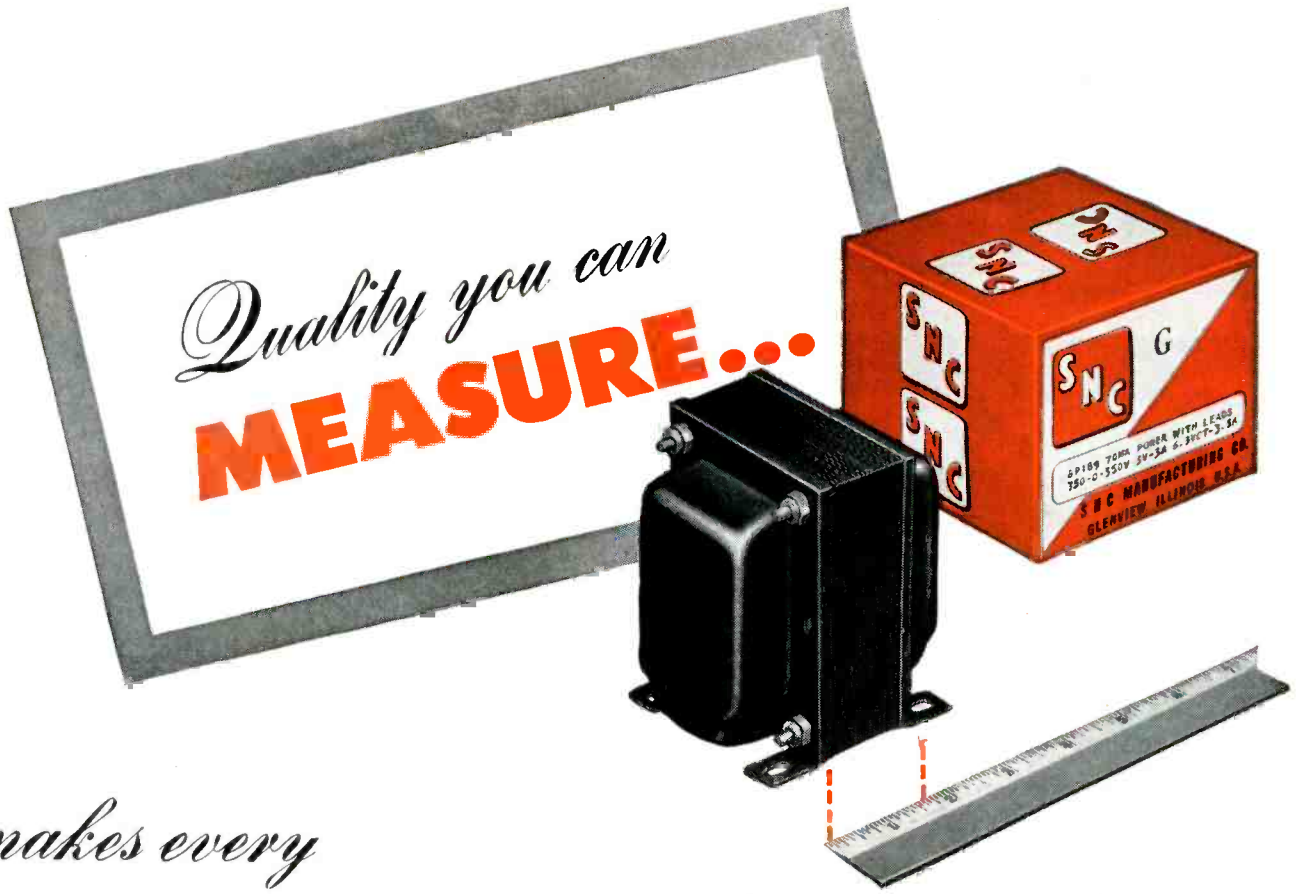
7 High quality, long life, dependability — that's the reason more manufacturers are switching to CRL'S *Hi-Kap* Ceramic Capacitors.

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.



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.

SNC MANUFACTURING CO., INC.

Quality Transformers

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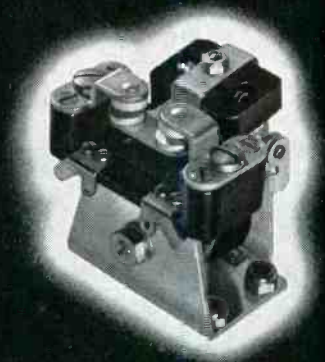
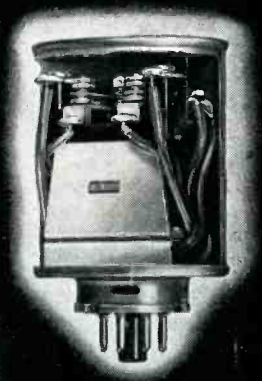
Export Department: 308 W. Washington St., Chicago 6, Illinois, U. S. A.

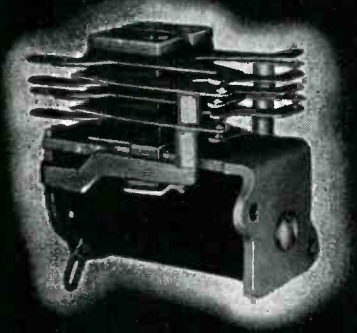
RELAYS OF ADAPTABILITY



Type CN

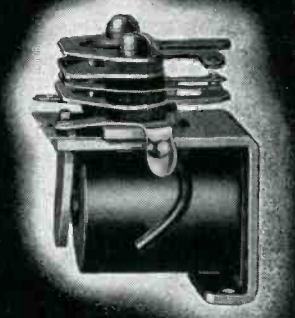


Type BOHO

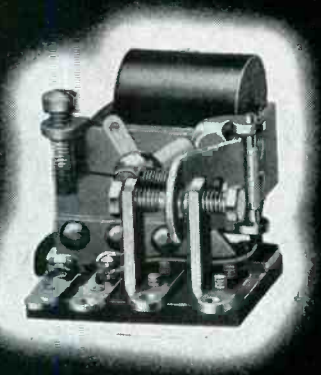


Type SK

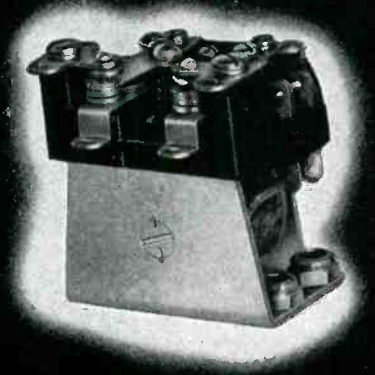
Type BN



Type F



Type BG



Type BO

Thousands of specifications are filled by the complete line of Allied Relays—seven of which are grouped around the Allied emblem of engineering leadership.

Allied Control engineers pioneered the design of relays from signal circuits to 75 ampere contacts, coils from 12 milliwatts to 3½ watts to give the smallest mounting area and accessible wiring facilities.

*Type "BOHO" is D.P.D.T. relay sealed with standard octal plug. Contact rating of 5 to 10 amperes and coil capacity of 115 v. D.C. at 2.5 watts and 220 volts; 25 and 60 cycles at 4.5 volt-amperes.

*Type "CN" is S.P.S.T. double break relay with 50 ampere contacts and coil capacity of 115 v. D.C. at 3.5 watts and 220 volts; 60 cycles at 10.5 volt-amperes.

*Type "BN" is 6 P.D.T. relay with 15 ampere contacts and coil capacity of 115 v. D.C. at 3.5 watts (not available in A.C.).

*Type "BG" is S.P.D.T. relay with 2 ampere contacts and coil capacity of 25 v. D.C. at 50 milliwatts (not available in A.C.)

*Type "BO" is D.P.D.T. relay with 15 ampere contacts and coil capacity of 115 v. D.C. at 2.5 watts and 220 volts; 25 and 60 cycles at 4.5 volt-amperes.

*Type "F" is S.P.D.T. with 2 ampere contacts and coil capacity of 85 v. D. C. at 1.5 watts (not available in A.C.).

*Type "SK" from S.P.S.T. up to 4 P.D.T. with 1 ampere contacts and coil capacity of 60 v. D.C. at 750 milliwatts (for 4 P.D.T. relay) not available in A.C.

Allied Control representatives are located throughout the United States. A short note to our home office will give you the name of our nearest representative.

AL-119

ALLIED CONTROL CO., INC. 2 EAST END AVENUE, NEW YORK 21, N. Y.

RUBBER RECIPE

Rubber compounds to the tune of some 35 million pounds a year go into Bell System plant. Each compound must meet many requirements for resistance to humidity, oxygen, ozone, light and abrasion. The right properties depend on skillful selection and compounding of ingredients; this is one of the jobs of Bell Laboratories.

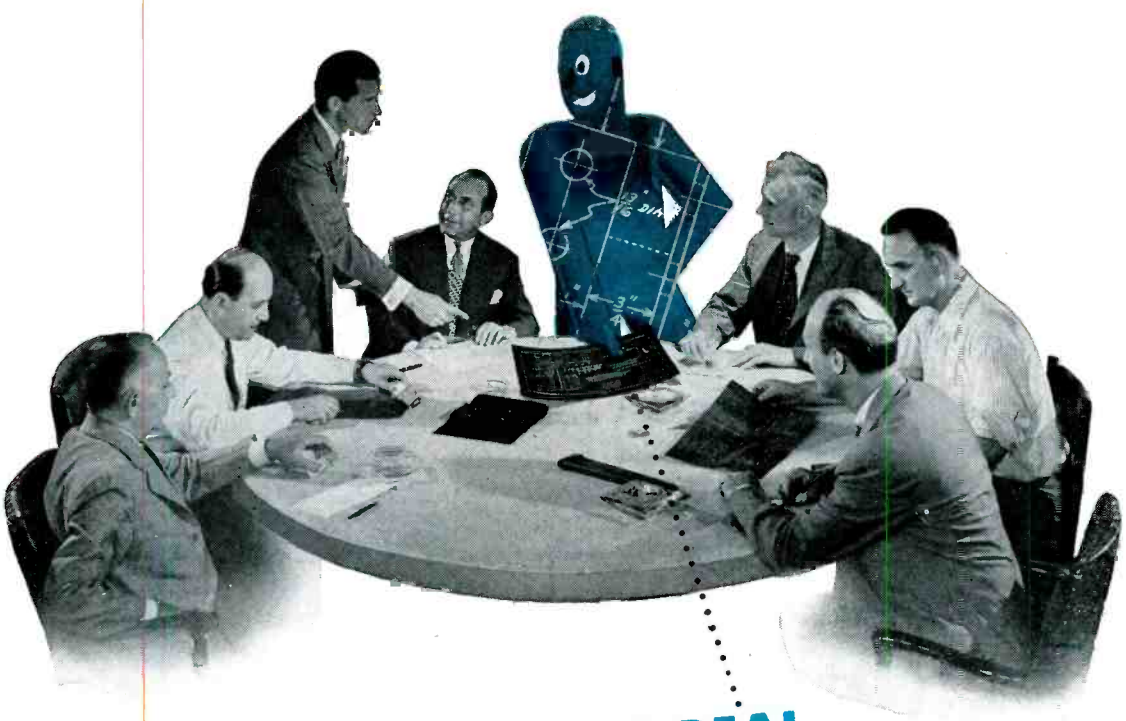
Sulphur, one essential ingredient of rubber, can also be corrosive. That seemed to rule out rubber on telephone cords. But Bell chemists found that if they held sulphur to the bare minimum, corrosion ceased. Now your handset cord has long life, is less susceptible to moisture as, for example, from a wet umbrella.

Connecting your home to the telephone wire on the street is a "drop" — one hundred feet or more of rubber-insulated wire. Once this wire was protected from ozone, light and abrasion by an impregnated cotton braid; but water leached the impregnant, and the braid rotted. Bell chemists tested scores of synthetics, and selected neoprene as an exterior covering with many times the life of braid.

Rubber is only one of many types of insulation developed by the Laboratories for the Bell System; insulation is only one of the Laboratories' problems in providing a quick, economical path for your voice.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE.



YOU GET A SQUARE DEAL AT OUR ROUND TABLE

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

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

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

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

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

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The H-2-P

A NEW PURIFYING JET OIL DIFFUSION PUMP,

for electronic tubes and general laboratory use.

The blank-off pressure of this all-metal pump, untrapped, is 2×10^{-7} mm of Hg, measured on an ionization gauge.

The speed and forepressure characteristics of the pump are remarkable. Speeds at three significant points follow—
50 litres per second at 10^{-5} mm Hg. 60 litres per second at 10^{-4}
35 litres per second at 2×10^{-3}

High Vacuum of 2×10^{-7} *mm Hg. is maintained when the forepressure is increased to* 0.34 *mm Hg.*

This pump is designed for *unlimited continuous service.* The jet tube is so constructed that it may be completely disassembled in a few moments with an Allen wrench. This makes every part of the pump freely accessible for cleaning. The heater is buttoned to the bottom of the pump and can be replaced easily. The permanent maintenance of this pump in condition to achieve the pressures and speeds listed above is assured by its construction. Recommended particularly for the requirements of Cathode Ray Tube production. Special models for exhaust equipment will be made to customer's specifications. For further details, please write—Vacuum Engineering Division, National Research Corp., Cambridge 42, Mass.

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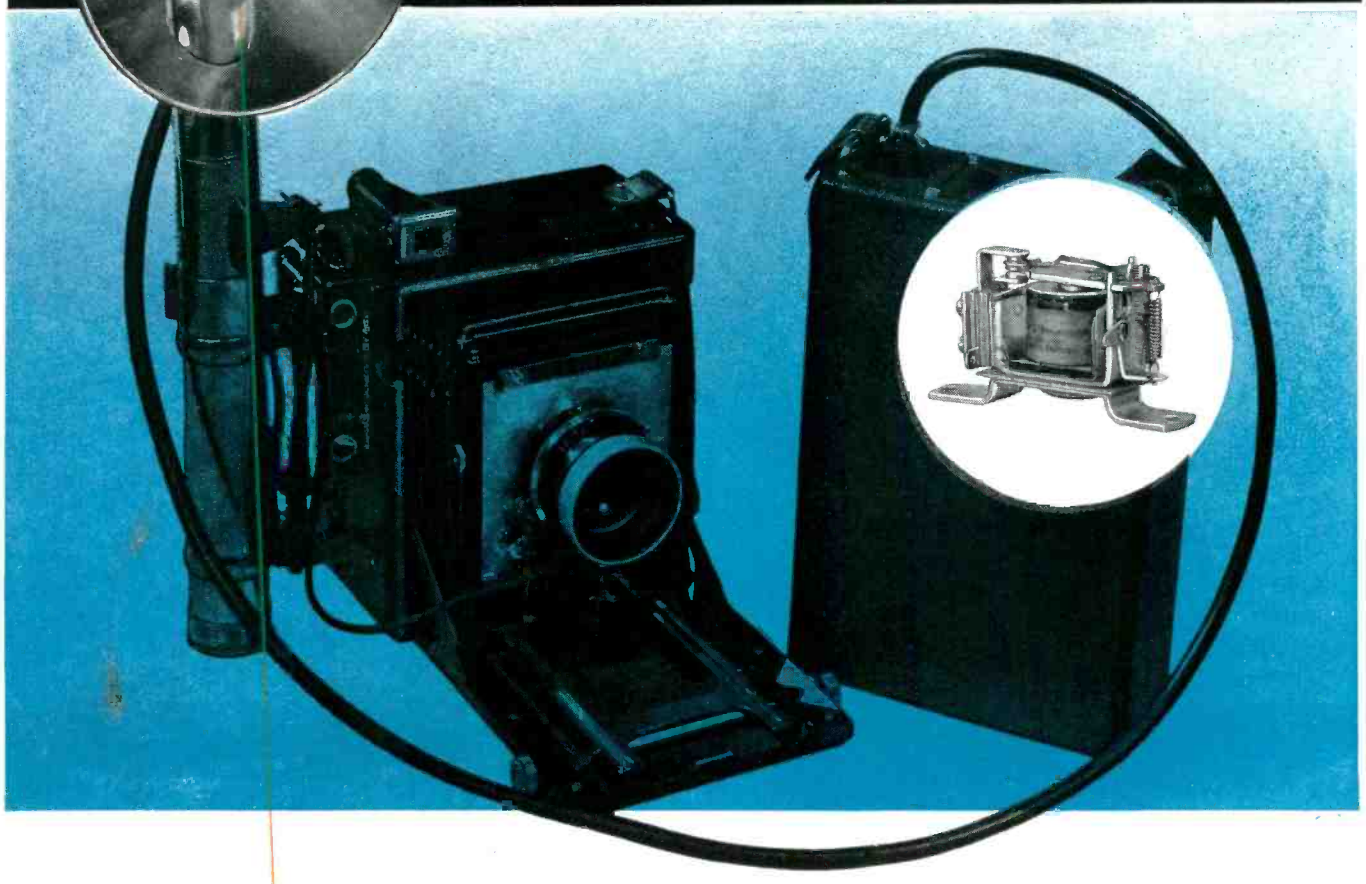
NATIONAL RESEARCH CORPORATION

Vacuum ENGINEERING DIVISION

THE HIGH STANDARD OF YOUR NAME IS ASSURED WHEN YOU BUILD IN

Potter & Brumfield *Relays*



For Uniform Repetitive Accuracy In Transit Time And For High Surge Current, The Triumph Speed Flash Unit Depends On A Specially Designed Potter & Brumfield Relay.

Here is another example of Potter & Brumfield performance engineering to meet inflexible requirements upon which the satisfactory operation of the end product is dependent.

This product is a high voltage actuated xenon gas ultra-high speed photo-flashlight unit. For acceptable performance, the relay must be even more uniformly repetitive than the precision shutter of a fine camera. When energized by a manual switch on the "flash gun" the relay discharges 2,500 volts from a saturated condenser in 1/10,000 second in synchronization with the shutter of the camera (approximately 48.6 watt seconds energy). Unfailingly positive contact is vital to synchronization and uniformity of color temperature. Contacts developed specially for this application carry this high surge current without sticking, burning or pitting. This relay has capably proven its ability in the field to take wide ranges of temperature, humidity and shock, in its stride. It is being supplied well within the customer's cost allowance.

POTTER & BRUMFIELD engineers are always available to design special relays to the performance requirements of your new or unusual applications—for low production cost. Your inquiries are solicited and assured of prompt attention.

POTTER & BRUMFIELD also offers a complete line of stock relays in power, midget, latching, leaf, plate-circuit, telephone, shock-proof and motor-starting types. Complete data on these standard assemblies is available in the comprehensive, illustrated P&B catalog. Write for your copy.

YOUR LOCAL ELECTRONICS PARTS DISTRIBUTOR STOCKS STANDARD P&B RELAYS

POTTER & BRUMFIELD SALES COMPANY

549 W. WASHINGTON BLVD., CHICAGO 6, ILLINOIS • FACTORY AT PRINCETON, INDIANA

Export: 2020 Engineering Building, Chicago 6, Illinois

CORRECT *in every detail!*

...this LIONEL

steam turbine type locomotive is recommended for model railroaders from 8 to 80 years old. Natvar Saturated Fiberglas Sleeving and Natvar Saturated Rayon Sleeving are used to give internal wiring permanent protection from shorts.

Natvar

Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing
- Extruded vinyl identification markers

Ask for Catalog No. 21

Trains and accessories built by The Lionel Corporation are a source of satisfaction not only because they *look* authentic, but because they actually operate for years, absorbing the shock of collisions, derailments, wrecks, and still surviving to run on schedule for the next generation—that is, if the youngsters can get the controls away from their parents.

Natvar Saturated Fiberglas and Natvar Saturated Rayon Sleevings are used on internal circuits because they give ample and uniform protection, and because they are smooth and easy to apply.

If your requirements call for insulating materials with good physical and electrical performance characteristics, it will pay you to use Natvar. Get in touch with your Natvar distributor, or with us direct.

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE
RAHWAY 7-2171

CABLE ADDRESS
NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

FOR DIATHERMY...

Two widely used pliotrons of special design—with frequencies in the 15-to-80 mc range, and power output ample for effective therapeutic treatment.

FP-285 FP-265

"IF YOU BUILD DIATHERMY EQUIPMENT, G-E SERVICE-PROVED OSCILLATING TUBES WILL STRENGTHEN YOUR PRODUCT'S STANDING WITH HOSPITALS AND OTHER USERS."

THERE'S a good and growing market for diathermy apparatus, based on the increasing use of electronic heat for treating many physical disorders.

To medical institutions and doctors, potential buyers of short-wave therapy equipment, one question comes first: has your unit, throughout, *proved itself* under rigorous conditions of actual service?

G-E tubes play an important part in your "yes." These tubes are the heart of diathermy apparatus; their oscillations produce the high-frequency electrical impulses which are applied to the patient's body. The General Electric monogram they carry means user-confidence—FP-285's and FP-265's are on the job *now* in hospitals and physicians' offices from coast to coast, where their dependability, their performance-to-ratings, and long service life are a byword.

Let G-E tube engineers work with you in applying to your new circuit the right G-E oscillator type engineered for diathermy! Benefit from (1) a well and favorably known tube product, (2) G.E.'s background of specialized experience in your field. Your nearby G-E electronics office will give prompt response to your inquiry, or write *General Electric Company, Electronics Dept., Schenectady 5, N. Y.*

TUBE RATINGS

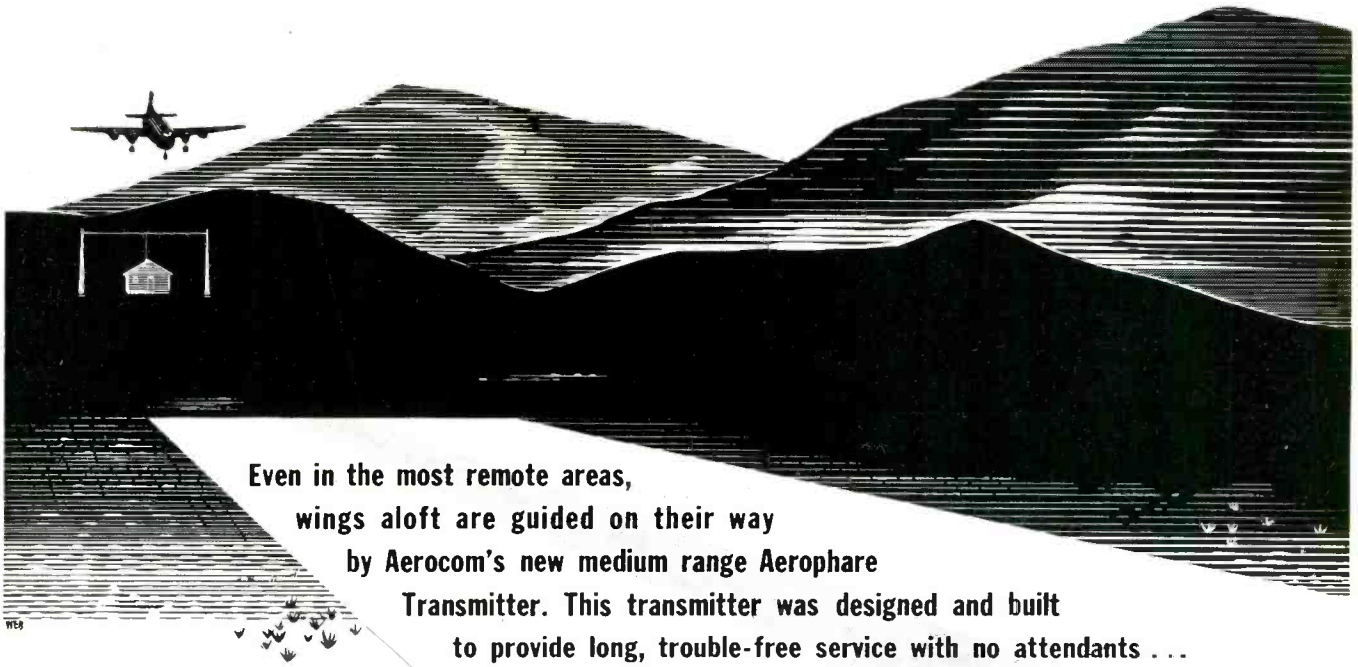
	FP-285	FP-265
Cathode voltage	10 v	10 v
current	3.25 amp	5.2 amp
Max plate voltage	1,350 v	1,500 v
current	200 ma	200 ma
input	270 w	350 w
dissipation	100 w	160 w
Frequency at max ratings	20 mc	15 mc
at 50-percent ratings	80 mc	40 mc

GENERAL ELECTRIC

161-G28-8850

FIRST AND GREATEST NAME IN ELECTRONICS

POPULATION - 0



Even in the most remote areas, wings aloft are guided on their way by Aerocom's new medium range Aerophare Transmitter. This transmitter was designed and built to provide long, trouble-free service with no attendants . . . even where the total population is Zero.

AEROPHARE

The 100 Watt Aerophare illustrated consists of the following units--AK-3 automatic keyer; Model 100XL transmitter, (100 Watt carrier power, minimum of 30%-high level tone modulation for identification but with no provision for voice modulation); and antenna matching unit.

The smaller unit is similiar, except transmitter is of 50 Watts carrier power with 90% high level tone modulation for identification, or, 90% high level voice modulation. Microphone P-T-Switch, when depressed interrupts tone, permitting voice operation. This feature makes this unit ideal for airport operation where both aerophare and traffic control are needed.

Both units are completely "tropicalized" to allow operation under unusual climatic conditions. Each unit is ruggedly constructed and conservatively rated, providing low operating and maintainence costs. Engineering data on both units upon request.

CONSULTANTS, DESIGNERS AND MANUFACTURERS OF STANDARD OR SPECIAL ELECTRONIC, METEOROLOGICAL AND COMMUNICATIONS EQUIPMENT.

AER -O- COM
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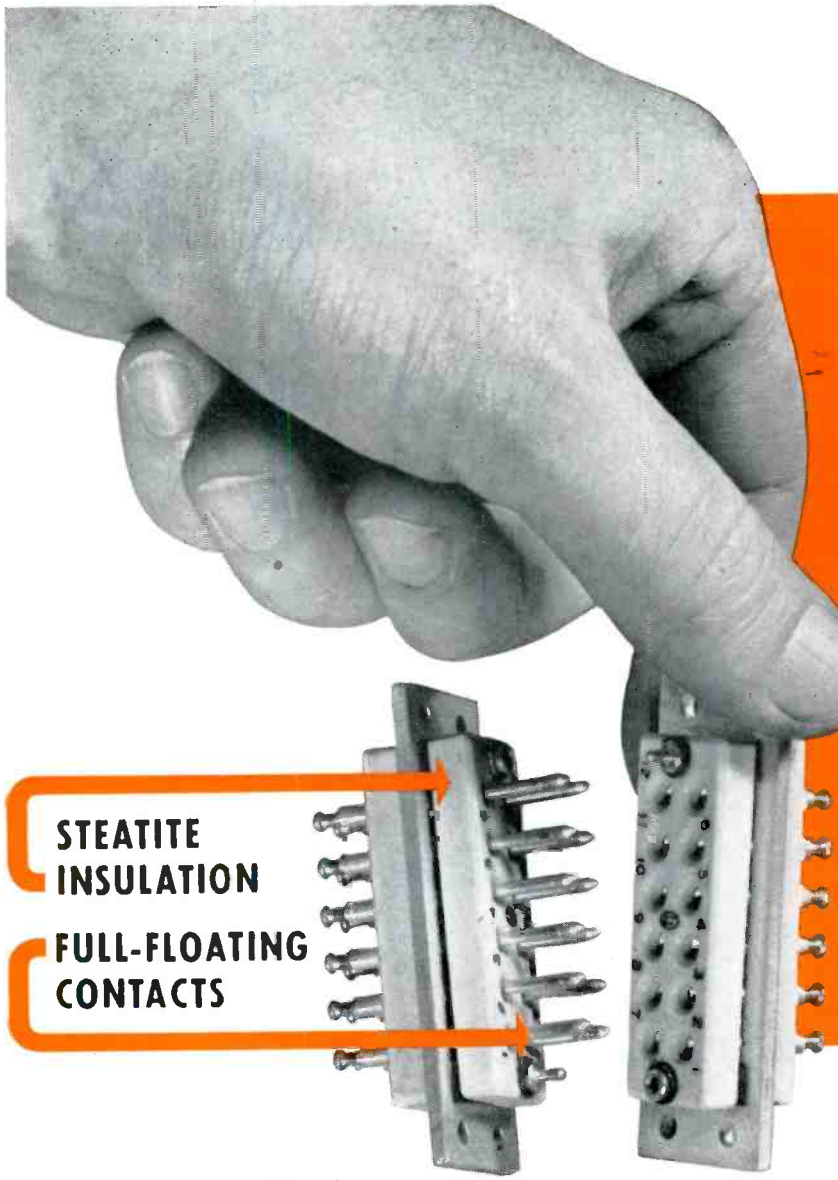
3090 Douglas Road, Miami 33, Florida

DEALERS: Equipeletro Ltda., Caixa Postal 1925 Rio de Janeiro, Brasil ★ Henry Neuman, Jr., Apartado Aéreo 138, Barranquilla, Colombia



Lapp

PLUG-AND-RECEPTACLE for Sectionalizing Circuits

STEATITE INSULATION

FULL-FLOATING CONTACTS

SIMULTANEOUS contact of any number of leads can be made or broken by use of Lapp Plug-and-Receptacle units, for panel-rack assembly or other sectionalized circuits. Insulation is Steatite, the low-loss ceramic which is non-carbonizing, even when humidity, moisture or contamination sets up a leakage path. The unit shown above provides twelve contacts, rated for operation at 2.5Kv peak terminal-to-terminal, 1.5Kv peaks terminal-to-ground, 25 amps at 60 cps. All contacts are silver-plated; terminals are tinned for soldering. Polarizing guide pins assure positive alignment. Write for specifications of this and other available units, or engineering recommendations for special units for your product.

Lapp

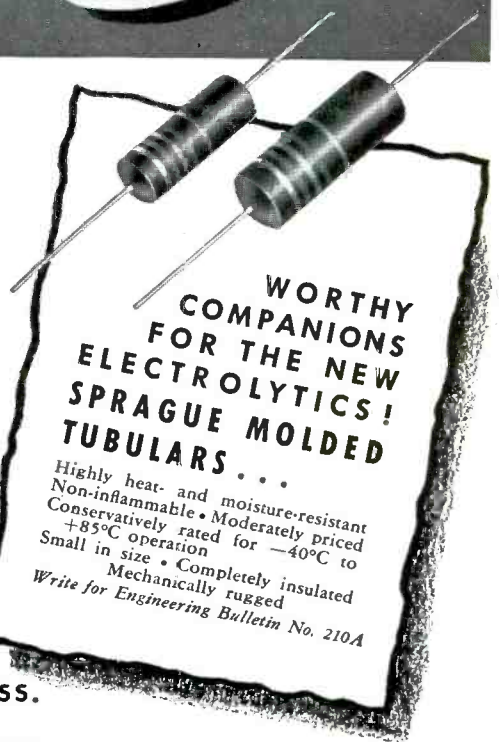
LAPP INSULATOR COMPANY, INC., LE ROY, NEW YORK

Announcing A NEW LINE OF SPRAGUE ELECTROLYTIC CAPACITORS

Designed for Television Use
(for operation up to 450 volts at 85° C.)

With some 7 times as many components in a television receiver as in the average radio, the possibility of service calls is greatly increased. The new SPRAGUE ELECTROLYTIC line offers the first practical solution to this problem.

Designed for dependable operation up to 450 volts at 85° C. these new units are ideally suited for television's severest electrolytic assignments. Every care has been taken to make these new capacitors the finest electrolytics available today. Stable operation is assured even after extended shelf life, because of a new processing technique developed by Sprague research and development engineers, and involving new and substantially increased manufacturing facilities. More than ever before your judgment is confirmed when you *SPECIFY SPRAGUE ELECTROLYTICS FOR TELEVISION AND ALL OTHER EXACTING ELECTROLYTIC APPLICATIONS!* Sprague Electric Company invites your inquiry concerning these new units.



WORTHY COMPANIONS FOR THE NEW ELECTROLYTICS!

SPRAGUE MOLDED TUBULARS . . .

Highly heat- and moisture-resistant
Non-inflammable • Moderately priced
Conservatively rated for —40°C to +85°C operation
Small in size • Completely insulated
Mechanically rugged

Write for Engineering Bulletin No. 210A

SPRAGUE ELECTRIC COMPANY · NORTH ADAMS, MASS.

SPRAGUE Capacitors * Koolohm Resistors

PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

*Trademarks reg. U. S. Pat. Office

NEW! BATTERY-OPERATED!

-hp- 204A AUDIO OSCILLATOR

Range:	2 cps to 20 kc
Distortion:	1%
Output:	5 v into 10,000 ohms
Response:	Flat within ± 1 db

-hp- 404A VACUUM TUBE VOLTMETER

Range:	2 cps to 50 kc
Voltage:	.001 to 300 v, 11 ranges
Accuracy:	± 3% to 20 kc
Input:	10 meg., 20 uufd shunt

Portable, light-weight, completely hum-free, weather-proofed, designed for general use where power sources are not available—that's the new *-hp-* 204A Audio Oscillator and 404A Vacuum Tube Voltmeter. Now—*anywhere, anytime*—you can accurately make geophysical, remote broadcast line, carrier current, strain gauge, telemetering circuit, telephone and telegraph, motion picture sound, marine and aircraft circuit measurements. And in the laboratory, these instruments make possible completely hum-free measurements.

-hp- 204A Audio Oscillator

Like other *-hp-* oscillators, the new *-hp-* 204A is easy to use, requires no zero setting. Tuning is direct or by a 6:1 vernier control. Frequency range of 2 cps to 20 kc is covered in 4 decade ranges. Five flashlight and three 45 v "B" batteries are easily accessible, mounted in rubber-lined anti-corrosion case, balanced for over 60 hours life. In average use they need be replaced only once every three months. Entire instrument is mounted in a welded dural case with splash-proof cover. All components are instantly accessible for servicing. Neon on-off pilot light shows when oscillator is operating. Size 10½" x 10½" x 11". Weight 24 lbs.

-hp- 404A Vacuum Tube Voltmeter

The new *-hp-* 404A battery voltmeter is designed for a-c measurements from 2 cps to 50 kc, at voltages from .001 to 300 v. The 404A is modeled after the *-hp-* 400A voltmeter, but has 10 times the sensitivity. Input impedance is high (10 megohms), and accuracy is within ± 3%, 2 cps to 20 kc, ± 7% to 50 kc. The instrument is also useful as a hum-free amplifier, with standardized gain up to 60 db. Operation is virtually independent of battery, temperature or humidity changes.

A linear meter reads rms sine wave values, with continuous db readings from −62 to +52 db. 11 voltage ranges selected with a single switch; no other adjustments necessary during operation. Neon on-off warning light, welded dural case, splash-proof cover. Size 7½" x 10½" x 9". Weight 14 lbs. approx.

Early Delivery! Get Full Details!

HEWLETT-PACKARD CO.
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Export Agents: Frazar & Hansen, Ltd.
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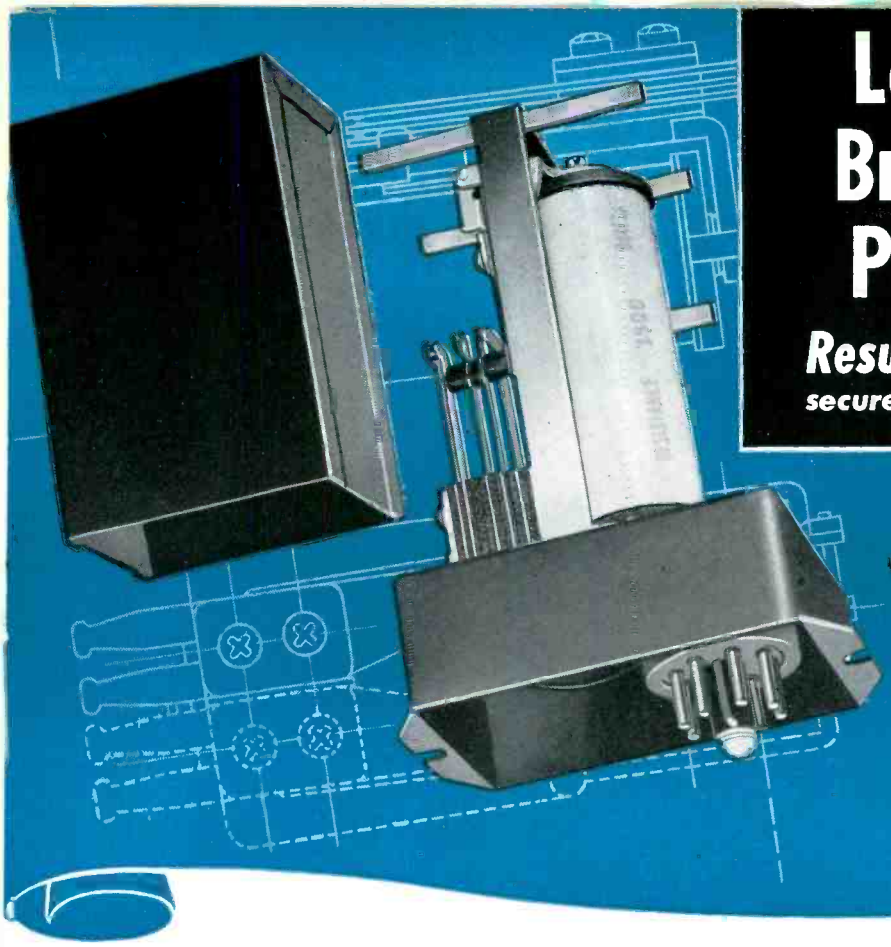
hp laboratory instruments
FOR SPEED AND ACCURACY

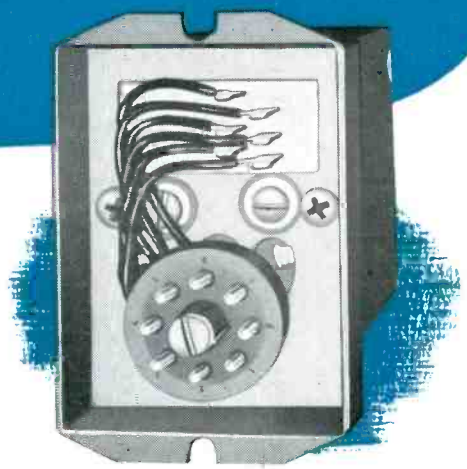
Power Supplies Audio Signal Generators Amplifiers Electronic Tachometers Frequency Meters
UHF Signal Generators Square Wave Generators Audio Frequency Oscillators Attenuators
Frequency Standards Noise and Distortion Analyzers Wave Analyzers Vacuum Tube Voltmeters

Leeds & Northrup Brought This Relay Problem to CLARE

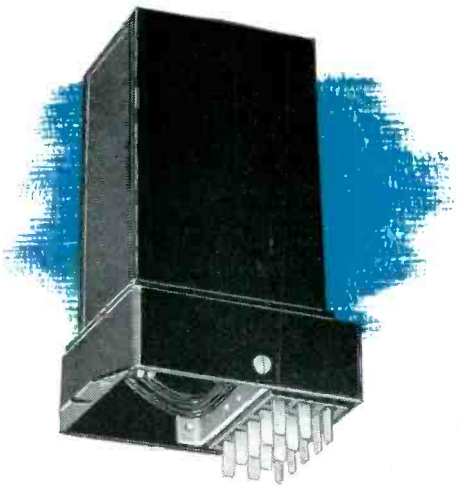
Result... ***A dust-tight relay base and cover, securely fastened, with cover easily removed!***



Clare Type "C" d-c Relay, dust-tight mounted on base provided with Neoprene gasket, with easily removable dust-tight steel cover, as developed for Leeds & Northrup.



View of base assembly of dust-tight relay mounting showing terminals brought through Neoprene gasket. Note radio-type plug and flanges for securing to chassis.



Same installation as changed for use of United Air Lines. Note installation of the 15-point plug and single flange for mounting to chassis.

Electrical controls produced by Leeds & Northrup, Philadelphia, are frequently called upon to operate at plant locations where dust conditions may affect the operations of unprotected components.

Their engineers called on CLARE for a plug-in relay that could be firmly secured to a chassis so that the plug could not be jarred or pulled out accidentally. A thoroughly dust-tight cover was required, yet it had to be easily removable for inspection.

CLARE engineers, in cooperation with Leeds & Northrup engineers, provided a cover base which contained a Neoprene gasket, closely fitted to the relay terminals for effective dust protection. They devised a steel cover which, firmly secured to the base by a thumb nut, could be readily removed. A standard radio type plug and notched flanges to permit rigid chassis installation completed the equipment.

Flexibility of this installation was soon demonstrated when a similar dust-protection problem came to CLARE engineers from United Air Lines. In this case a 15-point plug of different design was provided and a single flange for securing to the chassis.

If your problem has to do with relays, save time and expensive experiments by bringing it to CLARE. Take advantage of our long experience with every type of industrial relay problem. Call on CLARE sales engineers, located in principal cities, or write now to C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada, contact Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

First in the Industrial Field

All over the World

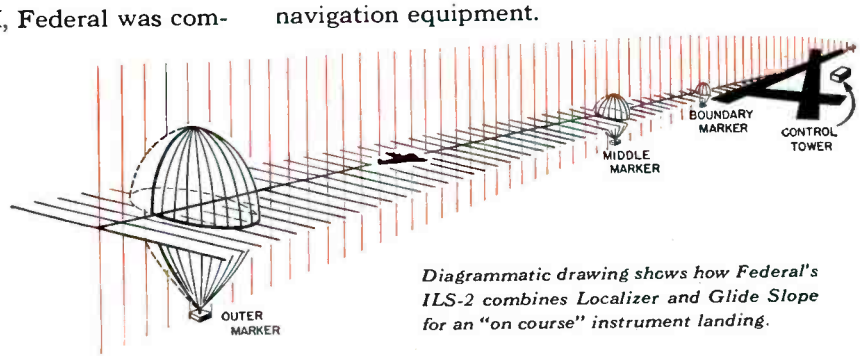
Federal's Instrument Landing Equipment Provides Increased Safety

Since the earliest days of radio aids to navigation, Federal has been closely identified with the development and manufacture of equipment designed to promote safety and dependability in aircraft operation.

Over the years Federal has continuously demonstrated leadership in the field of radio by such achievements as the marine radio compass . . . low frequency simultaneous voice four-course radio range . . . VHF multi-loop localizer . . . equi-signal glide slope for more accurate instrument landing . . . the first standard ILS developed for the U. S. Bureau of Air Commerce.

With the advent of World War II, Federal was commissioned to design and manufacture the SCS-51 for the United States and allied countries. At the end of the war, Federal redesigned the military SCS-51 to provide such additional features as remote monitoring and control.

Now Federal has designed and placed in production a complete post-war system designated ILS-2. It is produced in accordance with the standards of the International Civil Aviation Organization. Federal's ILS-2 offers an *all-in-one* system—a complete system designed, produced and tested by the leader in the field of air navigation equipment.



Diagrammatic drawing shows how Federal's ILS-2 combines Localizer and Glide Slope for an "on course" instrument landing.

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.

Federal Telephone and Radio Corporation

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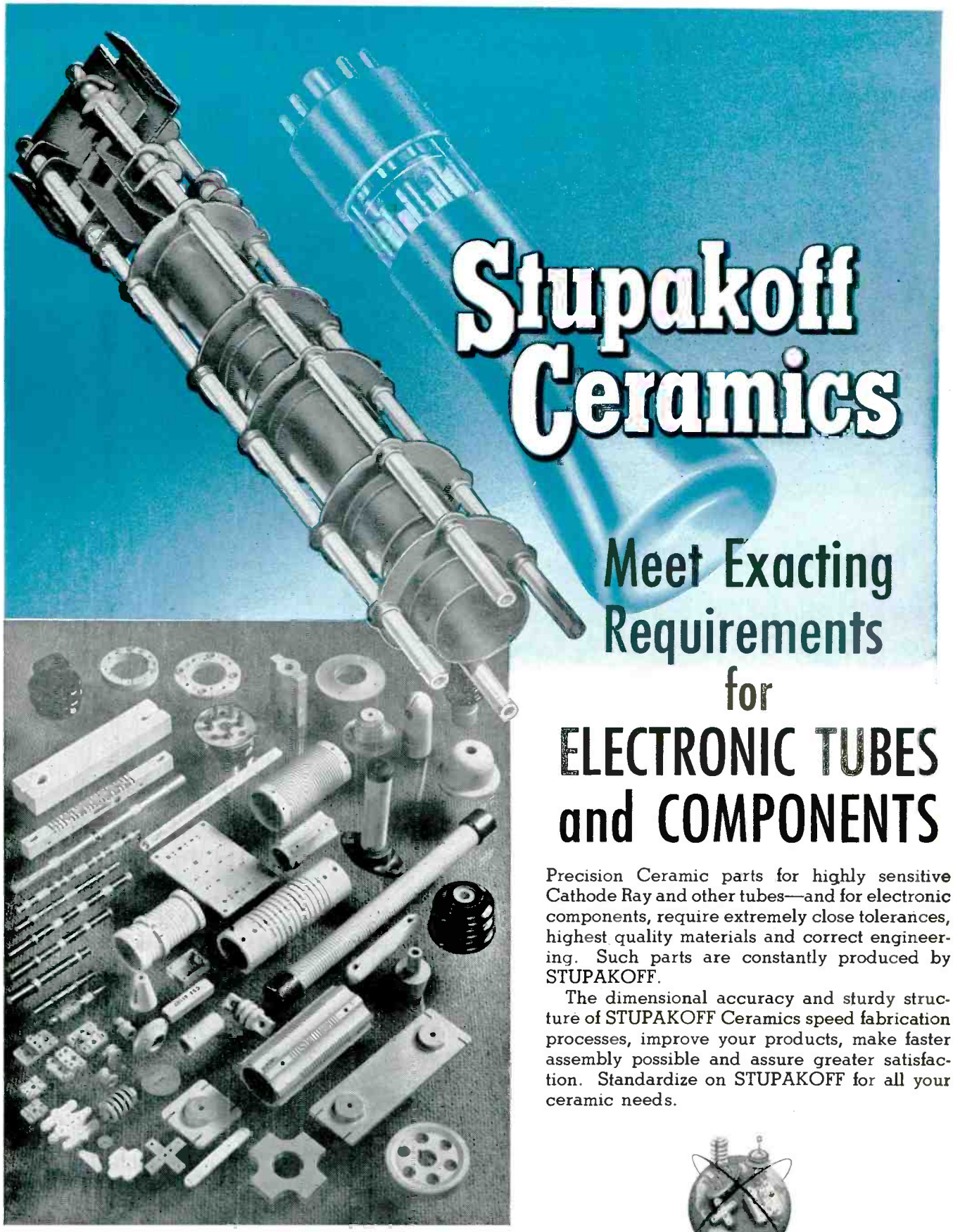


Stupakoff Ceramics

Meet Exacting Requirements for ELECTRONIC TUBES and COMPONENTS

Precision Ceramic parts for highly sensitive Cathode Ray and other tubes—and for electronic components, require extremely close tolerances, highest quality materials and correct engineering. Such parts are constantly produced by STUPAKOFF.

The dimensional accuracy and sturdy structure of STUPAKOFF Ceramics speed fabrication processes, improve your products, make faster assembly possible and assure greater satisfaction. Standardize on STUPAKOFF for all your ceramic needs.

STUPAKOFF CERAMIC AND MANUFACTURING CO.

LATROBE, PENNSYLVANIA

Cable Address: Stupakoff, Latrobe, Pa.

FOR *FM* AND *Television*

PHILCO VISUAL ALIGNMENT GENERATOR

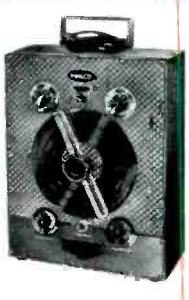
PHILCO 7008. The only instrument of its kind, combining all functions for complete, accurate visual alignments on Television and FM receivers. Includes 5 different signal generators and their associated controls; a complete oscilloscope with centering, gain, focus, intensity, phasing and blanking controls, and power supplies. Separate RF probe permits measurements of sensitive circuits without disturbance. Removable crosshatch screen for special ultra-short 3″ cathode-ray tube. Compartment for storage of all cables, including RF probe.

PHILCO MAKES TEST EQUIPMENT HISTORY

In creating precision instruments for radio measurements, in compact, portable, inexpensive form . . . Philco engineers have repeatedly achieved results considered impossible by experts. Especially so, in the new Philco 7008 Visual Alignment Generator for FM and Television . . . which combines in one economical instrument functions that can be approached only by a cumbersome, costly collection of conventional devices. The 7008 *alone* performs complete, accurate visual alignments . . . saves the test engineer's time . . . makes the job easier. In every unit of today's Philco Test Equipment line you will find equally important advantages.

WRITE FOR TECHNICAL LITERATURE TO: PHILCO CORP., PHILADELPHIA 34, PA.

NO. 7008 PHILCO VISUAL ALIGNMENT GENERATOR
NO. 7001 PHILCO ELECTRONIC CIRCUIT MASTER
NO. 7070 PHILCO R.F. SIGNAL GENERATOR
NO. 5072 PHILCO CROSSHATCH GENERATOR
NO. 7030 PHILCO DYNAMIC TESTER
NO. 7019 PHILCO JUNIOR SCOPE

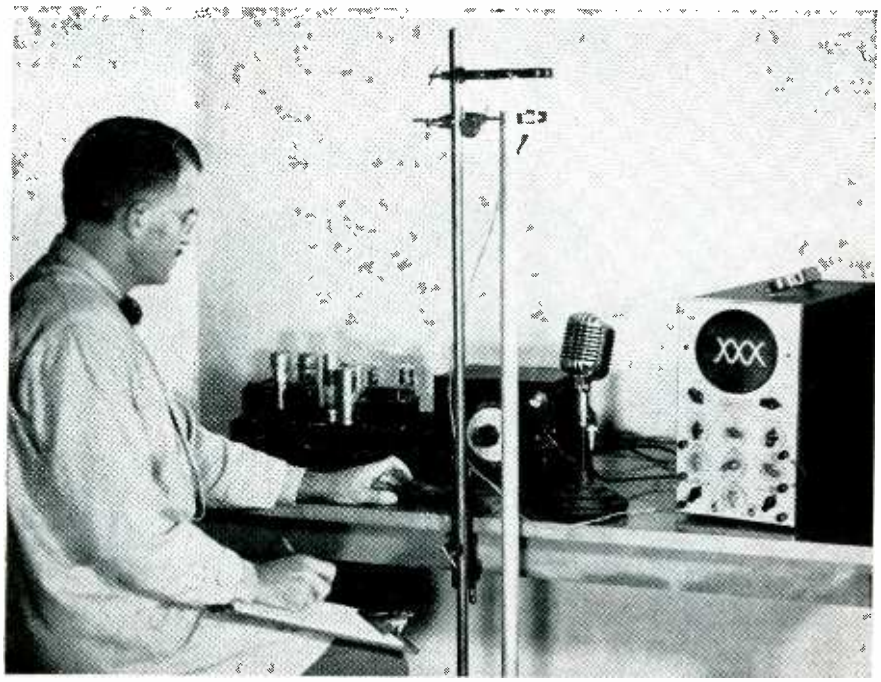


PHILCO SIGNAL GENERATOR

MODEL 7070. Range from 100 kc to 110 mc—all fundamentals! No switching trouble at any frequency. Residual output less than 5 micro-volts! Model 7170 for FM also available.

PHILCO ELECTRONIC CIRCUIT MASTER

MODEL 7001. Uses exclusive vacuum tube voltmeter and electronic bridge circuit. All ranges and functions including 10,000 volts AC or DC. Probe available for RF measurements.



Laboratory set-up for measuring tone of chime tubes. Lissojous figure on screen of cathode ray oscilloscope is being used to determine the frequency (cycles per second) of the chime's fundamental note.

Revere Tubes make Good Music

BECAUSE of the importance of the market for brass tube used in door chimes, Revere some time ago embarked upon a complete scientific study of the musical qualities of such tube, to determine the factors responsible for pleasing tone. Here is a brief report of the work, which offers an example of the thoroughness with which Revere attacks problems concerning the application of its mill products.

The first step was purely experimental. We proceeded by ear. Over 100 samples of tubes in various alloys, tempers and gauges were hung up, struck, listened to, and preferences obtained from many people. These tests indicated not only what was the best alloy, but also what were the proper temper and wall thickness requirements to produce the most acceptable and desirable tone. But Revere did not stop there. It was desirable to know what made that tone preferable, what were the factors that influenced it, and how they could be controlled. It was felt that only with such complete information in hand could Revere be in position to control chime tube quality accurately, and fill customers' orders reliably with a standard product.

The project then was turned over to a laboratory physicist who is also a talented musician. Here began the most ambitious and lengthy and scientific part of the work, employing the most modern electronic apparatus, including a beat-frequency oscillator and a cathode ray oscilloscope. These made it possible to dissect the tone produced, measuring the frequency and intensity of the fundamental note and its partials with an accuracy of one cycle per second. Much new information was uncovered. For example, the strike tone so clearly heard when the chime is struck does not actually exist in the tube, but is a difference tone between the 1st and 3rd partials. Hence, for good tone, those partials must be equal in intensity and duration.

It requires seven closely-typed pages just to sum up the work in general terms; the laboratory records fill a large volume. The net of it is that Revere really knows about all there is to know about chime tube, scientifically, musically, physically, and, of course, how to produce it. If you need such tube, come to Revere.

Perhaps you use brass tube not for its sound, but for its corrosion resistance, strength, machinability, the polish it takes, the ease with which it can be bent, soldered, brazed, plated. Revere also knows how to control the factors influencing such applications, so come to Revere for brass tube for any purpose.

Revere also makes other types of tube, including copper water tube, condenser tube in such alloys as Admiralty, Muntz, cupro-nickel, tube in aluminum and magnesium alloys, lockseam tube in copper alloys and steel, and electric welded steel tube. Many of these can be had not only round, but also square, rectangular, oval, and in various flutings and special shapes. The Revere tube line therefore is complete, and awaits your orders.

The Technical Advisory Service will gladly collaborate with you in such matters as selection of alloys, tempers and gauges, and in fabrication processes.

REVERE

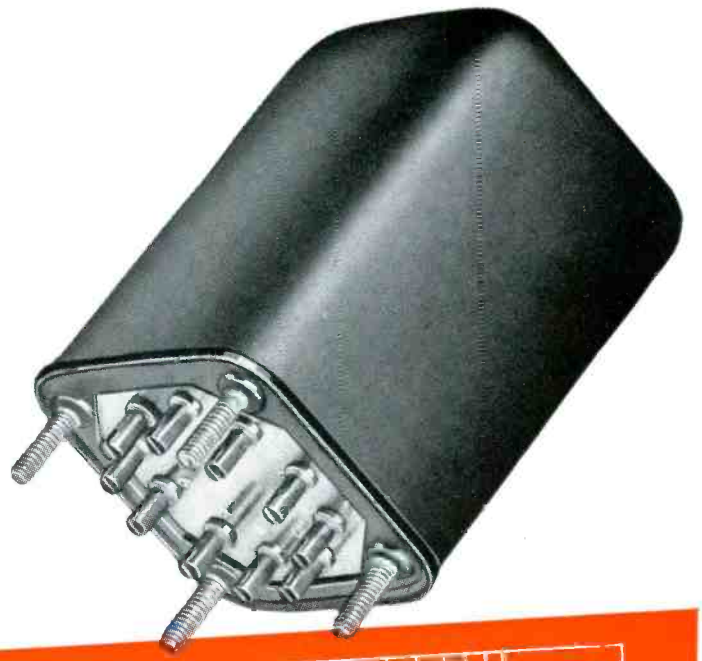
COPPER AND BRASS INCORPORATED

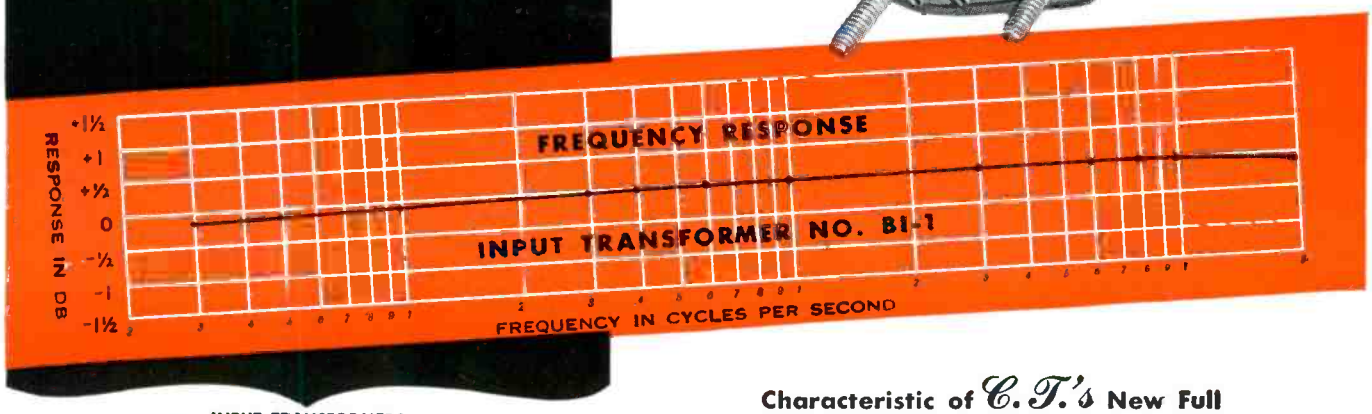
Founded by Paul Revere in 1801

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.

LOOKING FOR HIGH FIDELITY IN AUDIO COMPONENTS?





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.

Characteristic of *C. T.'s* New Full Frequency Range Input and Output Transformers

They provide response within ±½ db over the full range from 30 to 15,000 cycles . . . and response within ±1 db up to 20,000 cycles. That's tested performance . . . not *just* a curve.

Their percentage of distortion is exceptionally low over the full range . . . at low as well as high frequencies.

They're *Sealed in Steel* to protect the delicate, fine wire coil windings against corrosion by atmospheric moisture. The drawn steel cases are compact and streamlined . . . help achieve a clean, uncluttered appearance for any gear.

Input units have hum-bucking core construction and additional inner cases of special alloy for hum shielding of −70 dbm or better.

For 250-watt, 1-KW, and 5-KW Transmitters

Matched sets of Driver and Modulation Transformers, and Modulation Reactors, Response within ±1 db over the Full Frequency Range of 30 to 15,000 cycles. Distortion very low . . . well within FCC limits for transmitters.

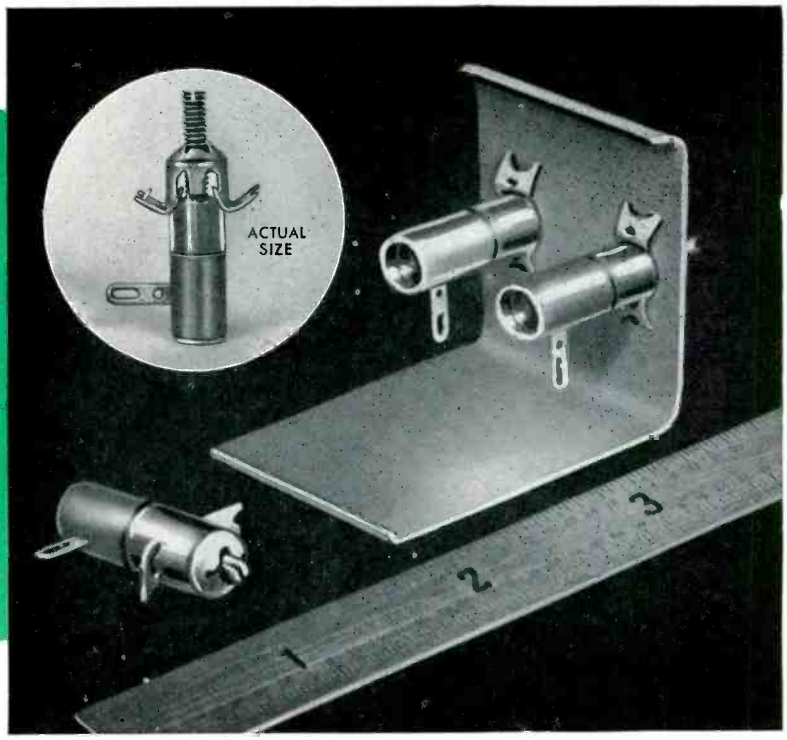
Distributorships for this new stock line are now being established. For full information, see your radio parts jobber or write direct.

CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

3501 ADDISON STREET • CHICAGO 18, ILLINOIS

To the engineer who wants high quality at low cost



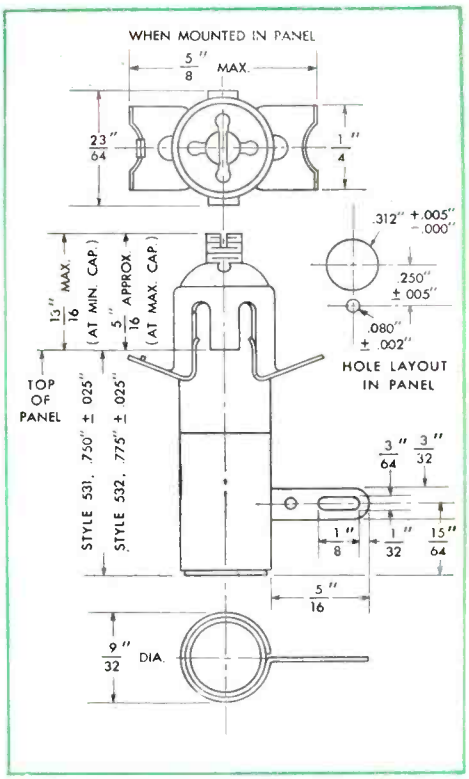
The NEW ERIE Styles 531 and 532 TUBULAR TRIMMERS

THIS new trimmer condenser was released to production only after prolonged months of engineering development in quest of stable plastic materials and reliable manufacturing techniques. It is the most recent among a series of new ERIE RESISTOR capacitor designs, both fixed and variable.

Every characteristic desired in a trimmer is found in the Styles 531 and 532 Erie Tubular Trimmers. The capacity range of 1–8 MMF provides a low minimum with high ratio of maximum to minimum. Capacity stability is assured by the use of high temperature thermoplastic dielectric and simple but efficient mechanical design.

The change from maximum to minimum setting occurs in practically a straight line, without peaks or valleys, permitting accurate trimming over the entire range. Style 531 is designed for installation on panels from .015" to .039" thick, Style 532 from .040" to .065".

These miniature trimmers are built right and priced right. It will pay you to write for additional information.



Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • • TORONTO, CANADA

From this package come the finest recordings in the world

Presto

GREEN LABEL DISCS

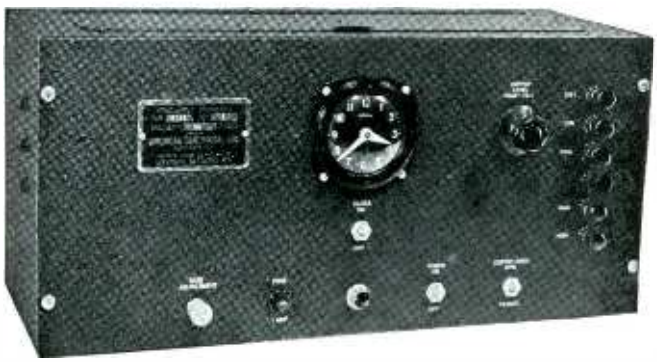
ALSO AVAILABLE—
Presto Brown Label discs. They're one-side perfect . . . with a flaw on the other side you probably couldn't find. Perfect for one-side recordings, reference recordings and tests, and at greatly reduced cost.

PRESTO
RECORDING CORPORATION
Paramus, New Jersey

Mailing Address: P. O. Box 500, Hackensack, N. J. • In Canada: WALTER P. DOWNS, Ltd., Dominion Sq. Bldg., Montreal

Watch Master

Frequency Standards



GUARANTEED ACCURACY
1 part in 100,000 (.001%)

Type 2121 A.

TERMINATION
Front and Rear
CONSTRUCTION
Standard 8¾" x 19" Panel
HOUSING
8¾" x 19" x 8" Metal Cabinet
WEIGHT
25 pounds

Uses

Time bases, rate indicators, clock systems, chronographs, geo-physical prospecting, control devices and for running small synchronous motors.

Features

1. **Bimetallic, temperature-compensated fork, no heating or heat-up time is required.**
2. **Fork is hermetically sealed, no barometric effects on frequency.**
3. **Precision type, non-ageing, low coefficient resistors used where advantageous.**
4. **Non-linear negative feedback for constant amplitude control.**
5. **No multi-vibrators used.**
6. **Synchronous clock simplifies checking with time signal.**

Specifications

Accuracy—1 part in 100,000 (.001%).
Temperature coefficient—1 part in 1,000,000 per degree centigrade (or better).
Outputs—

1. **60 cycles, sine wave, 0-110 volts at 0 to 10 watts (adjustable).**
2. **120 cycle pulses, 30 volts negative.**
3. **240 cycle pulses, 30 volts positive and negative. Pulse duration, 100 micro-seconds.**

product of

AMERICAN TIME PRODUCTS INC.

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

Operating under patents of the Western Electric Company

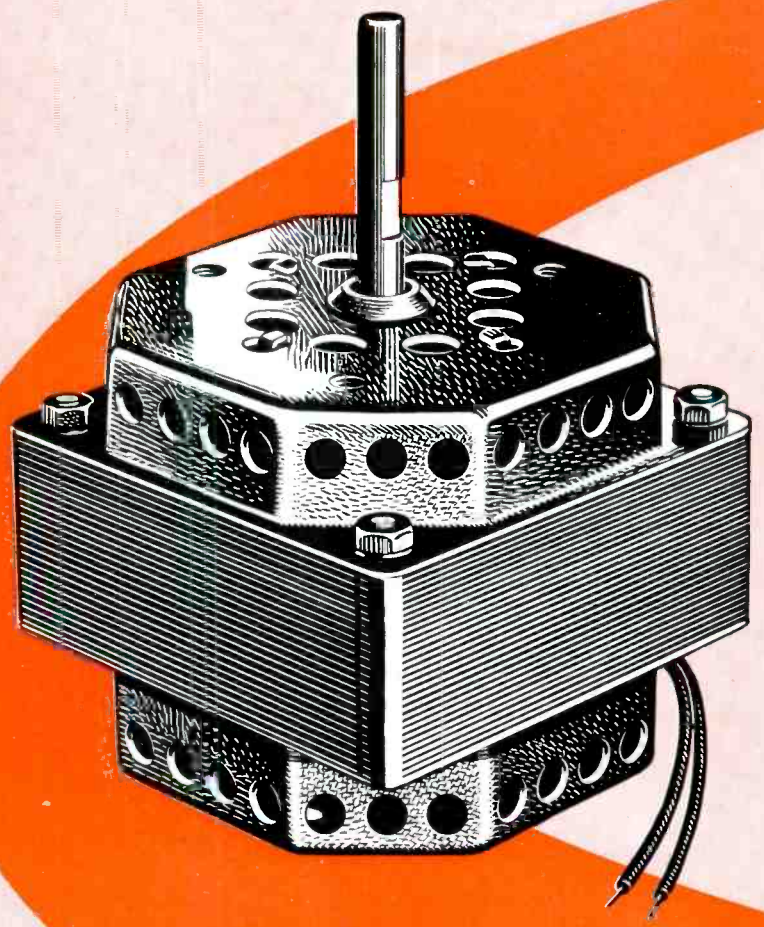
American Time Products, Inc.,
580 Fifth Ave., New York 19, N. Y.
Gentlemen:
Please send descriptive folder, No. 2121A.

Name.....

Company.....

Address.....

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



TAPE RECORDERS

WIRE RECORDERS

DISC RECORDERS

Smooth Power . . .

FOR EVERY TYPE OF RECORDING UNIT

There's plenty of long-lasting *Smooth Power* in this compact General Industries recording motor. Originally developed for and widely used with marked success in disc recorders, it has been redesigned to meet the increased power requirements of tape and wire recorders. Here, indeed, is the *one* motor that meets *all* recorder requirements.

Like its companion motors in the famous *Smooth Power* line, this motor features a dynamically balanced rotor, with precision accuracy assured by the latest type of electronic testing equipment. Other features include special locating and locking means for both top and bottom covers . . . self-aligning, oil-impregnated sleeve and end thrust bearings . . . dual aluminum cooling fans and scientific air intakes for maximum cooling effectiveness.

For additional information and performance data, write *today* to:

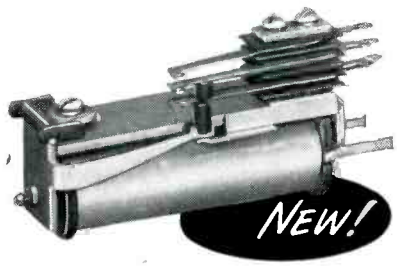
The GENERAL INDUSTRIES Co.

DEPT. B · ELYRIA, OHIO

ELECTRONICS

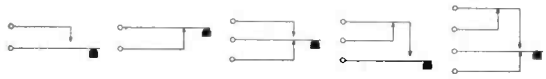
Designers

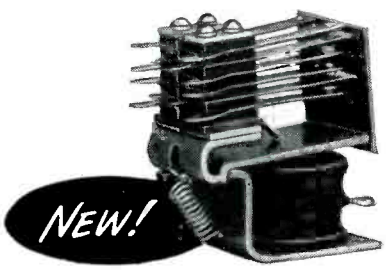
RELAYS . . . for any duty, any duty cycle



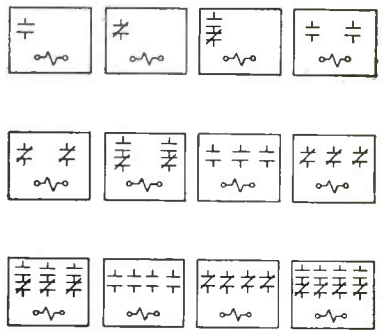
COMMUNICATIONS AND SIGNALING Designed specifically for use in industrial electronic equipment, communications and signaling equipment, this General Electric telephone-type relay has a service life measured in many millions of operations. Working from five basic contact arrangements, combinations can be stacked to satisfy intricate circuit switching requirements.

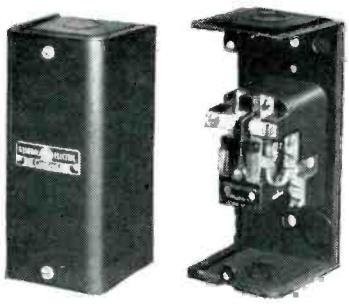
Welded-crossbar palladium contacts, new-type molded insulation and stainless steel bearings contribute to this d-c relay's longevity. Coils rated 1 to 250 volts, 0.1 to 26,000 ohms; contacts 3 amps maximum. Bulletin GEA-4859.





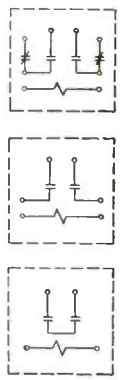
VENDING MACHINES AND DISPENSERS Designers of coin changers, coin-operated phonographs, drink dispensers, and similar automatic devices will soon be familiar with G.E.'s new appliance relay, an inexpensive multi-contact unit. Featuring quiet operation, reliability and compactness, the CR2790G relay is available in ratings of 24 and 115 volts a-c, 24 volts d-c, 5 amps continuous. Bulletin GEA-4864.





HEAVY-DUTY GENERAL-PURPOSE Three contact arrangements —spst, dpst, and dpdt—plus four mounting arrangements give the CR2790E real versatility. Mounting arrangements available are the enclosed form shown here, open form, back-connected form for panel mounting, and a plug-in form for use in process control equipment.

Its heavy silver contacts are rated 10 amps continuous at 115/230 volts, 60 cycles; normally open contacts will make and break 45 amps, normally closed contacts 20 amps. Bulletin GEC-257 gives full details.



GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS

DYNAMOTORS FOR QUICK DELIVERY!

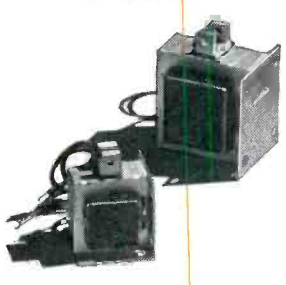
Shopping for fractional-hp dynamotors? General Electric can now supply you on a short-shipment basis! Production has finally caught up on these d-c

to a-c converters for communications service. Standard dynamotors are available in ratings of 200 and 500 volt-amperes, 60 cycles, continuous duty. Specials are also available, but on a slightly longer shipment. For more complete information on these fhp equipments, contact your G-E representative or write Fractional-horsepower Motor Div., General Electric Co., Fort Wayne, Indiana.

MORE PULL IN LESS SPACE

You'll find these new, small, all-welded solenoids useful in any application where a straight-line thrust is required . . . they're a natural for vending machines. The small unit requires only three cubic inches of space, and develops 0.26 pounds pull at ½-inch stroke; its "big brother" produces 3.7 pounds at ¾-inch stroke.

Brazed-in pole shader increases efficiency, insures quiet operation. Varnish-impregnated coil provides high resistance to shock, splashing water, oil. Check Bulletin GEA-4897.



SHOW IT, THEN THEY'LL KNOW IT

If your organization has an educational program underway, or plans one, ask your G-E representative to show you the Industrial Electronics Training Course. Rated tops in visual training by the nation's industrials, schools and institutions now using it, the complete kit contains twelve half-hour slide films with records, individual lesson guides keyed to the film, and a manual for the course instructor.

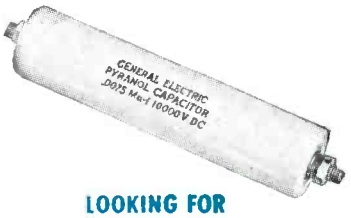
Everything from fundamental electronics to up-to-the-minute electronic

production tools are forcefully described and explained in this easy-to-take visual course. Check Bulletin GES-3303.

NEED SOMETHING SPECIAL IN CAPACITORS?

Here's a new .0075-muf, 10-kv d-c capacitor for television, precipitation, and similar electronic equipment requiring filtering in high-voltage power supply. Other capacitances (.0005 to .01 muf) and voltages (3 to 30 kv) can be supplied.

Ceramic container acts as insulator, simplifies mounting, cuts size (volume) to 1/5th without lowering quality in any way. Ingenious internal hermetic silicone seal eliminates solder. Pyranol filled. Contact your G-E representative or write Transformer Div., General Electric Co., Pittsfield, Mass., for quotation.



LOOKING FOR PERMANENT MAGNET DATA?

These two new bulletins are packed full of application and design information to help you build magnets into your electronic equipment. CDM-1 covers "Permanent Magnets"; CDM-2 describes "Cast and Sintered Alnico Magnets." Coupon below will bring this valuable information to your desk quickly. Check it now.

GENERAL ELECTRIC COMPANY, Section F 642-17
Apparatus Department, Schenectady, N. Y.

Please send me the following bulletins:

☐ GEA-4859 Telephone-type Relay ☐ GES-3303 Electronics Training Course
☐ GEA-4864 Appliance Relay ☐ CDM-1 Permanent Magnets
☐ GEC-257 General-purpose Relay ☐ CDM-2 Cast & Sintered Alnico Magnets
☐ GEA-4897 Solenoids

Name.....

Company.....

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

"Hearing is Believing"

THAT

AMERICAN PHILLIPS SCREWS

Cut Costs···Kite Sales

...when you listen to makers of Electronic Products like these:

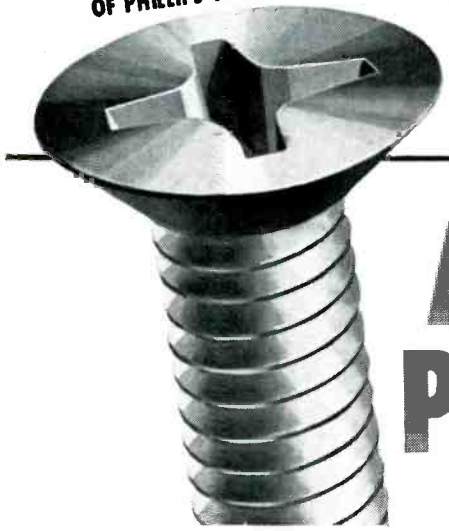
HOW THEY CUT COSTS: Says one hearing-aid manufacturer, "American Phillips Screws save us as much as 50% in time alone — and what they've saved us by banishing spoilage runs into even *more* money!" Simply because American Phillips Screws can't slip, can't slash, *can't drive any way but straight*. And because they're so much easier to handle, aim, and drive . . . without "dropsy."

HOW THEY KITE SALES: American Phillips Screws give all types of products a smart new look . . . a strikingly improved appearance over ugly, burred, slotted screws. And when you really *merchandise* their better holding power and greater vibration-resistance —which add up to fewer servicing needs — you've got an earful that drives home more sales. Find out what American Phillips Screws can do for *your* product. Write.

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

Chicago 11: **589 E. Illinois St.** *Detroit 2:* **502 Stephenson Building**

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



AMERICAN PHILLIPS *Screws*

ALL TYPES

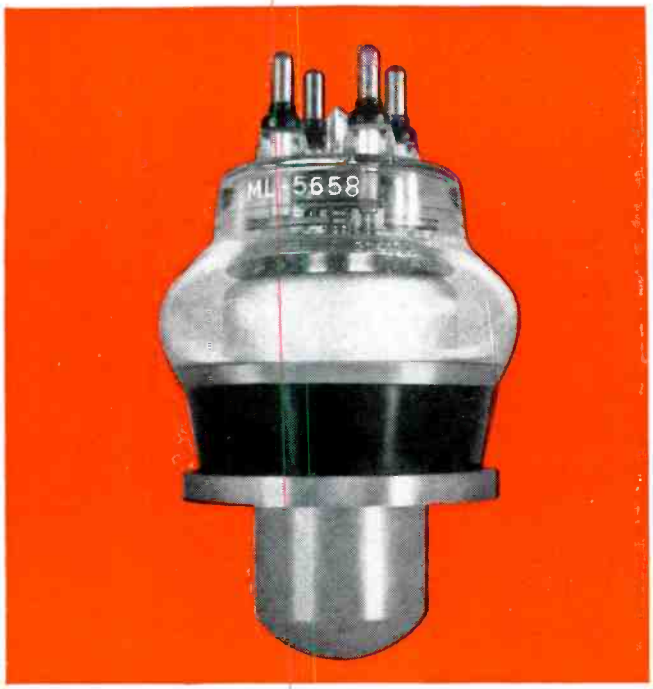
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

BETTER PERFORMANCE... LONGER LIFE WHEREVER TYPE 880 IS USED

ML-5658

ELECTRICALLY & MECHANICALLY INTERCHANGEABLE WITH TYPE 880

AVAILABLE WITH OR WITHOUT MACHLETT AUTOMATIC SEAL WATER JACKET*



ML-5658, water-cooled RF oscillator, amplifier, completely interchangeable with Type 880. Max. Input, 60 kw. Max. Plate Dissipation, 20 kw. May be used at full power at frequencies as high as 20mc., and at reduced powers up to 45mc.

MACHLETT AUTOMATIC SEAL WATER JACKET.* No tools are needed to open and close this new jacket. No worry about tube breakage or water leakage. Jacket cannot be opened unless water pressure is off, nor closed unless tube is properly seated. *Pat. applied for

TYPE ML-5658, recently developed by Machlett to provide better performance and longer life in new installations, and as a replacement in existing 880 sockets, merits the consideration of all users of Type 880 electron tube. Since this new tube was designed to perform satisfactorily under severe operating conditions encountered in RF heating applications, its advantages will be felt particularly in that field; however, communications and other users will also benefit from its more rugged structure and improved operating characteristics.

The tube has been substantially ruggedized internally, and its grid and cathode are mechanically sturdier. In addition, the terminals have been greatly strengthened by the use of Kovar seals, minimizing the danger of fracture when tightening or otherwise handling the terminal connectors and leads, and assuring freedom from internal element displacement resulting from terminal distortion. If desired, the tube may be had with special Machlett terminal connectors and leads. The ML-5658 may be placed in any 880 socket, no changes whatever being required. However, if it is desired to enjoy the advantages of the Machlett Automatic Seal Water Jacket, this can be installed quickly. Then, when changing tubes, the water jacket can be operated by hand, safely and without the use of any tools.

* * *

The advantages of the ML-5658 are also available to manufacturers and users of equipment employing other communication-type tubes. The ML-5666 is the Machlett replacement for the 889A; ML-5667 replaces the 889RA; ML-5668 replaces the 892; ML-5669, the 892R. All these tubes were designed and built for better performance and longer life. Write for the complete story of the better values Machlett offers you in these tubes. Machlett Laboratories, Inc., Springdale, Connecticut.

MACHLETT

Over 50 Years of Electron Tube Experience

MACHLETT LABORATORIES, INC.

Springdale, Connecticut

THEY KNEW WHAT THEY WANTED

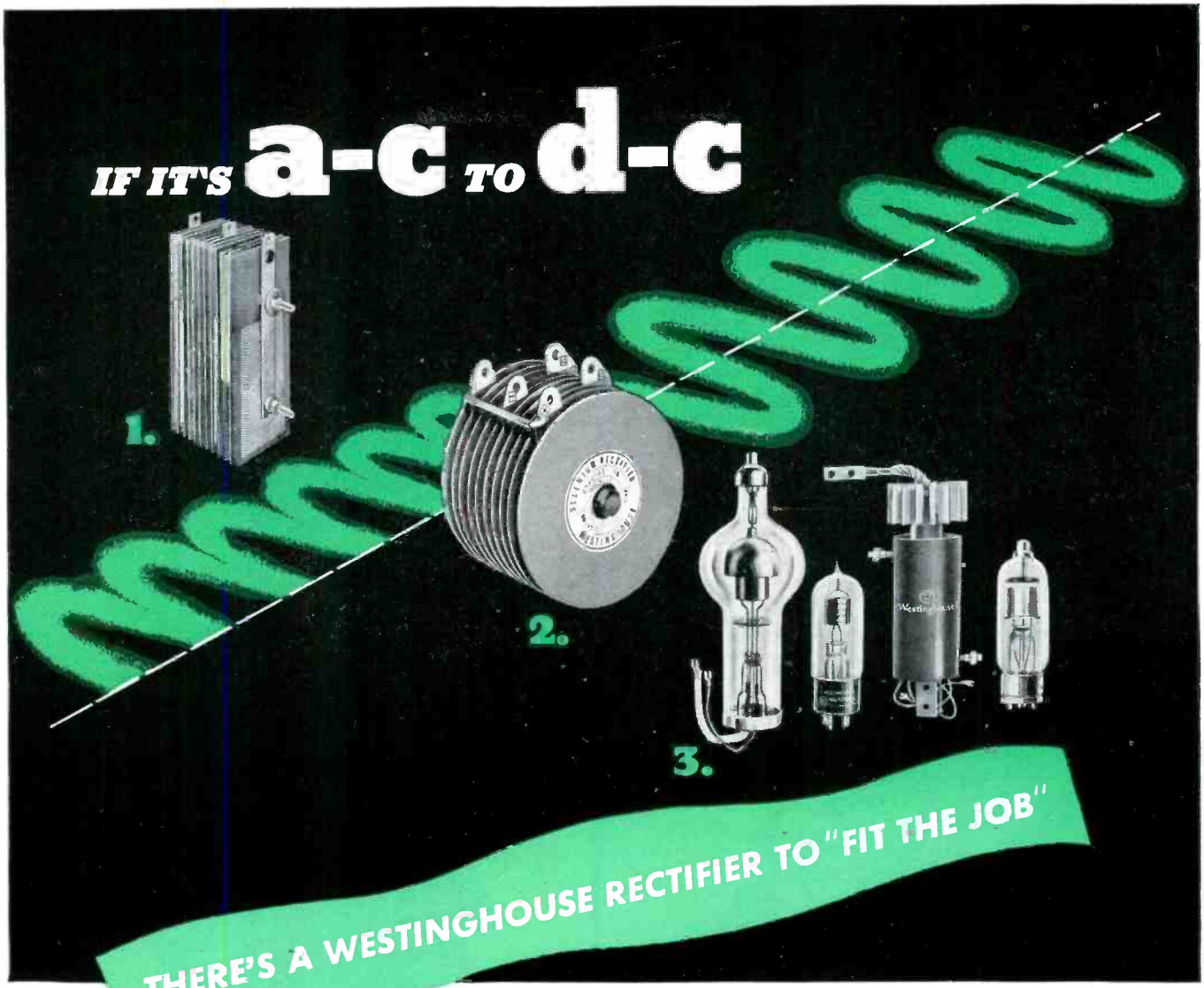
And, like many other radio engineers, they also knew where to bring their plans for successful completion.

Among recent Blaw-Knox installations is this rugged 500 ft. Special Heavy Duty H 40 Tower for the Crosley Broadcasting Corporation's Station WLWT, supporting a 5-section RCA Television Antenna.

Tower-building experience dating back to the days of "wireless" is at your disposal when you enlist the services of Blaw-Knox engineers.

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2077 FARMERS BANK BUILDING • PITTSBURGH 22, PA.

BLAW-KNOX ANTENNA TOWERS



1. **RECTOX** . . . for dependability and long life. Original Rectox Copper-Oxide units installed 20 years ago are still in use today . . . a service record not duplicated by any other metallic rectifier.

2. **SELENIUM** . . . providing a dependable, economical source of d-c power where small size and minimum weight are prime factors. Westinghouse Selenium Rectifiers are the result of more than nine years of continuous research.

3. **ELECTRONIC TUBES** . . . Westinghouse Phanotron, Thyratron, Kenotron, Ignitron and other types of tubes meet the requirements of such varied applications as radio transmitters, speed controls, resistance welding control and x-ray equipment.

Whatever the application—if it's a problem of converting a-c to d-c—there's a Westinghouse Rectifier to do the job. And whatever the problem, Westinghouse engineers, with a background of more than 20 years in the development and application of rectifiers, can offer you the best possible solution.

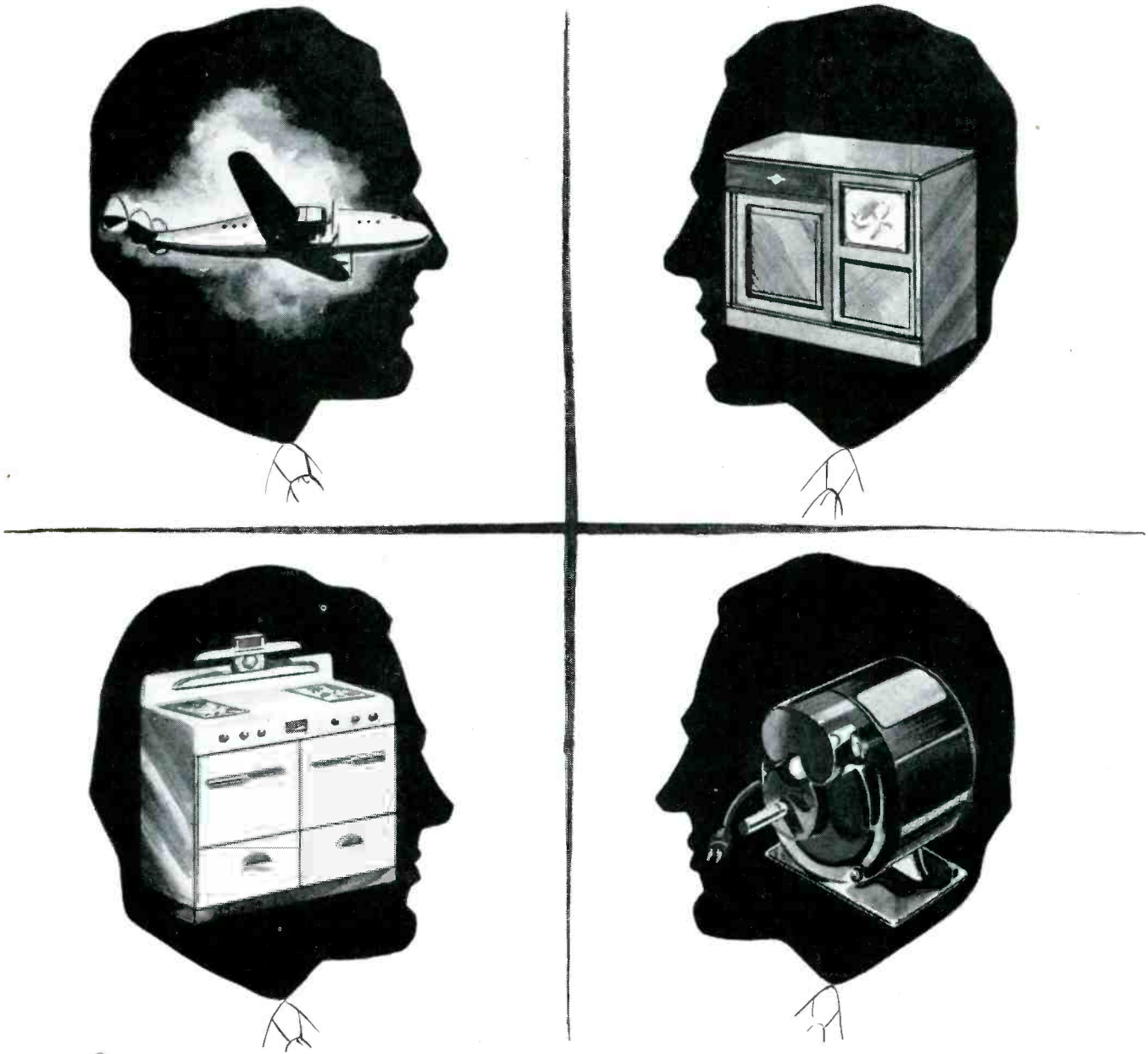
Manufacturing limitations can be met—maintenance problems avoided—control problems simplified—with the Westinghouse complete range of *all* types of rectifiers from which to select. Take advantage of this broad background of help on your rectifier problems—outline your requirements to your Westinghouse representative or write for further information—Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-21421

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Rectifiers

Which Head Can Help You ?



ROCKBESTOS FIELD ENGINEER

Rockbestos representatives are more than salesmen . . . they are seasoned, informed *Field Engineers*.

You can put a lot of faith in your Rockbestos Field Engineer. He didn't get his "savvy" from books alone—but by getting out and getting around factories and plants of every kind—learning at first hand the wire, cable and cord requirements of all sorts of products from waffle irons to huge transport planes.

Matter of fact, it's a big job for us just to keep up with him. He's seldom around his own office, because most of the time he's around your plant or office.

In short, your Rockbestos man has learned the answers to your wire needs by working *in* your business, by working *with* your business, and by keeping constantly informed on your day-to-day requirements.

Use the service he can give you. It doesn't obligate you . . . either in fact or in spirit. It's reliable. It's experienced. Use it.

Get your copy of the new No. 10-F Rockbestos Catalog, 96 pages sectioned for easy reference—write today—to our nearest district office or direct:

ROCKBESTOS PRODUCTS CORP.

461 NICOLL ST., NEW HAVEN 4, CONN.

New York Buffalo Cleveland Detroit Chicago
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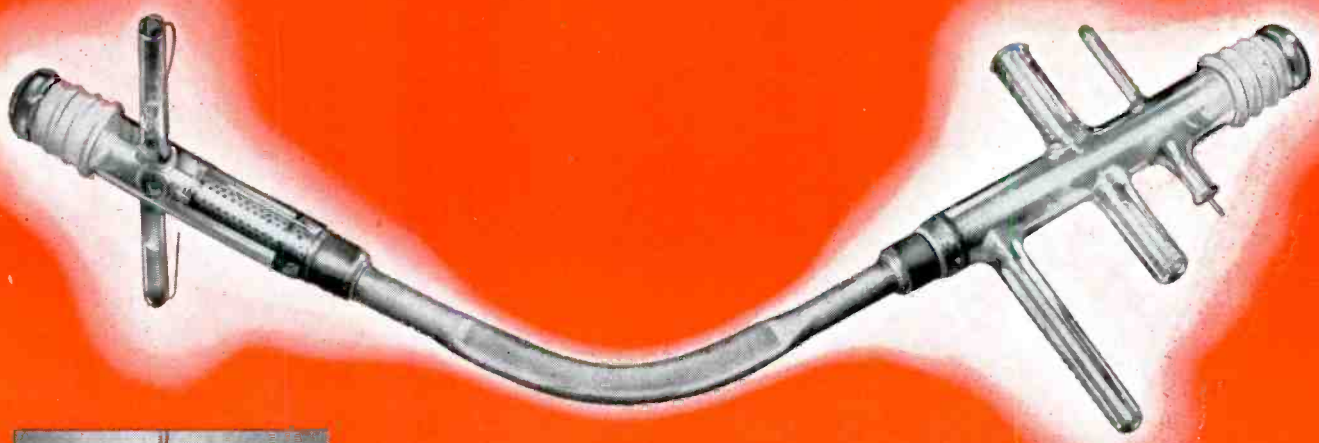
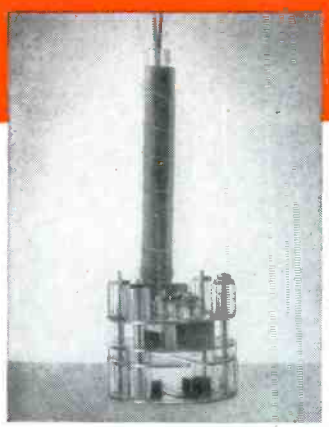
ROCKBESTOS

THE WIRE WITH PERMANENT INSULATION

URANIUM U-235 detector employs NICHROME* V exclusively



60° Mass Spectrometer Tube



Ionization Source

Mass Spectrometer—Model M60
(Process & Instruments,
Brooklyn, N. Y.)

THE Mass Spectrometer, which has played vital roles in the discovery of U-235 and its subsequent applications in fields of atomic energy and cancer research, is one of the most important measuring instruments of the modern age. Its ability to crack molecules and then sort them according to mass makes it unique for analytical purposes.

Materials entering into its construction must be superlatively stable, assuring the highest degree of accuracy at all times, and retain their characteristics unfailingly throughout a long life of trouble-free service.

Specifications for the metal used in the Ionization Source and Collector System typify the super-critical requirements that have to be met. The metal must be:

(a) non-magnetic (i.e. remain unmagnetized in the presence of the powerful magnet used in the Mass Spectrometer);

(b) able to withstand temperatures of approximately 665°F. in a vacuum of 10^{-7} mm. mercury *without deformation or evaporation;*

(c) non-porous, and non-absorbent of gases;

(d) easily machined, drilled, tapped, threaded, and spot welded;

(e) available in wire, sheet and rod forms.

"Of all available metals" states Process & Instruments Inc., of Brooklyn, N. Y., makers of Mass Spectrometers, "Nichrome V most satisfactorily meets all these requirements and hence, with the exception of the tungsten filament, is exclusively used by us in the construction of the Mass Spectrometer. In addition, a Nichrome heating element is used for outgassing the Spectrometer Tube of absorbed moisture".

If *you* have particularly exacting specifications to meet, consult with us. There are more than 80 Driver-Harris alloys specifically designed to fill the requirements of the Electrical and Electronic Industries. The fruits of our 48 years of specialized research experience are at your service.

Exclusive Manufacturers of Nichrome

Driver-Harris Company

HARRISON, NEW JERSEY

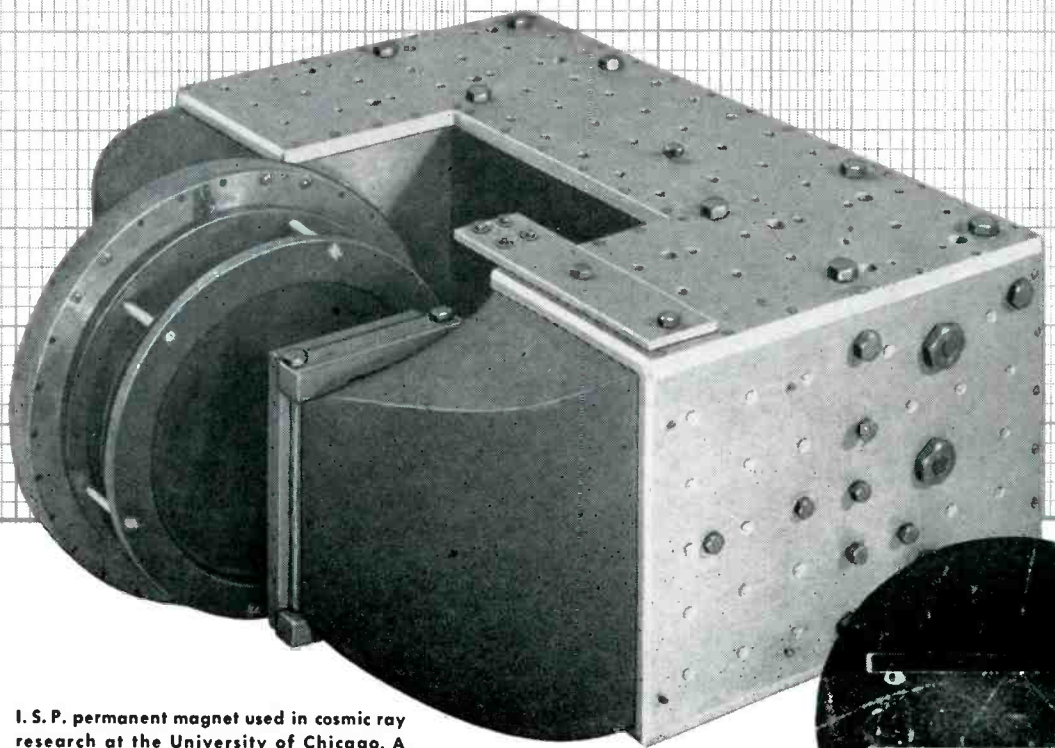
BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle
Manufactured and sold in Canada by
The B. GREENING WIRE COMPANY, LTD., Hamilton, Ontario, Canada

SPECIAL PURPOSE ALLOYS SINCE 1888 — D H — TRADE MARK REG. U. S. PAT. OFF.

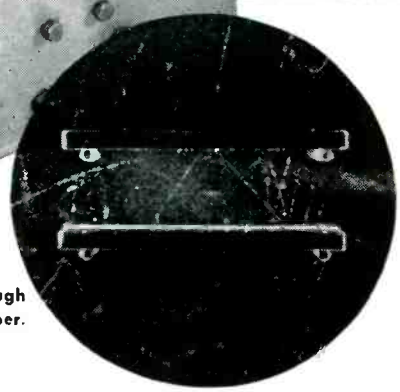
*T.M. Reg. U. S. Pat. Off.

Permanent Magnets do it Better in ...

Scientific Research



I. S. P. permanent magnet used in cosmic ray research at the University of Chicago. A "cloud chamber" is fastened rigidly within the air gap, so that cosmic rays entering the gas-filled chamber are deflected by the magnetic field. Physicists' calculations are based on the path made by the ray through the gas.



Photograph of "tracks" through the gas-filled cloud chamber.

In Cosmic Ray research at the University of Chicago, an I. S. P. permanent magnet helps speed the study of particles unbelievably small—yet with energy that staggers the imagination. U. of C. physicists asked our engineers to furnish this special permanent magnet—*with a 6.5 inch air gap*—to make their studies possible at high altitudes.

WORLD'S LARGEST

The resulting magnet—of Alnico V—is the most powerful permanent magnet in history. Yet its weight is only a *fraction* of that of an electromagnet with comparable strength; and it requires no electric current for operation. Thus it can be taken to mountain peaks or up in airplanes for work in rarefied atmospheres. And it has these additional advantages: no heat produced, no shock hazards, *no operating costs.*

"PACKAGED ENERGY" MAY BE *YOUR* ANSWER

Permanent magnets, with their "independent power," may be the solution to *your* problems—in new equipment designs—or in obtaining higher efficiency, more economy in present products. Investigate *now.* Sizes and materials for a complete range of uses. Write today, Dept. E-7.

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE · CHICAGO 2, ILL.
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

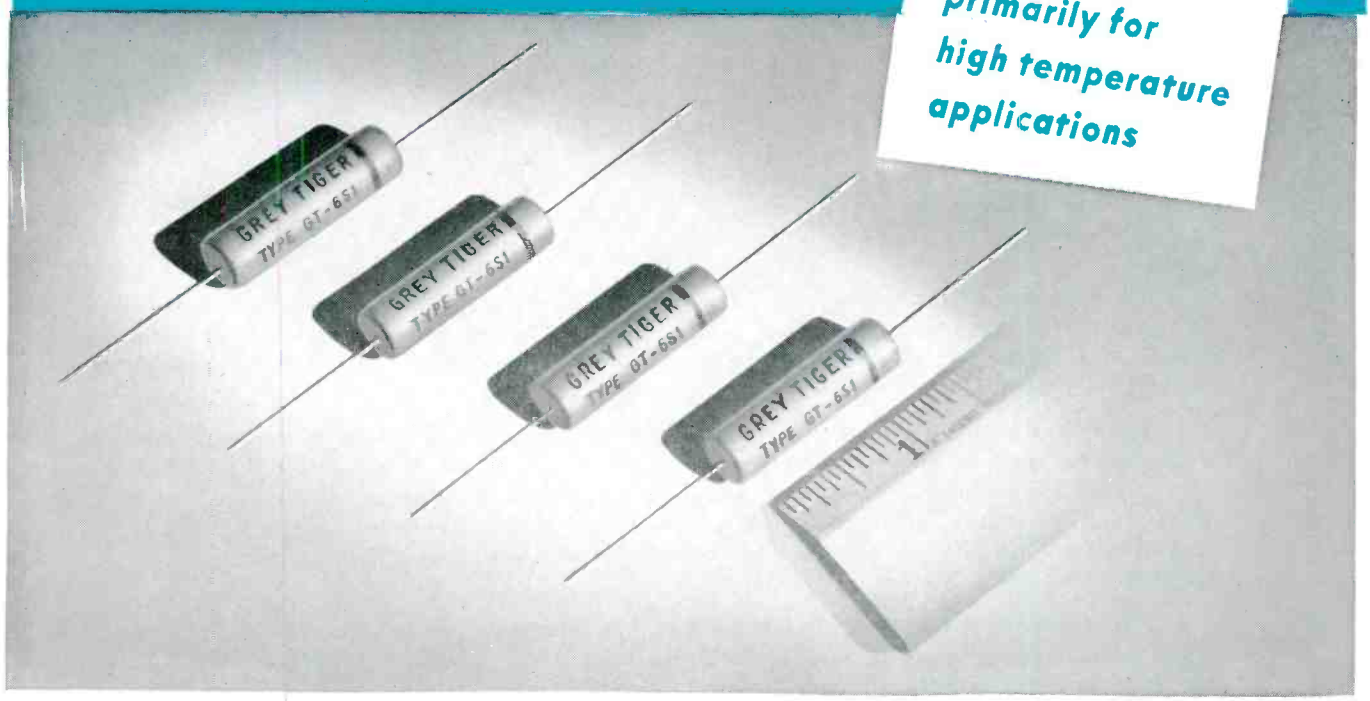
PLANTS { VALPARAISO, INDIANA
CHAUNCEY, NEW YORK

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. K-7, 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 1948

MICA · PAPER
DYKANOL
AND ELECTROLYTIC
CAPACITORS

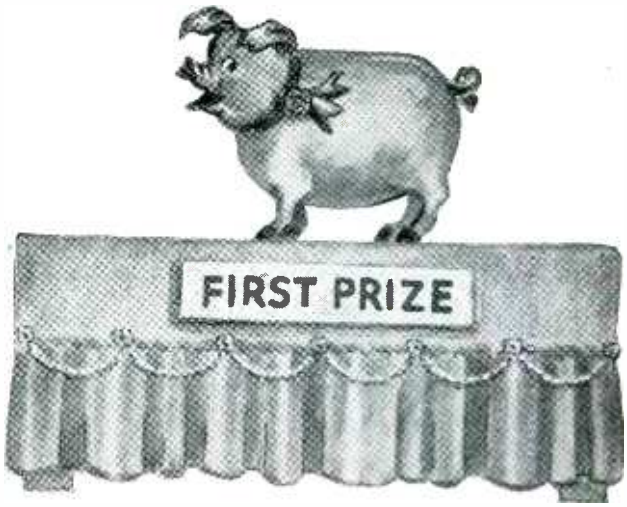
CORNELL-DUBILIER
WORLD'S LARGEST MANUFACTURER OF
CAPACITORS

CORNELL-DUBILIER ELECTRIC CORPORATION, Department K-7
SOUTH PLAINFIELD, NEW JERSEY

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

Name..... Title.....
Firm.....
Address.....

WHAT MAKES A GOOD RECORDING BLANK GOOD*?



INSPECTION

It has been said that "*pigs is pigs.*" Lacquer-coated discs, however, regardless of science in the manufacturing process, do not always turn out to be recording blanks. The suitability of each Soundcraft blank for broadcast-quality recording is judged by the highly trained personnel of the inspection department.

Aside from routine checking of center-hole size and disc concentricity, the prime task of inspection is visual search for minute physical imperfections in the recording surface. One of the few Soundcraft operations that depends on the human element, inspection is carried on in controlled surroundings. Scientific lighting, room-coloring, temperature, humidity, and dust-conditioning all contribute to consistent inspection, grading, and discarding of rejects.

The common dilemma of disc inspectors has long been the tendency toward sliding standards. When the runs are good, it is human to tend to grade down and vice versa. To assure *absolute* standards, Soundcraft maintains inspectors to check the inspectors. These *final* inspectors not only double check the original grading but also eliminate any recording blank accidentally damaged subsequent to initial inspection.

As additional protection to the Soundcraft user, all operators of punch presses, embossing equipment, and labelling machines scrutinize each disc they handle. Thus, with everyone *an inspector, many watchful eyes guarantee rigid standards of surface perfection, to establish your dics recording anew on a standardized, predictable basis.*

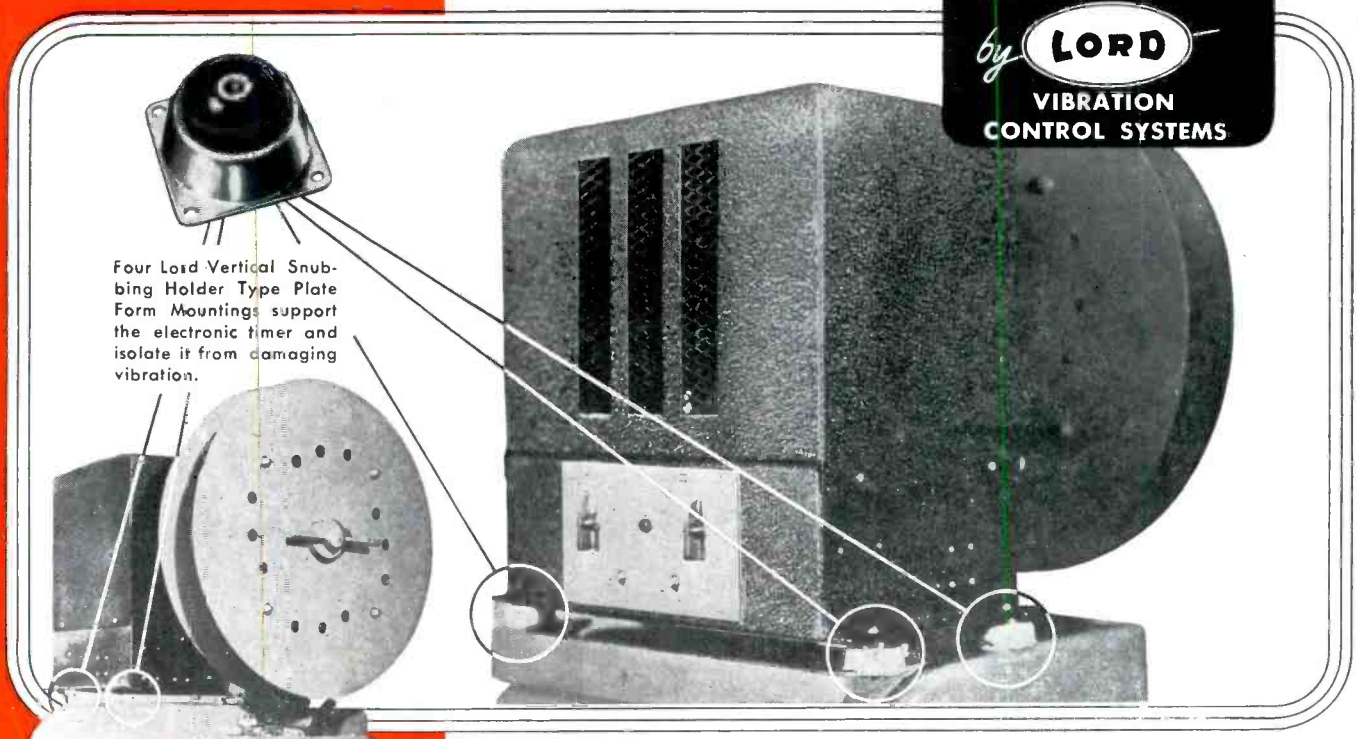
*No. 7 of a series. *Watch this space for succeeding ads on how Soundcraft discs are made.*

REEVES Soundcraft CORP.
10 EAST 52nd STREET • NEW YORK 22, N. Y.
Export Address
REEVINTER, N. Y.

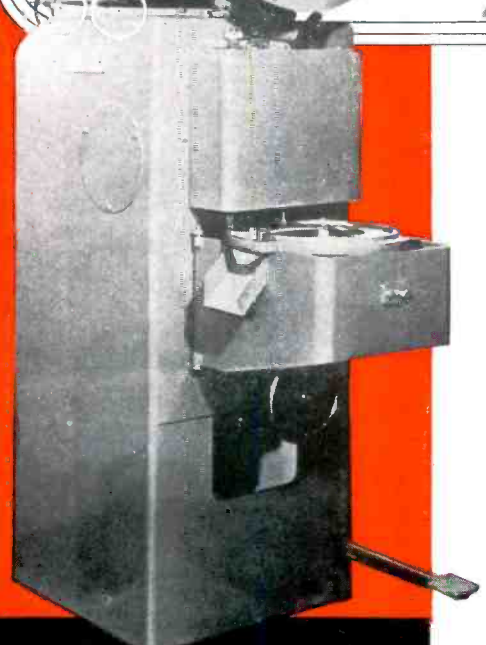
The 'Broadcaster' The 'Playback' The 'Audition' The 'Maestro'

a LORD VIBRATION CONTROL SYSTEM

ANOTHER EXAMPLE OF PRODUCT IMPROVEMENT by LORD VIBRATION CONTROL SYSTEMS



Four Lord Vertical Snubbing Holder Type Plate Form Mountings support the electronic timer and isolate it from damaging vibration.



Gives long life and compactness to this

AGNEW SPARK PLUG WELDER

This welding machine is used by practically all spark plug manufacturers. The operation is automatic; the wire is taken from the reel, fed to length, cut off and welded to the spark plug shells at the rate of 3600 an hour.

Let Agnew Electric Company tell the story. "The Lord Mountings as used to support the electronic weld timers on our equipment are proving very satisfactory in their performance . . . . we feel certain that they will save our customers a considerable amount of money by prolonging the life of the Mercury Vapor Tubes. A much more compact unit is made possible, as previously it was necessary to use a floor mounted electronic control which occupied as much floor space as the machine."

Whether your product embodies electronic controls, high speed operation, or the force of heavy impact, its life can be lengthened, its service improved, its acceptance increased, by a Lord Engineered Vibration Control System.

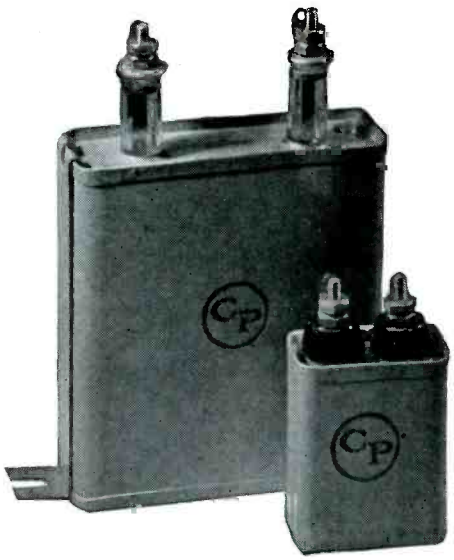
Various Bulletins available on Vibration Control Mountings, Flexible Couplings and Bonded Rubber Products. For applications providing vibration isolation regardless of direction of disturbing forces, Bulletin No. 106; for applications isolating vibration but not subject to intense shock, Bulletin No. 104; for applications involving transient shock loads in addition to vibration, Bulletin No. 103; Flexible Couplings, Bulletin No. 200-C.

LORD

MAKE GOOD PRODUCTS BETTER with *Vibration Control*

LORD MANUFACTURING CO. • ERIE, PA.

Field Offices: Detroit • Chicago • New York • Washington, D.C. • Providence, R. I.
Burbank, Cal. • Philadelphia, Pa. Canadian Representative: Railway & Power Engineering Corp., Ltd.



PLASTICON
Plastic Film Oil-Filled
CAPACITORS—

1. More Economical

2. Smaller—Lighter

3. Better Electrical Characteristics

1. MORE ECONOMICAL

MFD.	VOLTS DC	List Price PAPER CAPACITOR	List Price PLASTICON AOC	SAVING
10	1000	$15.18	$10.67	$4.51
4	2000	13.67	9.24	4.43
2	3000	22.78	15.40	7.38
1	4000	33.54	27.50	6.04
2	5000	48.73	41.25	7.48

Above are typical examples.

PLASTICONS are the result of technological advances . . . cost less to manufacture, give better performance.

2. SMALLER—LIGHTER

MFD.	VOLTS DC	Approx. Weight		Approx. Cubic Dimensions	
		PAPER CAPACITORS	PLASTICONS	PAPER CAPACITORS	PLASTICONS
10	1000	1.95 lbs.	1.7 lbs.	31 cu. in.	30 cu. in.
4	2000	2.0	1.23	31	23
2	3000	2.0	1.21	31	19
1	4000	1.77	.94	28	19
2	5000	5.2	2.9	70	60

3. BETTER ELECTRICAL CHARACTERISTICS

	Paper Capacitors	Plasticons
Power Factor at 85°C 60 cycles	0.7%	0.3%
Resistance at 85°C megohms per Mfd.	40	100
Capacitance/Temp. Coefficient 100% at 25°	−40°C=73% +85°C=97%	−40°C=94% +85°C=103%

PLASTICON CAPACITORS given are Type AOC, mineral oil-filled.
PLASTICON ASC silicone-filled have better characteristics.
Paper Capacitors given are chlorinated diphenyl impregnated.

Condenser Products Company

1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

MANUFACTURERS of GLASSMIKE CAPACITORS and HIGH VOLTAGE POWER SUPPLIES.

These proved tubes are "money in the bank" for medium-size AM broadcast stations

- **Plenty of power . . . Either tube in push-pull will handle the final output of a 10-kw transmitter.**
- **Dependable . . . Already GL-892's and GL-892-R's are on the job in scores of stations where a 24-hour day and 7-day week make exacting demands.**
- **Long-lived . . . General Electric superior design and workmanship pay valuable dividends in extra hours of tube service.**
- **Versatile . . . Applications include broadcast and communications work as amplifiers and modulators—also industrial electronic-heating use as oscillators. A plus-feature: the special 2-unit filament will take 2-phase or single-phase a-c current, or d-c.**

TYPE GL-892
Water-cooled

TYPE GL-892-R
Forced-air-cooled

Your tube investment is soundest when backed by *proved* quality, a *proved* record of performance. In key radio stations—in factories where electronic heating speeds production—GL-892's and GL-892-R's are respected because their performance is well known, their reliability demonstrated many times over. *G-E tubes are a standard by which others may be judged . . .* Builders of equipment, by specifying General Electric tubes, take an important step toward buyer acceptance. Your G-E electronics office gladly will help you choose the correct types for new circuits in the development stage . . . On tubes for replacement, station operators and manufacturers will obtain the fastest, most efficient service from *their nearby G-E tube distributor or dealer*, with same-day delivery a customary feature! *General Electric Company, Electronics Department, Schenectady 5, N. Y.*

	GL-892		GL-892-R	
	Class C Telegraphy	Class C Plate-modulated	Class C Telegraphy	Class C Plate-modulated
Filament voltage	11 v	11 v	11 v	11 v
Filament current	60 amp	60 amp	60 amp	60 amp
Max plate voltage	15,000 v	10,000 v	12,500 v	10,000 v
current	2 amp	1 amp	2 amp	1 amp
input	30 kw	10 kw	18 kw	10 kw
dissipation	10 kw	6.6 kw	4 kw	2.5 kw
Power output (approx), typical operation	14 kw	6 kw	10 kw	5 kw

NOTES: (1) Filament voltage and current are per unit of 2-unit filament. (2) Max frequency for both tubes is 1.6 mc at top plate input; up to 20 mc at reduced ratings.

GENERAL ELECTRIC

161-G5-8850

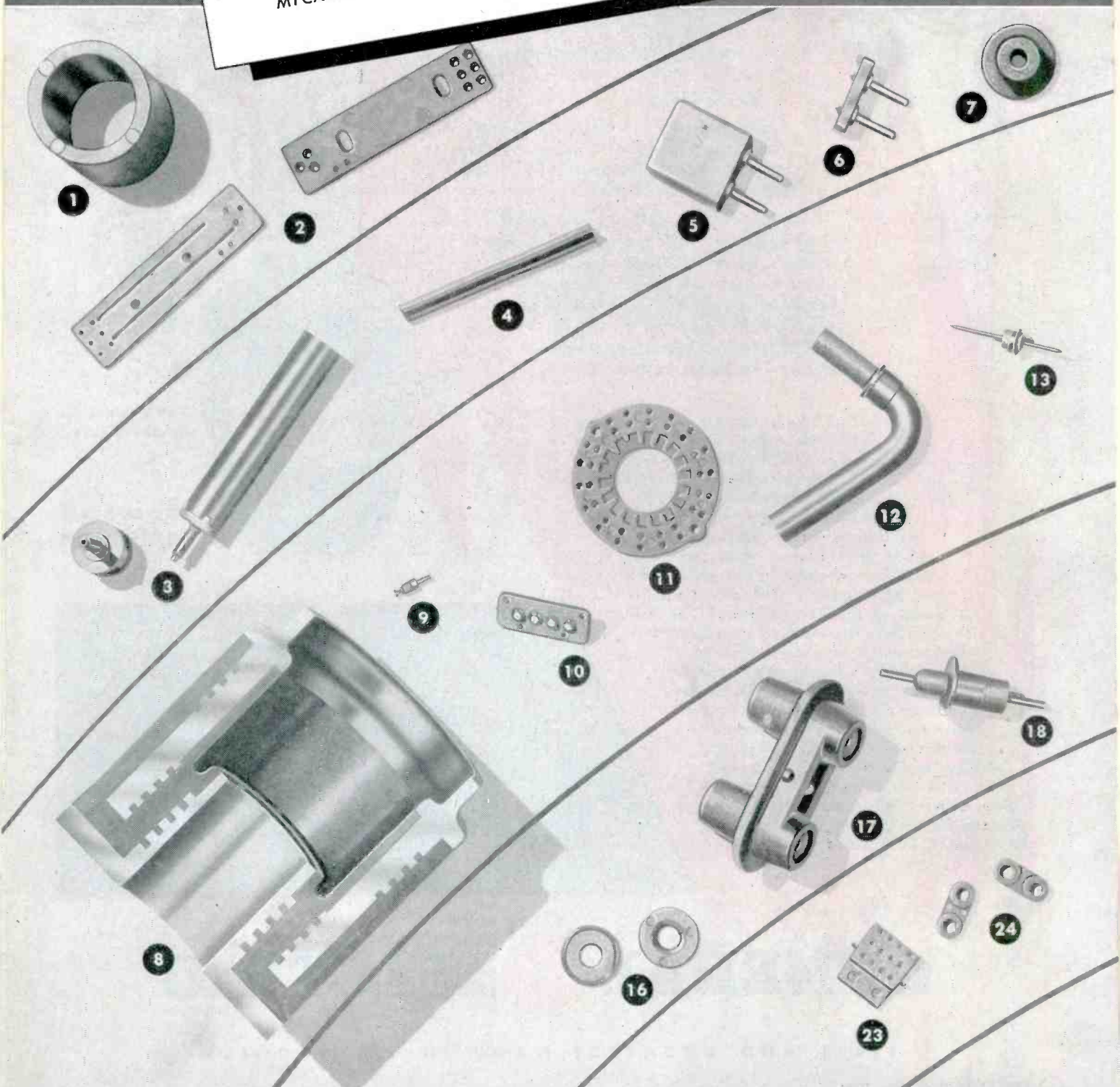
FIRST AND GREATEST NAME IN ELECTRONICS

SINCE 1919
MYCALEX
THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

Memo to... DESIGN ENGINEERS

about... MYCALEX 410 - MOLDED

In the design of components or complete equipment for industrial controls or communications—where insulation qualities are of critical importance—where mechanical precision must be a fixed factor—where strength is essential—where electrical characteristics must accurately meet high frequency circuit needs . . . then remember MYCALEX 410 as the insulation that designs-in with your most exacting requirements.



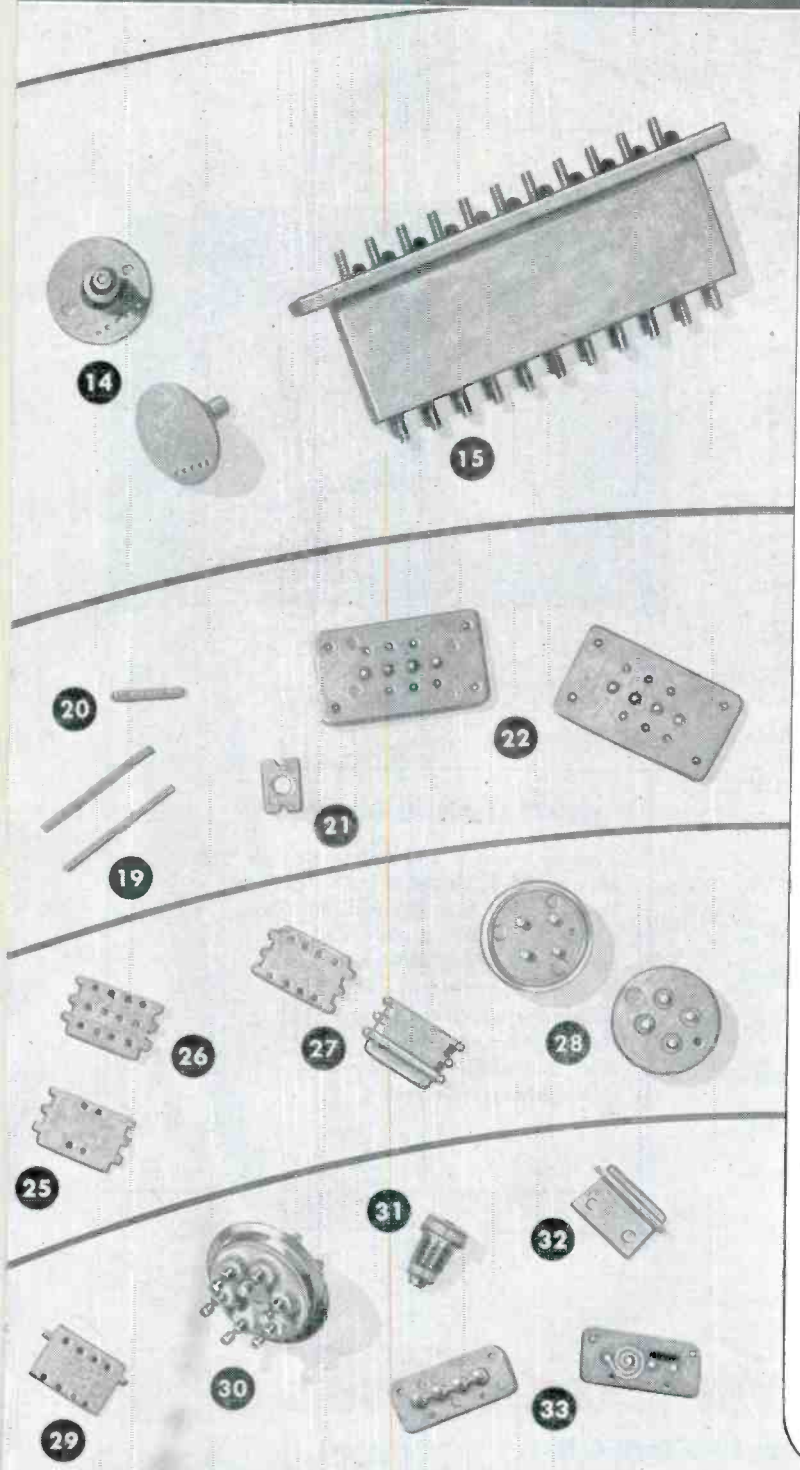
MYCALEX is today's improved insulation — designed to meet the exacting demands of all types of high-frequency circuits. MYCALEX is unusual in that it possesses a combination of peculiar characteristics that make it ideally suited for insulation in all types of electronic circuits. In tomorrow's designs for communications and industrial control equipment, MYCALEX 410 will be specified more than ever before because of its . . . Low dielectric loss · High dielectric strength · High arc resistance · Dimensional stability over wide humidity and temperature changes · Resistance to high temperatures · Mechanical precision · Mechanical strength · Ability to mold metal inserts in place. If you have any insulation problems, our engineers will be glad to help you in their solutions.

MYCALEX CORP. OF AMERICA

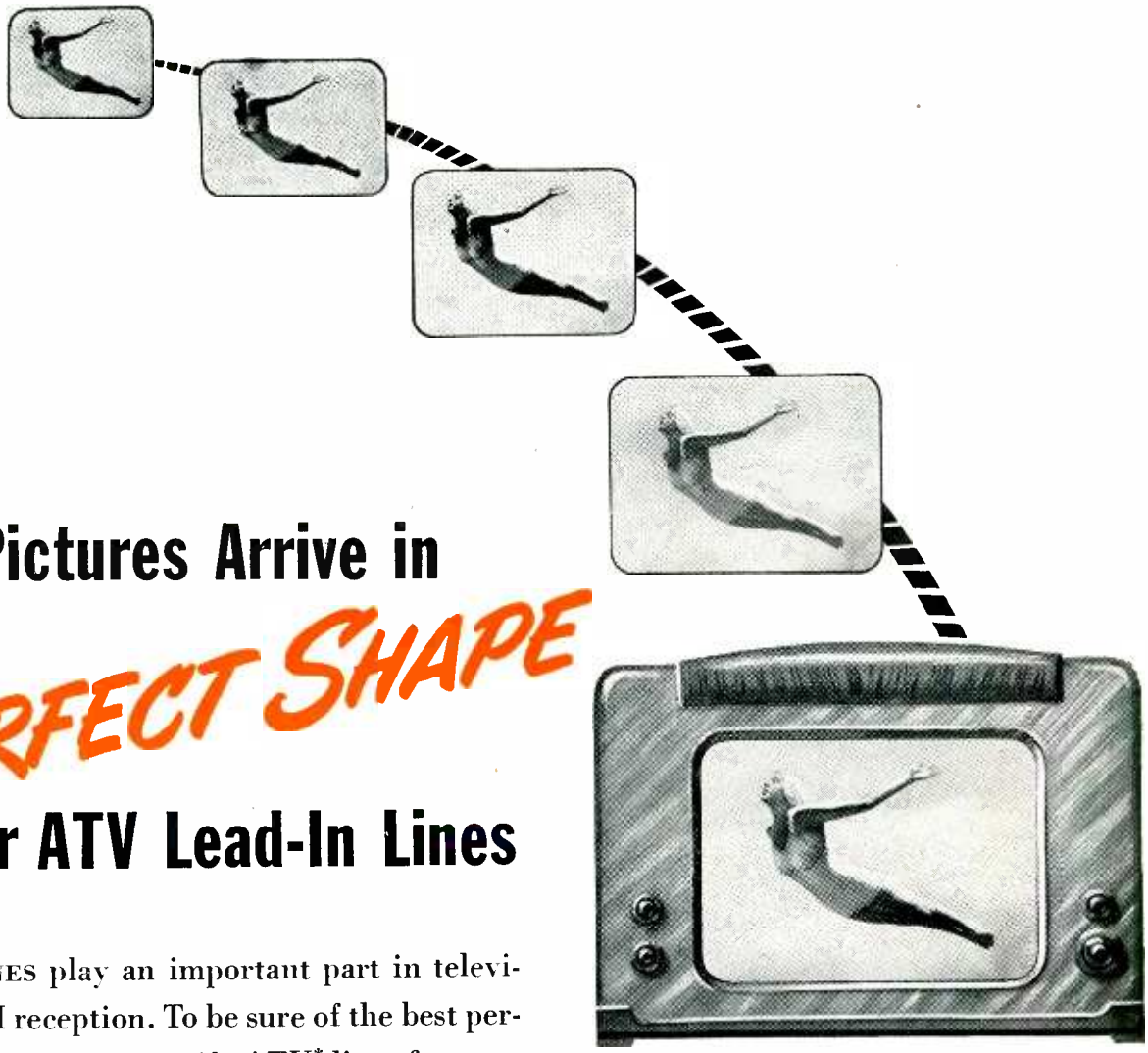
"Owners of 'MYCALEX' Patents"

Plant and General Offices: Clifton, N. J. Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

SINCE 1919 MYCALEX THE INSULATOR TRADE MARK REG. U. S. PAT. OFF.



	PART NAME	APPLICATION	INSERTS	MAX. DIMEN.
1	Bushing	Motor Generator	None	1.75"
2	Insulator	Electrical Instrument	None	3.18
3	End Seal	Thermostat Shell	Stainless Steel	3.75
4	Insulator	Electrical Instrument	None	3.00
5	Hermetic Seal	Crystal housing	Nickel and Copper	0.88
6	Hermetic Seal	Crystal housing	Copper	1.09
7	Insulator	Automobile Antenna	None	1.06
8	Bushing	Ignitron	Steel	4.50
9	Stand-Off Insulator	Electronics circuit	Brass	0.56
10	Panel	Television Selector Switch	Silver	1.38
11	Switch Wafer	Television Selector Switch	None	2.31
12	Elbow	Aircraft ignition	Steel and Brass	2.75
13	Lead	Transformer	Monel	1.75
14	Insulator	Polarizing relay	None	1.09
15	Lead through block	Oscillator	Brass	4.69
16	Insulator	Telephone Transmitter	None	0.88
17	Dual Bushing	Oil Burner Transformer	None	3.00
18	Lead	Transformer	Monel	2.50
19	Actuating Bar	Telephone relay	None	1.44
20	Actuating Bar	Telephone relay	None	0.78
21	Spacer	Radio vibrator	None	0.56
22	Panel	Television Selector Switch	None	1.75
23	Spacer	Telephone relay	None	1.00
24	Spacer	Relay	None	0.91
25	Spacer	Telephone relay	None	1.00
26	Spacer	Telephone relay	None	1.00
27	Clamping Plate	Telephone relay	None	1.00
28	Electrode Mounting	Level Indicator	Brass	1.13
29	Spacer	Telephone relay	None	1.00
30	Six Terminal Header	Transformer	Monel	1.42
31	Test jack body	High Frequency Circuits	Monel	0.75
32	Clamping Plate	Telephone relay	None	1.00
33	Printed Circuit Base	Experimental	Silver	1.38



The Pictures Arrive in PERFECT SHAPE Over ATV Lead-In Lines

LEAD-IN LINES play an important part in television and FM reception. To be sure of the best performance of your set, specify ATV* lines for your set.

The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV lead-in lines.

The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest developopment in coaxial cables.

48447

A Type ATV Lead-In for Every Need

Anaconda offers a complete selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and shielded lines of high impedance. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

*An Anaconda Trade-Mark

ANACONDA

Anaconda Wire and Cable Co.

25 Broadway, New York 4, N. Y.

5,000,000 Youngsters Need Our Help Now

THE bumper wartime crop of babies, about 5,000,000 larger than the population experts expected, is reaching school age.

At school these youngsters should find a good education awaiting them. That is their most cherished American birthright.

But unless something is done quickly, millions of these children will be cheated. They will crowd into classrooms already run on double shifts. They will move in with children who are now sitting two in a single seat. They will read germ-loaded books mangled by a generation of use by grimy hands.

I

So the continuing crisis in American education is given a new twist by unexpected pressure on school plant and equipment.

The U. S. birthrate has jumped by leaps and bounds. Instead of declining in the '40s, as the experts expected it would, the rate climbed from 17.9 per thousand in 1940 to 21.5 in 1943. It jumped to 25.9 in 1947, an increase of 45 percent since 1940. Result—by 1956 elementary school attendance in the United States is expected to jump from 18,200,000 to more than 23,400,000, an increase of about 5,200,000, or more than one-fourth.

The rush has already begun. It will pick up speed next fall.

Now, while this pressure has been building up, our public schools and their equipment have been running down—first through inevitable wartime neglect, then because inflation and material and labor shortages made it difficult to catch up.

If we are to give this bumper crop of youngsters the break they deserve—and reach the educational standards the nation needs—we must speedily do a major job of educational rehabilitation and expansion.

II

Some headway has been made in overcoming the teachers' salary crisis.

Teachers' salaries are improving. Pay problems were driving good teachers away from their posts in droves not long ago. But in the year since the 57th editorial in this series emphasized that crisis, the average teacher's annual salary has increased about $300—from $2250 to $2550.

True, increases vary enormously from state to state and from town to town. In a few states the average increase has been $500; in some less than $100. But, for the nation as a whole, last year's increase put teachers about even in the race with the cost of living. After taxes, their salaries have risen 68%, and the cost of living 67%, since 1939. In terms of pay increases, however, they are not nearly as well off as are industrial workers, whose average weekly wages after taxes have risen 108% since 1939. They are far behind farmers, whose net income is now four times what it was in 1939. And teachers had notoriously low salaries to start with.

A great deal more needs to be done in raising salary standards to put our school system on a firm footing. There are still about 100,000 teachers, nearly 12% of all public school teachers, who hold temporary or emergency credentials. They cannot meet

prevailing standards, and not very severe standards at that, for persons holding their posts.

The salary crisis, however, is easing.

III

But now comes the new crisis in school buildings and equipment.

We would have been hard put to get our schools back into shape after years of wartime neglect—even without a booming birthrate complicating the problem. Right now, 85% of all public school buildings need major remodeling to remove health and safety hazards.

And we aren't building enough new schools to keep up with current needs, to say nothing of catching up on those we were not able to build during the war years. School construction expenditures for 1948 are estimated at $375 million — which is less than what was spent in 1939. With building costs twice as high as they were in 1939, that means we aren't even holding our own—we are falling further behind.

And now comes the rush of war babies.

IV

We must spend at least $11 billion on new schools and equipment in the next decade.

Public and elementary schools must have $6.6 billion. Equally important, another $4.4 billion must be invested in buildings and equipment in our private schools, colleges and universities if they are to meet the demands which will be made upon them. The private school and the privately endowed university are doing their full share and doing it well. The need for them is increasing.

These figures cover only rockbottom needs for educational plant and equipment. But statistics are a very restricted recorder of this crisis.

You can see it better, I'm sure, in schools not very far from your home. There are schools with leaking roofs and outdoor toilets in our greatest cities. There are schools where students still use histories and geographies copyrighted before 1920—books with no mention of World War I, the depression of the 1930's, the Russian Revolution or the rise of the dictators. There are countless schools where modern methods of visual education are completely unknown.

All of these conditions promise to get worse — promptly — as that scheduled 5 million increase in the school population gets rolling.

V

The Metropolitan Life Insurance Company does not indulge in lurid prose. It says after painstaking study of the educational crisis that:

"Unless definite measures are taken immediately . . . large numbers of American boys and girls will be deprived of an adequate education."

Currently we are deeply concerned about our military defenses. We are taking, and I think rightly, emergency measures to strengthen them. But we must regard our schools as a part of our national defense as vital as are our armed forces. This is particularly true in these times of fifth columns and ideological warfare.

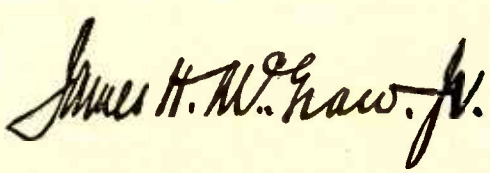
If we are wise, we will raise our sights. We will give the continuing crisis in education the same urgent attention being given the more obvious but no more real crisis in national defense.

Go to the school house in your neighborhood and discover what needs to be done to provide for the rising tide of young Americans. Ask your school board and your school administrators and teachers how you can help them.

That is good citizenship.

That is patriotism.

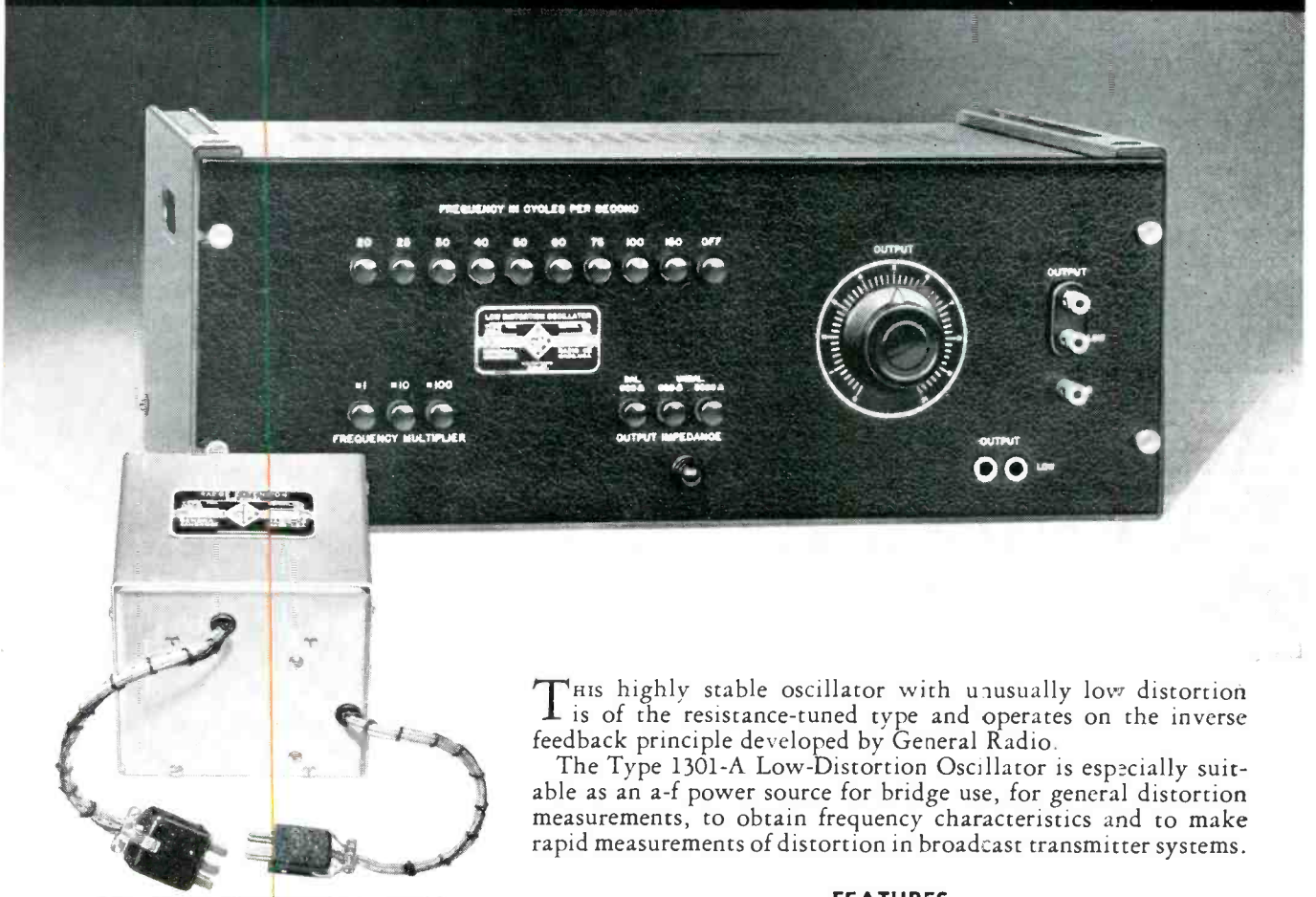
That is our duty to the oncoming generation.



President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 68TH OF THE SERIES

for DISTORTION and BRIDGE MEASUREMENTS at 2 to 15,000 CYCLES



● The normal range of this oscillator is 20 to 15,000 cycles. The Range Extension Unit (above) lowers this range by a full decade to 2 to 15 cycles, greatly extending its usefulness to frequencies considerably below those heretofore practicable.

With its very high stability, unusually low distortion and many operating conveniences, the Type 1301-A Low-Distortion Oscillator fills a universal need in distortion and bridge measurements.

TYPE 1301-P1 RANGE EXTENSION UNIT $70.00

THIS highly stable oscillator with unusually low distortion is of the resistance-tuned type and operates on the inverse feedback principle developed by General Radio.

The Type 1301-A Low-Distortion Oscillator is especially suitable as an a-f power source for bridge use, for general distortion measurements, to obtain frequency characteristics and to make rapid measurements of distortion in broadcast transmitter systems.

FEATURES

- **WIDE FREQUENCY RANGE** — 20 to 15,000 cycles (with Range Extension Unit, 2 to 15,000 cycles)
- **CONVENIENT TO USE** — 27 fixed frequencies, selected by two push-button switches in logarithmic steps — any desired frequency between steps obtained by plugging in external resistors
- **THREE OUTPUT IMPEDANCES** — 600-ohm balanced to ground; 600-ohm unbalanced; 5,000 ohm unbalanced
- **EXCEPTIONALLY PURE WAVEFORM** — Distortion not more than the following percentages: with 5,000-ohm output 0.1% from 40 to 7,500 cycles; 0.15% at other frequencies. With 600-ohm output 0.1% from 40 to 7,500 cycles; 0.25% from 20 to 40 cycles and 0.15% above 7,500 cycles
- **HIGH STABILITY** — Frequency is not affected by changes in load or plate supply voltage. Drift less than 0.02% per hour after a few minutes operation
- **ACCURATE FREQUENCY CALIBRATION** — Adjusted to within 1½% ± 0.1 cycle
- **NO TEMPERATURE OR HUMIDITY EFFECTS** — In ordinary climatic changes, operation is unaffected

TYPE 1301-A LOW-DISTORTION OSCILLATOR $395.00

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38

BUSINESS BRIEFS

By W. W. MacDONALD

Fair-Haired Boy of the communications business at the moment is obviously television. The public is going for it in a great big way, and this interest is quickly reflected in engineering circles. Papers on the subject are reaching the editorial offices of ELECTRONICS in increasing numbers. Three appear in this issue (pages 72, 80 and 110) and many more are in process.

We Hear that an a-c/d-c television receiver is about to hit the market for about $150.

Television Receivers shipped by RMA-member companies in 1947 totalled 162,181. Here's where they went, by States:

New York	61,245
New Jersey	27,000
Pennsylvania	19,389
Illinois	13,727
California	7,898
Ohio	4,991
Michigan	4,887
District of Columbia	4,782
Missouri	4,090
Maryland	3,723
Connecticut	3,303
Wisconsin	2,315
Massachusetts	1,403
Minnesota	400
Virginia	399
Indiana	326
Delaware	174
Florida	41
New Mexico	21
Tennessee	15
Rhode Island	3
Texas	3
Unidentified	2,046

Power Companies in some cities are in a minor dither about television. Somebody has been spreading the misinformation that receivers won't work if the line voltage varies more than 3 percent from the nominal 115. Actually, most sets are ok from about 105 to 125 volts, which is better than 8 percent tolerance.

Rapid fluctuation of line voltage is more serious in connection with video images than the line voltage itself, partly because television receiver circuits are more critical than radio receiver circuits but largely because the eye is a more demanding organ than the ear. This has led a number of set manufacturers recently contacted to suggest that utilities commissions should tighten line voltage requirements from the present 5 percent tolerance (10 percent is actually permitted in many cases) to 2.5 percent or better.

The fact of the matter is that it would take three years or more for power companies to comply with such an order. Home appliances of all kinds are being sold in tremendous quantities and it is, we are told by good authority within our own McGraw-Hill shop, still impossible to buy enough pole transformers and other transmission gear to keep up with the rapidly increasing load. Utilities are trying hard, not only because of television, but also because fluorescent-light flicker is becoming serious.

It is this columnist's carefully considered opinion that makers of television receivers would do well to face the situation realistically and equip at least their better sets with voltage regulators and/or other automatic controls. Relief from the power companies will come slowly.

Indoor Tele Antennas (p 66, June) were exhibited by two manufacturers at the Parts Show. One was an extremely compact directional affair smaller than the average table lamp, and intended for use near the set. The other was an extremely novel metal-foil-covered cardboard antenna of the bi-conical type, designed to be set up like a folding advertising display and placed in an attic.

This, friends, is just the beginning.

Speaking Of Antennas, the Parts Show was once again forrested with trick f-m and television types. How, gentlemen, about adding parallel bars for the athletically inclined, and a swing for junior?

Not Many Test Instruments suitable for servicing television receivers were ready for exhibition at the recent Parts Show in Chicago. They were, booth at-

THE TREND . . . is definitely toward single-sideband operation. Advantages are obvious. Elimination of a continuously running carrier saves power and reduces interference. In fact, a signal is put on the air only when something is said.

HOWEVER . . . it does present some problems. To reproduce voice and music the equipment must handle high peaks of power even though the average power is very low. Unlike conventional AM service, where the modulation level must be held down so that the high peaks will not exceed available carrier, single-sideband modulation levels because of the absence of carrier are unrestricted by peaks and in general are limited only by the average power an r-f amplifier can produce.

TUBES . . . which can handle high peak powers in excess of normal rating are a natural for single-sideband work.

EIMAC TETRODES ARE THE ANSWER

REMEMBER . . . the universal use of Eimac tubes in radar? They were specified because of their ability to handle high peak power. Now, this ability enables them to take the lesser requirements of single-sideband service in stride. Eimac tetrodes handle high peaks because of their inherent ability to take momentary overloads, their reserve supply of emission, and freedom from internal insulators.

IT IS FAR EASIER . . . to produce a single-sideband signal at a low power level. Here again Eimac tetrodes fill the bill. Because of their high power-gain, this valuable low-power signal can be built up from the modulator to high power in a single amplifier stage.

IN ADDITION . . . the single-sideband driver must "see" a constant load resistance, and Eimac tetrodes with their low driving-power requirement mean a minimum of swamping action. It is even possible to run up the screen voltage until no grid current is drawn and no changing load is presented to the driver.

DATA AVAILABLE

PICTURED . . . above is the popular 4-65A tetrode. A new complete data sheet on it has been prepared. You will find SSSC ratings and suggestions in it . . . write today. Other Eimac tetrodes suited to SSSC application include 4X150A, 4-125A, 4-250A, 4-400A and the 4-1000A.

Follow the Leaders to

Eimac TUBES

The Power for R-F

EITEL-McCULLOUGH, INC.
199 San Mateo Avenue
San Bruno, California

EXPORT AGENTS: Frazar & Hansen—301 Clay St.—San Francisco, Calif.

tendants said, "not quite ready."

Prediction: There'll be a healthy demand for such instruments soon, and the manufacturer that gets there "fustest with the mostest" will do very well indeed.

Farmers' Cooperative installation of five f-m stations in the vicinity of Ithaca, New York may start a trend and swell rural business. At last report the co-op was dickering with several manufacturers for 30,000 receivers.

Big Four items in the field of industrial electronics at the present writing appear to be, in this order, (1) high-frequency heating, (2) resistance welding control, (3) power rectification and, (4) motor control.

Pocket Screamer carried by people dabbling in radioactive materials consists essentially of an ion chamber, a low-leakage capacitor that is charged each morning, and a buzzer. When things get too hot to be healthy the capacitor lets go through the chamber and the buzzer buzzes.

The market for gizmos of this kind appears to be infinite.

Packaging of electronic equipment leaves much to be desired. Our products are particularly vulnerable to the idiosyncrasies of carriers and we get quite a lot of mail on the subject, most of it unprintable. A number of manufacturers are giving special attention to the problem, some with and some without outside aid. A lot more ought to devote time to it.

Radio-Teletype receiving unit developed by one of our readers appears to be extremely compact, inexpensive, and easy for nontechnical users in out-of-the-way places to keep running. Someone with a genuine need for such a unit and the facilities for trying it out is needed. *Business Briefs* will be glad to pass along correspondence.

Drive A Car? If so, you can handle the new wire and tape recorders ok. Several of them have a control for running the machine

forward and backward, erasing and etc., that for all the world resembles a gear-shift lever.

No license required.

Taxi Dispatching by radio is becoming so essential, particularly where competitive systems have snapped up all available channels, that some fleet owners are tempted to bootleg. FCC has already had to crack down on at least one illegal station. It won't be the last.

Dry Battery Sales are up this Summer, two of the biggest producers tell us. It seems like everyone and his brother has bought a portable radio.

Money To Burn is the only possible lead for this item. It seems that an eastern bank put some old and rare greenbacks in the window to stimulate business and slapped a mineral-oil filled television magnifier in front of it. Out came the sun next morning and set the stuff on fire.

Recently Published Figures (p 68, May) concerning the number of licensed amateur radio operators employed by manufacturers in our field stimulated several readers to conduct their own local surveys.

G. H. Floyd (W2RYT) says that he knows there are at least 200 hams working for G-E and suspects there might be twice that number. Airborne Instrument's Irwin Nye says his company employs 15. Lenkurt Electric has 6.

Practical Jokers are everywhere. In April we mentioned the fact that one of our draftsmen had made a mistake in connection with a circuit diagram of an electronic organ and lettered in the words "soft-shell crab" instead of "soft-swell tab." We went on to say that the error had been caught.

Several readers have since written in to tell us that the error actually appeared on page 118 of the May issue and we blush to report that they are quite right. It seems that one of the editors deliberately let it go through to give the readers a laugh.

P.S. He won't do it again.

Which Properties Do You Need Most in Electrical Contacts?

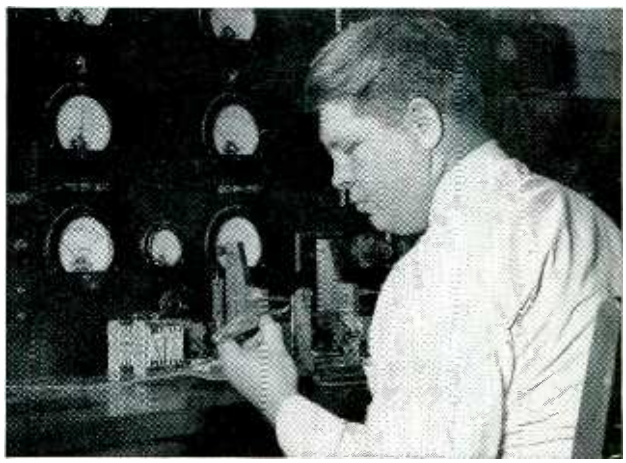
IN theory, the perfect contact material should combine non-sticking properties, low contact resistance, high thermal and electrical conductivity and resistance to electrical erosion with high strength and hardness. In actual practice (because operating conditions differ widely) only two or more of these properties usually predominate.

How does Mallory produce materials in which the correct properties for a specific job exist? You can be sure it isn't done by guesswork. Although Mallory has designed more than 5000 different contacts—has had 20 years of experience in metallurgy generally—it believes in rigid control. This control is accomplished by a series of spectrographic, chemical, electrical and microscopic tests such as you see at the right. They reveal the truth about chemical composition, grain structure, physical properties.

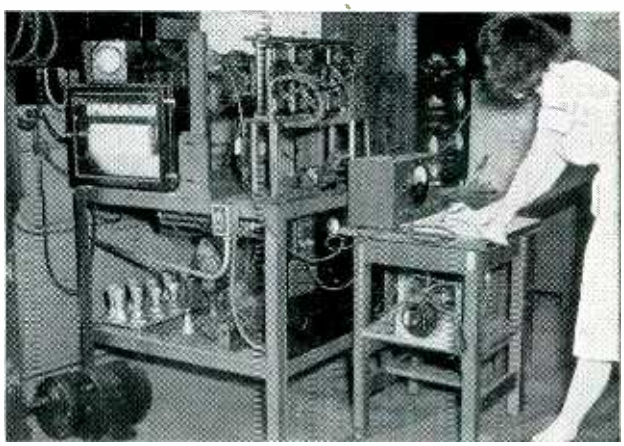
MALLORY STANDARDIZED CONTACTS

Yes, you're sure when you order Mallory contacts. Furthermore, you get the benefit of Mallory design experience, its manufacturing facilities for producing every kind of contact including contact assemblies. What's more, Mallory has developed eight basic contact designs that meet thousands of typical applications—save time and money involved in designing "specials." Send for the Mallory Contact Catalog.

This Mallory spectrograph determines the purity and composition of metals and alloys.



Here Mallory learns what happens in the electrical circuit when contacts are opened and closed.



With this unit, Mallory technicians measure contact resistance, temperature rise, and rate of wear.

IT'S 5000 TO 1 THAT A MALLORY STANDARD CONTACT WILL MEET YOUR "SPECIAL" REQUIREMENTS

In Canada, made and sold by Johnson Matthey & Mallory Limited, 198 Clinton Street, Mount Dennis, Ontario.

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MALLORY ELECTRICAL CONTACTS & CONTACT ASSEMBLIES

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

CROSS TALK

▶**STAMPEDE** . . . An item in a recent issue of Martin Codel's excellent weekly television newsletter has us stopped dead in our tracks. The subject was the current shortage of channels for television and the shock came from two proposed solutions to the shortage which, it was rumored, were being given serious consideration in unnamed quarters of the industry. The first solution proposed the immediate use of channels in the 500-to-900-mc region now reserved for experimental development of television, including color systems. The second proposal was to reduce the width of the standard channel to something less than 6 mc, to allow more channels to be squeezed into the available space between 54 and 216 mc.

Both proposals, brother, are bad. Consider first the 500-to-900-mc space. We didn't know how to use this space for color television a year ago and it was on this basis, primarily, that the FCC turned down the color proposal and gave the green light to black-and-white. We still don't know how to use it. Eventually many of the missing answers will be forthcoming and then the space may prove useful for extending the present service. But any immediate shift to the uhf bands would bring many more problems than it would solve.

Reduction of the channel width is a bad idea now and it will stay that way indefinitely. Six megacycles is narrow enough for television, just as 10 kc is narrow enough for standard broadcasting. The 10-kc figure was a bad guess in 1925; it prevented high-fidelity broadcasting for 20 years. Only now is the f-m system redeeming the mistake. We can count on no such redemption for television, even in 1970.

We think the stampede for channels requires careful evaluation. Granted there aren't enough channels for all those who would like to enter the television broadcasting business. Granted the entrepreneurs are influential and can bring great pressure to bear on Congress and the FCC. But FCC decisions are hinged on the convenience and necessity of the *public*, not the broadcasters. And there is no great clamor, at present, from the public for additional television service. If J. Q. Public wants television service he must, first and last, live in an area sufficiently populous and prosperous to support the service. If he lives in such an area he can have a choice of seven programs. If fewer programs are available it is not due to lack of channels. It is because the level of trade in that area will not support the heavy expense of a seven-choice service. In many areas the seven available stations will not be in the same city, but by judicious use of directional antennas they will be available to all who want to tune to them. Otherwise there is no shortage of channels in that area.

We are, in short, up against the problem that has bedeviled standard broadcasting these past ten years. Shall we let down the bars on allocation standards to allow more broadcasters to enter the business? Within limits this is sound policy because it enhances competition. But the limits are reached when the quality of service is degraded to such a point that the public loses interest. Then everybody loses.

The FCC, facing up to the problem, has called a hearing on this subject for September. Certainly the pressure for additional channels, so long as it resides so largely in the broadcasting camp and so little in the body politic, must be resisted until the technical implications of a new allocations policy are thoroughly explored.

▶**ACRONYM** . . . The cockles of our heart warm to the new American College Dictionary published by Random House. One of the new words included is *acronym*, defined as "a word formed from the initial letters of other words, as . . . loran (from long range navigation)". We can't imagine a nicer example. We are happy that such recognition is given of the important place of acronyms in electronics (radar, shoran, sofar, sonar and so on). The new dictionary has many accurate definitions of technical terms in our field, thanks to contributions of W. L. Everitt, K. S. Johnson and others. We recommend it.

Design Factors for INTERCARRIER

By STUART W. SEELEY

Director
Industry Service Laboratory
Radio Corporation of America
New York, N. Y.

THE intercarrier system of television sound reception, as previously described in these pages', amplifies the picture and sound signals together in the picture i-f amplifier. At the output of the picture second detector a beat note between the two signals appears. This beat is in effect a 4.5-mc intermediate frequency, frequency-modulated in accordance with the sound signal and amplitude-modulated (to some extent) in accordance with the picture signal. This intercarrier beat is passed through a frequency-modulation detector which is not sensitive to amplitude modulation. The sound modulation is thus separated from the picture and may be amplified and applied to the loudspeaker, as shown in Fig. 1.

When this system was first proposed the principal advantage appeared to be economy. The picture i-f amplifiers and video amplifiers do double duty in amplifying the sound signal, so a separate sound i-f amplifier is not necessary. Thereafter it became clear that the economic argument is by no means the most important one. There are many pros and cons rooted in the technical performance of the system which outweigh the cost factor.

Technical Advantages of Intercarrier System

The principal technical advantage of the intercarrier system is the fact that it is immune to the idiosyncrasies of the local oscillator of the receiver. Frequency modulation of the local oscillator due to hum and microphonics, as well as frequency drift, affect both sound and picture i-f signals substantially identically, so the 4.5-mc difference frequency remains unaffected. In a conventional receiver (using a separate i-f amplifier for sound, as shown in Fig. 2) these defects of the local oscillator produce an average effect four times as bad at the highest television channel (216 mc) as in the f-m band (108 mc) at full modulation. With television systen deviation (one third f-m sound broadcast deviation) the effect is emphasized by an additional factor of three.

Secondly, the tuning of an intercarrier receiver is considerably simplified by the fact that the sound is always correctly tuned in when switching from one station to another. Fine tuning of the local oscillator is not necessary to tune in the sound. Moreover, the intercarrier system is somewhat freer from the effects of interference.

Technical advantages related to economy of design include not only the dual use of the i-f and video amplifiers but also the fact that the local oscillator design can be somewhat less expensive. In fact, hum frequency modulation and drift may have values several times those allowable in a conventional receiver. In inexpensive receivers, the i-f passband may be made symmetrical, and this will allow the local oscillator to operate on the high side for the lower channels, and on the low side for the upper channels.

Disadvantages

The primary disadvantage of the intercarrier system is the fact that the 4.5-mc beat signal depends on the presence and character of the picture carrier. Any unusual effect present in the picture carrier can have a corrollary effect on the sound output and this possibility exists whether the effect arises in the transmitter or the receiver, or is caused by interference from other sources.

One of the most important examples occurs whenever the picture modulation is so heavy that the picture carrier disappears completely during the transmission of a peak white portion of the picture. When the picture carrier is thus modulated to zero, the 4.5-mc beat note disappears for that instant and no sound signal is received. This

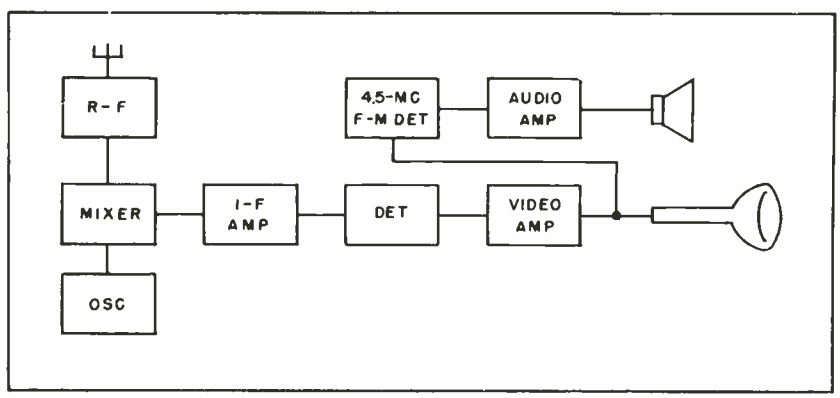


FIG. 1—Typical intercarrier receiver. The i-f, video detector and video amplifiers do double duty, handling picture and sound signals simultaneously

TELEVISION SOUND

Large scale production of television receivers employing intercarrier sound has focussed attention on the advantages and disadvantages of the system. This review emphasizes problems facing transmitter and receiver designers

causes severe interference in the sound signal, in the form of a 60-cycle buzz or 15,750-cycle hiss, since the loss of sound signal is repeated at the field and line-scanning rates. This possibility requires that the percentage modulation at the transmitter be monitored carefully, so that the minimum picture modulation shall not fall below approximately 10 percent of the peak value. There is at present no regulation requiring such monitoring. Before the intercarrier system can be employed with assurance of high-quality transmission at all times, such a regulation will be required.

A second effect, of nearly equal importance, is that caused by any phase or frequency modulation of the picture carrier. This carrier is nominally modulated in amplitude only, but actually may be modulated in phase or frequency to a slight degree. Such variations in picture phase or frequency are imposed on the 4.5-mc beat note and cannot be separated from the frequency modulation of the sound signal. The result is, again, a 60-cycle or 15,750-cycle note of magnitude depending on the extent to which the picture carrier is phase or frequency modulated. It should be noted that the frequency-modulation detector which converts the 4.5-mc beat signal to audio is in effect a phase detector, for all frequencies above about 2.5 kc, when 75 μsec de-emphasis is used.

There are many possible causes of phase or frequency modulation of the transmitted picture carrier. One is variation in the transit time (which produces a change in phase angle of the carrier) in any modulated stage of the transmitter. However, this is of negligible magnitude compared with the effects of unsymmetrical tuning or incomplete neutralization. In a 5-kw transmitter, even one-half watt of constant fed-through power can produce as much as a 6-degree total phase shift when the modulation level is at 10 percent of peak carrier. This amount of feed-through can occur even in a properly neutralized stage, and the effect can be identified in the output of an intercarrier sound receiver. For example, 4 degrees peak shift at 15 kc will produce interference only 28 db below average (30 percent) modulation without deemphasis.

Deemphasis improves the situa-

GOOD NEWS

In *Crosstalk* last month, we pointed to the growing use of intercarrier receivers, and quoted the misgivings of video transmitter designers, who feared poor reception from high-band stations. Since that item was written, Mr. Seeley and his colleagues have perfected a measuring technique and have applied it to a wide variety of stations, with the startling results reported here. Early opinion had it that even half a degree of transmitter peak phase shift (approximately one degree total) would produce noticeable interference. Before the tests, Mr. Seeley himself quoted 4 to 6 degrees total shift as the probable tolerable limit. But stations having 15 to 20 degrees total phase variation, measured by the new method, were found to produce excellent sound quality on properly designed intercarrier receivers. As a result of these tests industry opinion is undergoing a rapid shift on this subject. It appears that the necessary industry-FCC action to permit proper use of the intercarrier system will shortly be taken.—The Editors

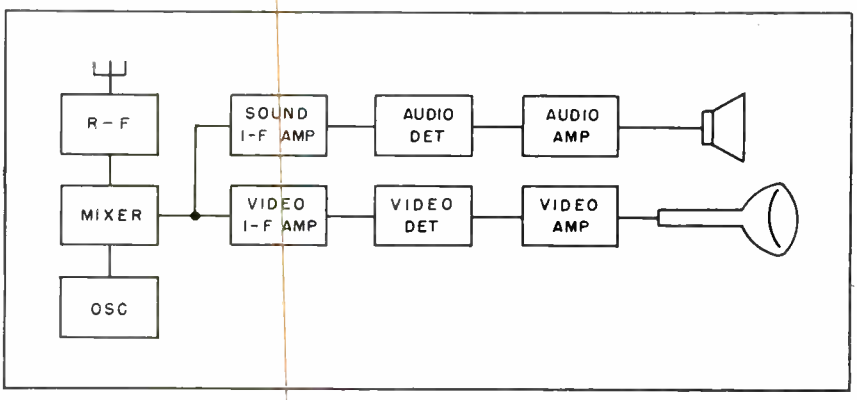


FIG. 2—Typical conventional television receiver. This type of receiver is more susceptible to faults in the local oscillator than is the intercarrier type

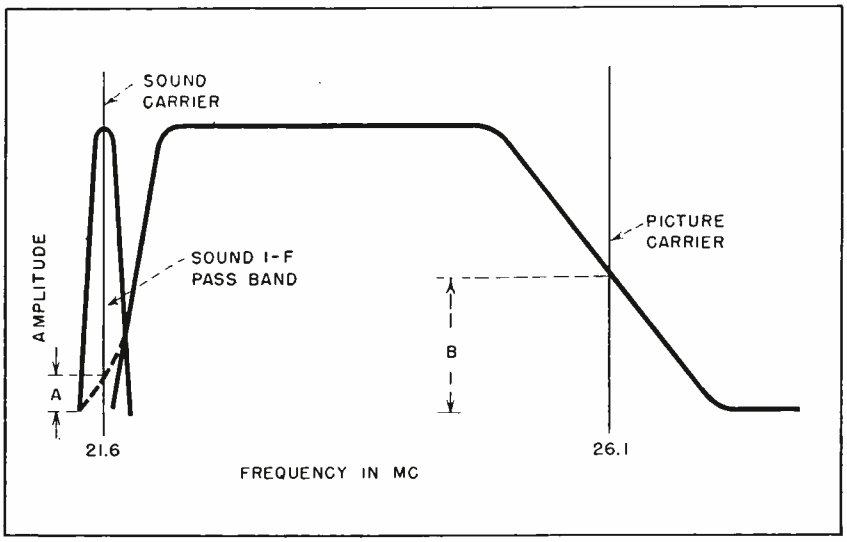


FIG. 3—Intermediate-frequency response characteristics of conventional (heavy solid line) and intercarrier (dashed-line extension) receivers

tion and the effect is less prominent at lower audio frequencies. But, even with deemphasis, over the range of audio frequencies from 3,750 to 15,000 cps, a 4-degree phase shift will produce interference from 48 to 45 db below average modulation. This would not be considered sufficient for a high-quality sound system. But recent tests have shown that much more than 4 degrees of phase shift can be present without adverse effects on sound quality. At least two additional factors tend to lessen the interference:

1 Since the transmitter's residual frequency modulation is caused by a phase-variation process the corresponding frequency modulation decreases 6 db per octave as the audible frequency of the video modulation causing the phase variation is decreased. Other types of interference (which the FCC specifies must be below a -60 db level in a high-quality aural broadcasting system) have more uniform distribution in the audible spectrum.

2 The second point concerns the distribution of audible energy in a composite video signal. If we examine the amplitude-modulation components between zero and 20,000 cycles derived from a picture-modulated transmitter we find one very strong component at the 60-cycle field frequency and another at the 15,750-cycle line frequency. What occurs in between depends partly upon the number, position and intensity of any horizontal lines in the picture. However, harmonics of 60 cycles up to a rather high order, but with rapidly decreasing level with frequency, are caused by the square-wave nature of the vertical synchronizing and blanking portions of the signal.

Obviously 60 cycles is too low to convert phase modulation to frequency modulation in any important degree, being 48 db below the 15,000-cycle conversion. Also, 15,750 cycles is outside the audible range and can be removed in the receiver if necessary. Therefore, it is apparent that we need only be concerned with audible video components lying considerably above the field frequency and below the line frequency. Observation has indicated that this entire range seldom, if ever, contains components stronger than those which occur at the start and finish of a vertical blanking pedestal transmitted with a white background picture. The latter cause spikes of frequency modulation which plainly delineate the vertical-blanking time when viewed on an oscilloscope.

The energy in those spikes from a transmitter having more than 20 degrees of total phase variation is still next to inaudible in a wide-range sound system even though the spikes are frequently as much as 15 db above the meter reading of the average incidental audible frequency modulation. Experience thus far has indicated that satisfactory performance, at least in receivers which do not offer the full range of audio fidelity, can be obtained without difficulty on all presently operating stations provided they do not overmodulate the picture carrier.

Another difficulty with the intercarrier system is the fact that any drift of the frequency-modulation detector from the 4.5-mc center frequency will introduce distortion, and there is no way to correct this condition except by adjustment of the detector itself. Similar distortion in a conventional receiver can be corrected by adjustment of the fine tuning control.

A final difficulty is that which occurs if the sound carrier, as presented to the second detector, exceeds a certain level relative to the picture carrier. If this occurs, severe distortion of the sound output and picture quality may occur, including possible reversal of the image tones ("negative" in the photographic sense). This effect may be controlled by care in the design of the i-f pass-band curve, as described below.

Design Considerations

The first question in the design of an intercarrier receiver is the method of setting the relative level of the sound and picture carriers at the input to the second (video) detector. In the conventional receiver the pass-bands of the i-f systems are as shown in Fig. 3. The picture i-f amplifier has substantially no sensitivity (on the average 45-db attenuation) at the associated sound channel frequency.

In the intercarrier system, the sound-carrier pass band is dis-

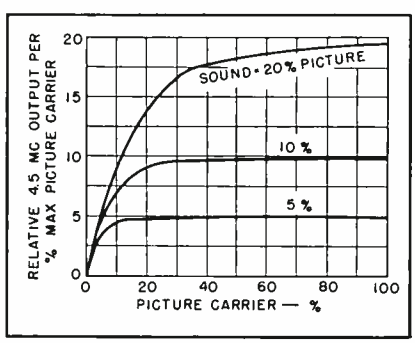


FIG. 4—Amplitude modulation of 4.5-mc beat note as a function of picture modulation, for various amplitudes of sound signal relative to picture signal

pensed with and the picture i-f pass band is extended slightly to increase slightly the gain at the sound carrier. This is shown in Fig. 3 as a dashed-line extension of the picture pass-band curve. The percentage response of this extended curve at the sound-carrier frequency is indicated by the dimension *A*. This dimension should never be greater than 10 percent of the carrier level (dimension *B*) in linear units. This is on the assumption that the sound and picture carriers are of equal strength as received from the transmitter. But variations in relative signal strength of as much as 10 db, arising from differential attenuation and wave interference effects dependent on the receiver location, are apt to occur so a more conservative figure for dimension *A* is 3 percent of *B*.

One basis for the 10 percent maximum figure may be seen from Fig. 4, which shows the relative output of a linear detector when f-m sound and a-m picture are fed to it simultaneously. So long as the rms level of the sound signal is 5 percent or less of the maximum rms picture signal, as in the lowest curve, the 4.5-mc beat note amplitude remains substantially constant as the level of the picture carrier (abscissas) varies under modulation from 15 to 100 percent of the peak value.

If the sound level is 10 percent of the maximum picture level as in the middle curve, the output remains flat from 25 to 100 percent modulation. At higher relative sound levels (top curve) the output would contain substantial amplitude modulation in accordance with the picture modulation. Also the picture quality would be badly degraded as previously stated.

Much of the residual amplitude modulation may be removed by the use of a limiter or by the use of a balanced discriminator or ratio detector. However, if the residual amplitude variation is too severe an excessive burden is placed on the f-m detector. This is the basis of the previous statement that the amplitude modulation level of the picture transmitter should not normally be allowed to fall below 10 percent of the peak synchronizing level.

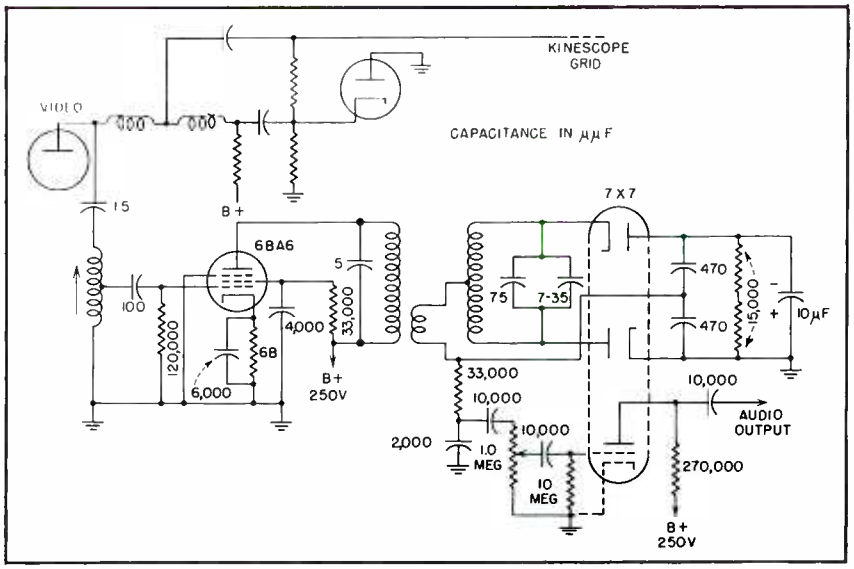


FIG. 5—Typical intercarrier sound circuit using a limiting amplifier and ratio detector for demodulation

The attenuation of the sound signal, to 3 percent or less of the picture carrier, implies a corresponding increase in amplification (relative to that provided in a separate sound i-f amplifier) to bring the sound signal up to the level required for detection and audio amplification. A portion of this extra amplification is provided by the passage of the sound signal through the video amplifiers. Normal peak video level at this point is about 30 volts, so the sound level usually does not exceed one volt. Conservative design suggests that this level be increased before the sound signal is applied to the f-m detector.

An auxiliary amplifier for this purpose also serves an important function in keeping the volume level substantially constant as the picture gain control is varied. Such constancy of gain is also useful in overcoming the tendency of the sound level to increase as the picture is detuned. Otherwise, if fine tuning is provided, the lay user might try to tune for loudest sound, which would produce a poor picture.

Care should be taken to avoid overload in any stage which could remove the picture signal (and its concomitant 4.5-mc sound i-f signal) even momentarily. The diode second (video) detector should be as linear as possible, and the ratio of a-c impedance to d-c resistance of the second detector load should be as near unity as possible. Finally the tuned circuits in the f-m detector should be designed to maintain proper adjustment since drift in these components cannot be corrected by the user. If these precautions are followed, and if the restrictions on transmitter operation previously mentioned are observed, the intercarrier system can give excellent performance.

A typical example following closely the design criteria mentioned is shown in Fig. 5. The 4.5-mc beat note is taken directly from the last video amplifier plate. The series resonant impedance at this point removes any remaining 4.5-mc beat from the picture tube grid. The first tube (6BA6) serves as a volume-leveling amplifier, or limiter. It is so designed that the tube operates under plate voltage overload when a small signal is applied to its grid. Hence the output does not change when substantially stronger signals are applied. The output of this amplifier is passed to a conventional ratio detector which develops the audio output. The output is about 2.5 volts rms for 25-kc deviation, so a voltage amplifier must precede the audio output stage. In this example, this is provided by a triode in the same envelope with the double diodes, in a 7X7 tube.

Reference

(1) R. B. Dome, Carrier Difference Reception of Television Sound, p 102, Electronics Jan. 1947.

Optical radar equipment set up at base site ready for use

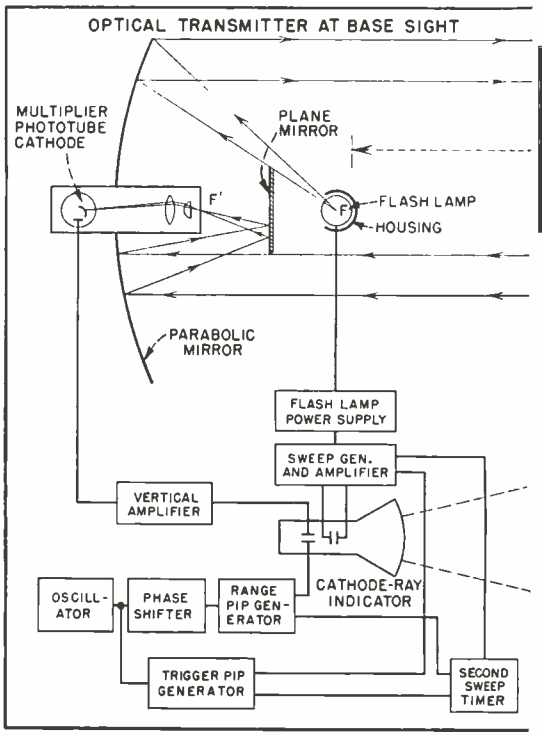


FIG. 1—Block diagram shows

Surveying With Pulsed-Light Radar

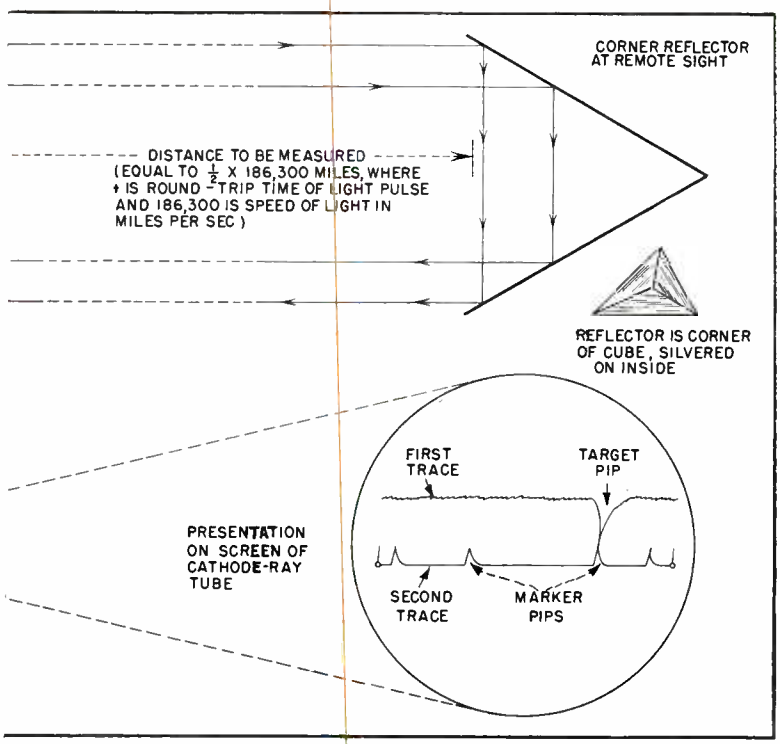
Adaptation of radar techniques to terrain surveys, wherein pulses of light from a flashlamp at one site are reflected back to a multiplier phototube by a mirror at the other site. Distance is read directly on dials after c-r tube pips are aligned

By W. W. HANSEN
Illinois Institute of Technology
Chicago, Illinois

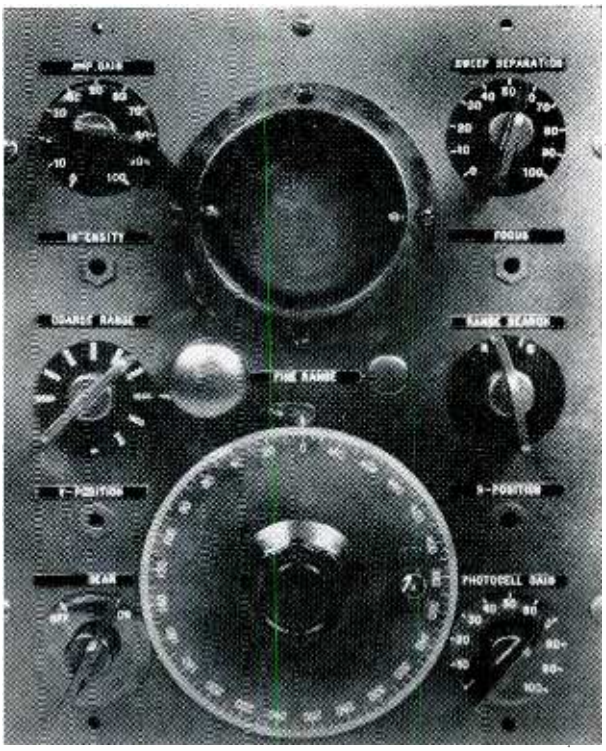
THE optical-electronic instrument described here is capable of making a survey of terrain when conventional survey methods would be too slow or when long traverses over inaccessible terrain are needed. The choice of light instead of microwave radar signals was made because of the improved resolution and because reflections of microwave signals from objects other than the target would limit the usefulness of the equipment.

Distance or range is determined by measuring the transit time of pulses of light traveling to and from a retrodirective reflector placed at a point whose relative position is to be found. Angles are determined by adjusting the position of the optical transmitter to produce a maximum return pip on a cathode-ray tube. While the accuracy of the survey which can be obtained with this instrument is not as good as that which can be achieved by conventional surveying methods, it does compare favorably with the accuracy of a third-class survey.

The over-all method of operation of the system is shown in Fig. 1. When the flashlamp in the optical transmitter breaks down, it triggers the sweep generator and causes a trace to appear on the cathode-ray tube. The light pulse transmitted by the lamp is returned from the distant reflector and falls on the cathode of the photomultiplier, causing a pip to appear on the trace. Upon returning to its normal state the sweep generator triggers the second sweep timer, which gates the range and trigger pip generators. These produce a second trace displaying range pips which can be matched with the target return pip by adjustment of the phase shifter.



how travel time of a flash of light is used in surveying



Front panel of main electronic unit

When the second trace is completed, the circuits return to their normal states and are ready to repeat the cycle when the lamp flashes again.

The instrument consists of four main units, called the optical head, the scope unit, the main power supply, and the converter unit.

The optical head is mounted on a tripod and contains the flashlamp and optical system necessary for transmitting the light from the lamp, receiving it from the distant reflector, and focusing it on the cathode of a photomultiplier. The output of the photomultiplier is amplified by a two-stage amplifier which is also part of the optical head and is contained, with the multiplier, in a chassis attached to the rear of the mirror housing. The optical head is mounted on bearings attached to graduated circles that permit its elevation and rotation to be determined within one minute of arc.

The output of the amplifier is fed through a delay line to the scope unit, where it is amplified by two additional stages of amplification to produce the vertical pip on the cathode-ray tube. The scope unit is mounted on top of the main power supply during operation and can be tilted for the convenience of an operator seated in front of it. This unit contains, in addition to two stages of vertical amplification and the cathode-ray tube, the sweep circuits and other circuits necessary for the precise determination of range.

The entire equipment is designed to operate from 110-volt, 60-cycle a-c power or from a 12-volt battery. When d-c operation is desired, a 12-volt d-c to 110-volt a-c rotary converter contained in the converter unit is used. This unit also contains a neon sign transformer and rectifier to operate the flashlamp. The flashing rate of the lamp is controlled by varying the voltage fed to the primary of the neon sign transformer by means of a Variac located in the main power supply. This unit supplies the plate and accelerating voltages to the tubes in the scope unit and in the optical head.

During operation the operator can turn the optical head by means of flexible shafts attached to cranks which fit on the scope unit. The electrical cables connecting the units during operation are stored in a compartment attached to the bottom of the scope unit when the units are packed for transportation. The sizes and weights of the units are such that they can be manborne.

The focal point of the parabolic mirror coincides with the center of the arc at point F′ (Fig. 1) so that an image of the arc is formed at infinity. The light returning from the target is focused on the pinhole or slit at point F′ and then passes through the center of the parabolic mirror to the cathode of the photomultiplier. A slit is used at point F′ for ease in finding the target when a search is being made for it; the pinhole is used for angular definition after the target has been found.

Ranging Method

The range accuracy requirements led to the adoption of a ranging scheme which involves the comparison of light transit time with the period of a crystal-controlled oscillator. An essential part of this scheme is a device which shifts the phase of the oscillator output to permit the matching of range pips to the target return pips. While no originality for this idea can be claimed here,' its application to an optical transmitter involved special problems in synchronization.

The process of pulsing a radio transmitter at a given instant is

fairly straight-forward and precise, but some concern was felt about the feasibility and possibility of triggering a gas discharge lamp within a very small fraction of a microsecond of a desired time, especially in view of the size and weight restrictions on the equipment. Instead of initiating the flashes of the lamp in synchronism with the oscillator, it would have been fairly easy to have started and stopped an oscillator in synchronism with the flash-lamp, but this usually entails some sacrifice in oscillator stability as compared to that of a free-running crystal oscillator and also introduces transient errors in the phase shifter.

Double Trace

These problems were avoided by the use of circuits which cause two traces to appear on the scope for each flash of the lamp. The first trace starts when the lamp flashes, and displays the target return pip; the second trace starts about 0.01 second later and in synchronism with the oscillator. The second trace can be shifted vertically relative to the first one and displays a series of ranging pips which can be moved horizontally by means of the phase shifter until one of them matches the target return pip.

The appearance of the scope screen when pips are matched is also shown in Fig. 1. The frequency of the oscillator is such that the interval between successive ranging pips corresponds to a range interval of 500 yards. A course range switch permits the interval containing the target pip to be brought to the center of scope screen, where it is expanded to give greater matching accuracy. When pips are matched the range is the sum of the readings of the coarse range dial and the fine range dial. The coarse range dial is marked in steps of 500 yards; the fine range dial is attached to the shaft of the phase shifter and is graduated from 0 to 500 yards at intervals of 1 yard.

Sweep Circuits

The schematic circuit diagram of the sweep generator and sweep amplifier is shown in Fig. 2. The sweep generator is a cathode-coupled flip-flop circuit whose holding time is about 35 microseconds. The sweep amplifier is a cathode-coupled push-pull amplifier which is direct-coupled to the horizontal deflection plates of the cathode-ray tube. When capacitor C_1 is charged to a potential equal to that of the breakdown of the spark gap, the lamp discharges this capacitor and, in doing so, applies a positive pulse to the left grid of T_1. This causes the normally conducting right half of the tube to be cut off for a time which is determined mainly by C_2 and R_1.

When T_1 is triggered the potential difference across C_3 increases and causes the left grid of T_2 to become more positive. The change in potential across C_3 is considerably larger than that necessary to drive the left half of T_2 from cutoff to saturation, and consequently the cathode spot moves across the cathode-ray screen only during a portion of the time that C_3 is charging. The time at which the sweep starts is determined by the setting of the coarse range switch which adjusts the bias on the left grid of T_2. If this grid were returned directly to ground, it would always be biased considerably beyond cutoff by the current flowing through the right half of the tube and cathode resistor R_2.

When T_1 is triggered the potential of its cathode drops abruptly. This change in potential is amplified by a deblanking stage and applied to the intensity grid of the cathode-ray tube, allowing the cathode spot to appear as long as T_1 is in its triggered state.

When the target is being searched for, a range-search switch (not shown) is turned to the search position. This places another capacitor in parallel with C_3 and biases T_2 so that the sweep starts at the instant the lamp flashes and the spot continues to move across the screen at a fairly uniform rate during the entire 35 microseconds sweep time. In this switch position, the second trace does not appear.

Second Sweep Timer and Trigger Pip Generator

When T_1 (Fig. 2) returns to its normal state the potential of its cathode rises abruptly to about 50 volts and then drops rapidly to its normal potential of about 20 volts. This abrupt rise in potential is used to trigger the second sweep timer, shown in Fig. 3, which is a flip-flop circuit with a holding time of about 0.01 second. The output of the oscillator is sufficient to overload T_1, causing its output to approximate a square wave. This is differentiated so that the signal appearing at the grid of T_2 is a series of alternately positive and negative pulses. Tube T_2 is normally biased sufficiently to prevent any signal from appearing at its plate. However, when T_3 returns to its normal state its cathode potential rises abruptly, producing a pedestal voltage at the control grid of T_2 and allowing a pulse to trigger the

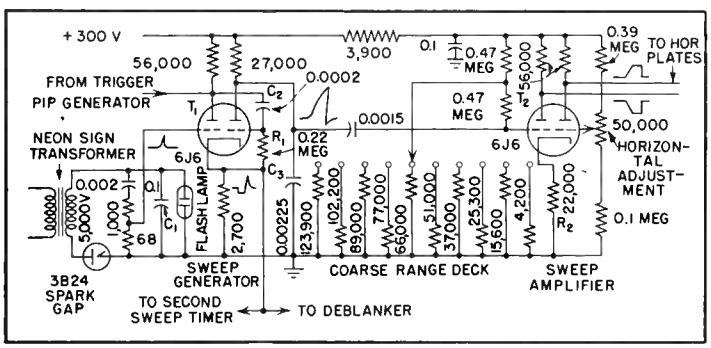


FIG. 2—Schematic circuit of sweep generator and sweep amplifier

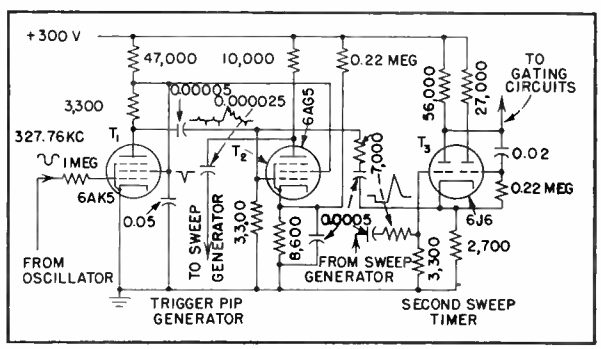


FIG. 3—Second sweep timer and trigger pip generator

sweep generator and initiate the second sweep. When the sweep generator returns to its normal state it does not trigger the second sweep timer again because the cathode potential of the second sweep timer does not drop sufficiently during the 35-microsecond second sweep interval.

Gating Circuits

When the second sweep timer is triggered at the completion of the first sweep, the drop in potential of its left plate is used to actuate gating circuits which shift the second trace vertically relative to the first and allow marker pips to appear on the second trace. These circuits also cut off the vertical amplifier during the second trace to prevent noise from appearing on it.

The schematic diagram of the gating circuits is shown in Fig. 4. The cathode-ray circuits are shown for clarity but only a portion of the range pip generator is shown because it is similar to the trigger pip generator except for an additional stage of amplification to compensate for the phase shifter attenuation.

The values of resistors R_1 and R_2 are chosen to apply a positive potential to the grid of T_2 when the second sweep timer is in its normal state. The cathode current of T_2 flows through the center-tapped potentiometer R_5 and produces a difference in potential between the vertical deflection plates of T_3 whose magnitude and sign depend on the position of the slider relative to the center tap and thus determine the position of the first trace relative to the second.

When the second sweep timer is triggered, T_2 is biased beyond cutoff. This releases some of the bias on T_1, allowing a signal consisting of a series of negative pulses to be applied to one of the vertical plates of T_3 and cutting off the plate current which flowed through R_5 during the first trace. Capacitor C_1 insures that T_2 remains cut off during the second trace.

Resistors R_3 and R_4 are chosen so that the final stage of the vertical amplifier is biased beyond cutoff during the second trace but is biased normally during the first. Capacitor C_2 insures that the vertical amplifier remains cut off during the second trace.

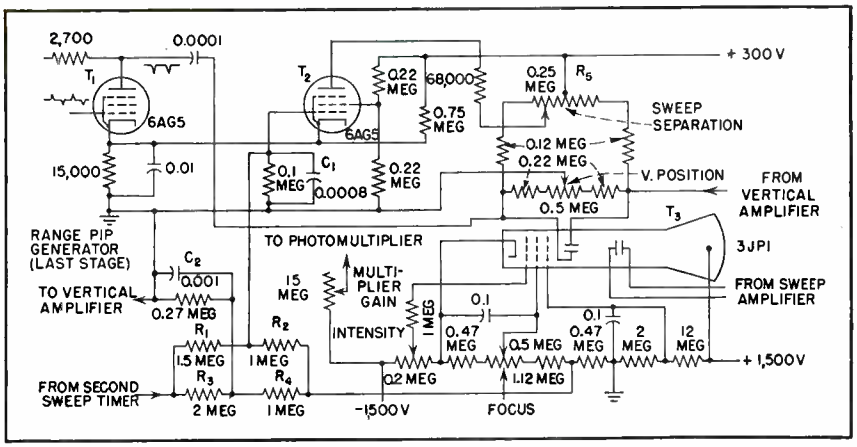


FIG. 4—Schematic diagram of gating circuits and cathode-ray tube

The schematic circuit diagram of the phase shifter and of the phase-splitting circuits which supply it is shown in Fig. 5. The phase shifter is a special capacitor[2] consisting of four quadrants that induce voltages in a common pickup plate which faces them. An eccentrically mounted circular Mycalex disk is mounted between the quadrants and the pickup plate so that the capacitance between each quadrant and the pickup plate varies as the disk is rotated. One mechanical degree of shaft rotation produces one electrical degree of phase change in the vector sum of the voltages induced in the pickup plate, provided the quadrants are supplied with voltages of equal amplitude but in phase quadrature. This situation will exist if the reactances of C_1 and C_2 (Fig. 5) are equal to the resistances of R_1 and R_2 at the oscillator frequency and if the network is balanced to ground. Capacitor C_3 helps provide a balance to ground by compensating for the interwinding capacitance between L_1 and L_2.

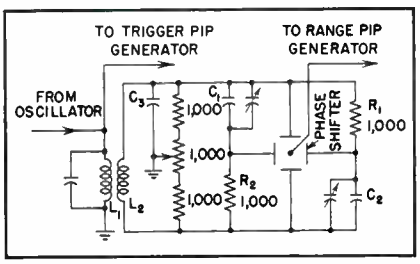


FIG. 5—Phase shifter and phase-splitting circuits

Vertical Amplifier

The vertical amplifier has a voltage gain of about 85 db and is shunt compensated to a top frequency of 2 mc. A delay line between the second and third stages serves as a flexible coupling between the optical head and the scope unit and delays the signals sufficiently to allow range readings to be made on very close targets. In fact, the zero adjustment of the phase shifter shaft is made by holding a reflector next to the framework of the optical head and in the light beam. This permits a ready determination of the zero correction in the field.

Acknowledgement

Acknowledgement is made to the U. S. Army Engineer Research and Development Laboratories under whose sponsorship and supervision the developments described were accomplished at the Armour Research Foundation; to the Radio Corporation of America who developed special photomultipliers, and to the General Electric Company and the Amglo Corporation for the development of flashlamps. Credit is also given to Bell Telephone Laboratories for their wartime work under NDRC contract resulting in basic developments in range measuring equipment utilizing the transit time of light pulses.

References

(1) A similar scheme was used in the AN/MPG-1 Radar, ELECTRONICS, p 140, March 1946.

(2) The theory of operation and a discussion of the errors of the phase shifting capacitor are given in the Dept. of Commerce, Office of Technical Services Reports No. PB 2810 and PB 3942. These capacitors are made by the P. J. Nilsen Company, Oak Park, Illinois.

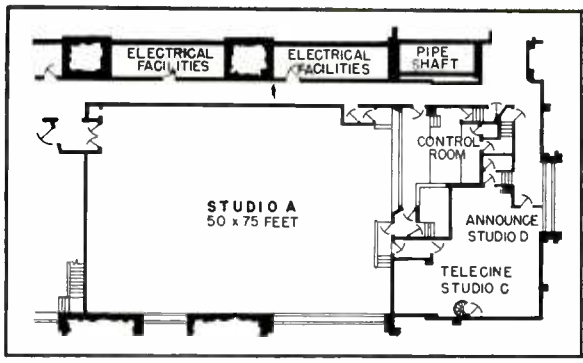


FIG. 1—Partial floor plan of Studio A, film-projection studio, control room and other facilities

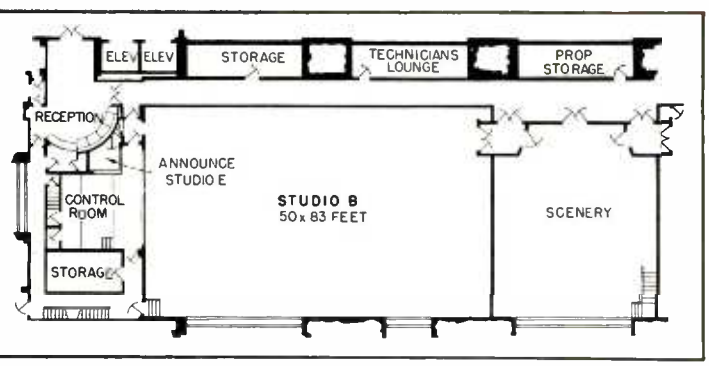


FIG. 2—Simplified floor plan of Studio B, control, announce Studio E, scenery, other storage, and technician's lounge

Design criteria for video and audio facilities capable of meeting the requirements of complex television program production are discussed in relation to future expansion. Included will be special provisions for studio lighting, air conditioning, communications, and sound effects

WCBS-TV . . . New Grand

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THE Columbia Broadcasting System now has under construction modern television studios at WCBS-TV, the New York key station of The Columbia Television Network. Over 700,000 cubic feet in the Grand Central Terminal Building are available for this large-scale operation. Adequate space, and thorough planning for operational flexibility and future expansion, are the twin keynotes of the project.

Closely associated with two large live-talent studios and their control rooms are a film scanning studio, master control, three announce studios; electrical, carpenter, and equipment shops, scenery painting space; rooms for dressing and makeup, film editing and splicing, viewing, staff lounges, key operating personnel offices, art and sound effects, studio lighting control, primary power switching and control, storage, reception, and other related facilities.

The equipment layout is designed to furnish a high degree of flexibility and will include ample facilities for handling previews, rehearsals, programming from studios, film and slides, as well as remote and network programs via coaxial cable or radio relay. The master control switching and distribution system for both audio and video is capable of handling any combination of twelve input circuits to six outgoing points. The switching system is a preset open-ended type which allows for convenient expansion or modification.

In general, facilities consist of:

(1) One large live-talent studio (Studio A) containing three cameras, seven or more microphones, portable video monitors and loudspeakers, talk-back loudspeakers, studio communication equipment, camera dollies, microphone booms, and other necessary components.

(2) A second large live-talent studio (Studio B) with two cameras and other facilities similar to those enumerated for Studio A.

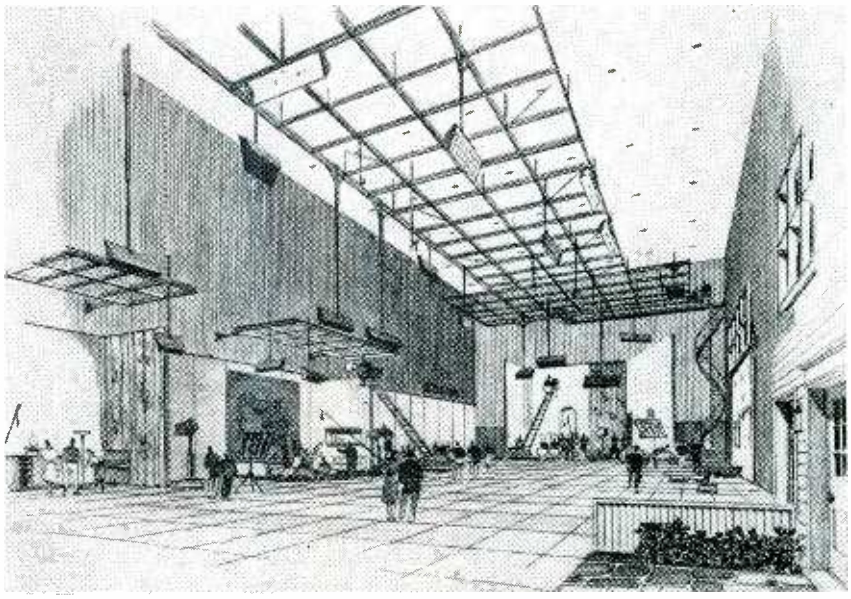
(3) A film projection room (Studio C) with four camera chains and eleven film and slide projectors.

(4) A combined master control and film control room where synchronized switching of all audio and video program material is effected as well as control of the four film camera chains. Provision is made for a flying spot scanner.

(5) Three announce studios (Studios D, E and F) equipped with microphones, in addition to audio and video monitoring equipment.

(6) Two sound effect rooms, a viewing room, and two studio lighting control rooms, all equipped with communication facilities, microphones, and audio and visual monitors.

Studios A and B and their associated control rooms are engineered for a total of four camera chains; Studio C, film scanning, is arranged to accommodate three more projectors and a fifth camera chain.



Artist's drawing of Studio B, as it will be seen from the control room

Central Studios

The audio and video pickup, control, switching and monitoring facilities are arranged in a more flexible manner than similar facilities in the past. They are also designed for maximum ease of operation and maintenance. It will be possible, for instance, to mix with the microphone and camera outputs of any studio, action originating from the film studio, from the other live-talent studio, or from local, remote, or network points. Such multichannel control can be exercised in either of the two studio control rooms or in master control, where the Studio C control consoles are located, as circumstances warrant.

The systems design of the audio and video facilities together with other related facilities such as primary power supply, studio lighting, air-conditioning, sound effects, clocks, and also the physical layout of the entire space, is based upon operating specifications representing the combined viewpoint of the General Engineering, Construction, Technical Operations, and TV Program Departments. This initial planning has resulted in an approved physical layout, a basic equipment systems design, procurement of technical and other facilities, and a work schedule covering the entire project.

When planning a new station, the need for developing operating specifications which take into account projected program production planning is extremely important. Without such consideration, the system engineering is likely to be inadequate, and may require many expensive modifications later. On the other hand, lacking such carefully established requirements, the system may become much larger than necessary, resulting in an unnecessarily large capital expenditure.

The Studios

Figure 1 shows the arrangement of Studio A which is 50 × 75 feet with a 26-foot ceiling. A potential ceiling height of 45 feet is available. The arrangement of this studio with its associated control room, announce Studio D, and film Studio C, are indicated. Although details are omitted, excellent traffic and visual contact are maintained between the studio, its control room, and announce Studio D. Other important facilities not shown here are the studio lighting control room located on a balcony over one side of the studio, and an arrangement in the center of the studio floor for the passage of camera, microphone or other cables in order that they may at all times be kept at minimum length and within the camera working areas. This studio will accommodate several program production sets arranged around the perimeter of the studio space so as not to block entrances and exits or the visual contact between the several control points and the studio action.

Studio B and its associated facilities shown in Fig. 2 are similarly arranged. This studio is 50 × 83 feet with a 45-foot ceiling. The control room and announce Studio E are similar to the facilities for Studio A. A large scenery painting area separates the two studios and acts as a sound isolation lock between them. Two sound effect rooms, one associated with each studio, and an art room, are located on a mezzanine floor directly above the scenery painting area.

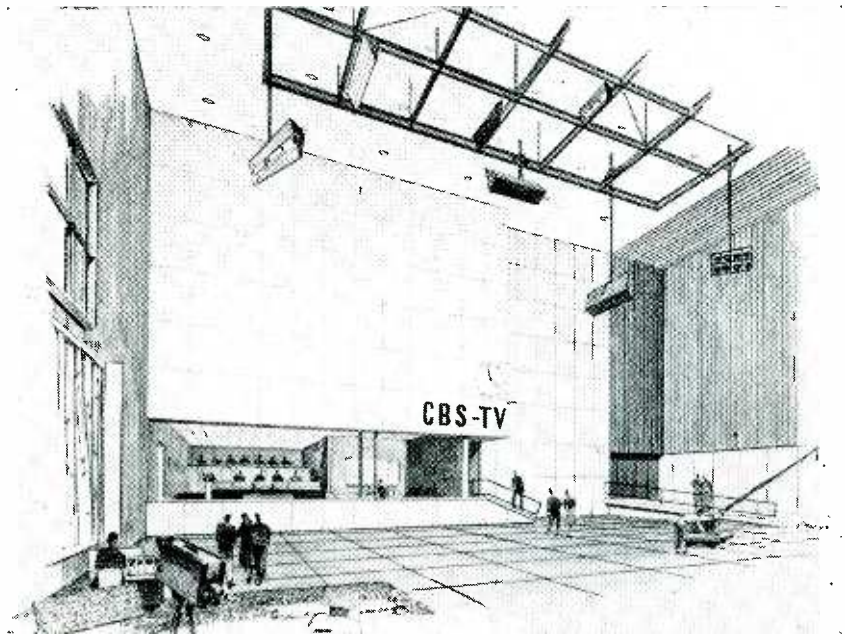
Studio acoustical properties are

OTHER FACILITIES

The studio facilities planned by WCBS-TV and described in this article will supplement the extensive remote facilities that have so far characterized the programming of the station.

Portable equipment includes: mobile unit with three camera chains and shf relay equipment; a similar two-camera chain; three portable camera chains, complete with synchronizing, switching, and monitoring equipment, presently in use at Studio A.

Two complete sets of additional remote facilities, one including shf radio relay, are on order. One set includes a three-camera, and the other a four-camera, chain



Studio B control room, from the studio

obtained by the use of rock wool blankets hung on the wall and ceiling areas interspersed at random without the usual broadcast studio decorative treatment. Acoustically, each studio is slightly on the dead side of the optimum characteristic for the size of enclosure considered. Control rooms are purposely a little on the live side to represent normal acoustical conditions encountered in an average living room. The studios are made a little dead acoustically in order to reduce ambient noise and also to create less critical sound pickups; in most cases, microphones are located at a much greater distance from performers than in ordinary aural broadcasting. Additional studio reverberation can be obtained by synthetic means. Two methods are available; reverberation chamber facilities, or dialogue and audio perspective equalizers. These latter features are incorporated as a standard part of the CBS Model 3C TV audio control console designed especially for this and similar applications.

Figure 3 is a detail of the left side of Fig. 2, illustrating the arrangement of audio and video control, switching and monitoring consoles, and also the location of operating personnel, in a typical studio control room. There will be three such control rooms in this plant initially, two for the live talent studios and one for handling film and slides. Normal personnel complement comprises one or two technicians, each handling one or two camera control units at the control console. This console is located just inside the observation window that separates the studio from the control room. Several feet behind this console, and elevated slightly, are located the audio technician at the extreme left (facing studio) and adjacent to the turntables (TT), and next to him the switcher who selects camera or other video outputs and preview inputs. He also fades and lap-dissolves video signals and performs other switching and control functions as may be requested by the director who sits at his immediate right. The assistant director is seated to the right of the director. Space has been provided in the control room for clients who are located at a third and higher elevation. Here they can see the preview and line video monitors as well as hear the entire control room action. This arrangement is more clearly illustrated in Fig. 4 which shows the sight lines from each elevation to video monitors, to studio action, and to a large video monitor located above the camera control console.

The simplified video block diagram in Fig. 5 shows the arrangement of facilities associated with Studio A. Similar facilities are provided for Studios B and C, although the latter are somewhat more complex. In Studio A, three cameras, mounted on dollies or pedestals, will be provided initially, with means to accommodate a fourth camera. Each camera control unit, located in studio control, has a 10-in. monitor and waveform indicator. A 10-in. line monitor is also located in the camera control console. The switching, fading, lap-dissolving and other video controls are located on the production console. The switching system is designed to accommodate four studio camera circuits, four film camera outputs, three remotes, and a cue circuit, all of which appear on video jacks in master control. They are also associated with other jacks looking into the relay switching system. There are two preview monitors and one line monitor on the production console. The mixer, stabilizing and isolation amplifiers shown are located in master control.

Studios A and B will each be equipped with a minimum of seven microphones, mostly directional types. The microphones will be used on booms, or suspended from overhead. A minimum of two booms for each studio will be provided. Each of the three studio control rooms will be equipped with model 3C audio control consoles. In order to accommodate the requirements peculiar to television sound pickup and production (as compared to aural broadcasting), it becomes necessary to include provisions for dialogue and perspective equalization, two disc-type turntables, a modified talk-back circuit, a special studio cue circuit, the outputs of film projector sound heads, several remotes, announce studio microphones, reverberation selector and controls, and other facilities necessary in a modern audio control console of this type.

The usual mistake of taking

audio facilities for granted, when considering a new television studio plant, has not been made here. The audio problem includes not only those elements common to network headquarters a-m and f-m requirements, but also entails a considerable number of additional engineering considerations covering the special features required by the combination of sound and pictures. To this end the model 3C television audio console, has been designed to accommodate not only all of the television studio operating requirements, but to afford the greatest flexibility yet demanded.

A suitable intercommunication system will be provided to permit necessary liaison between program director and studio floor manager, between the director and the telecine (film projection) studio, between video switcher and cameramen, between the camera control operators and the lighting operator, and between audio technician and microphone boom operators. Both audio and radio systems of communication will be employed for this purpose.

The Film Studio

The arrangement of film and slide projection facilities with their associated cameras is shown in Fig. 6. T-v film multiplexers are used in order to obtain maximum operational flexibility. Initially, two 35-mm and three 16-mm projectors will be installed, associated with three film camera chains. Two Balopticon projectors will be used with a fourth camera chain and the installation will be arranged so that an additional 35-mm, 16-mm, and slide projector unit may be used with a fifth camera chain. Accessory facilities, including a flying spot scanner, equipment racks, film splicing table and cabinet, and supply cabinet are provided as indicated. Projection controls and video monitors for each of the cameras are mounted on cabinet racks at locations consistent with best viewing. Switches for starting or stopping each of the film projectors are also remotely located on the program consoles in all three studio control rooms.

Master Control

Figure 7 shows the master control room facilities which are located directly over the Studio A control room and Studio C (telecine) areas. The arrangement of the film camera control switching and monitoring facilities are similar in plan and elevation to the facilities utilized in each of the other studio control rooms. The film control facilities are grouped at one end of master control so that if operating experience so dictates, a partition can be installed separating them from other master control audio and video operations. Initially, a curtain will probably be installed between these areas in order to segregate the general lighting and other operating features which are somewhat different from those in master control proper. The master control distribution switching console is located directly in front of twenty-one cabinet racks of audio and video equipment. The rack equipment is arranged so that those units requiring attention from the operating personnel are located on the racks closest to the control console. Fourteen cabinet racks of power equipment are located in a separate room with the panel fronts of six racks facing master control. Two types of standard power supply units for all video equipment in the plant are mounted on these racks and also a few power control and indicating panels. This equipment is segregated so that the 25 kw of heat dissipated can be removed from this space by exhaust fans. This arrangement facilitates air-conditioning the operating area within the master control room where only 10 kw is dissipated.

The audio, video, and power equipment components on the thirty-five racks consist of two sync generators with switching panel, video monitors, video distribution, stabilizing, isolation and fader amplifiers, audio amplifiers, audio and video jack and relay panels, radio relay control units, test equipment, power supplies and their control units, and other equipment. Spare major equipment components are provided. All equipment components are carefully segregated and arranged to allow for future expansion of various parts of the

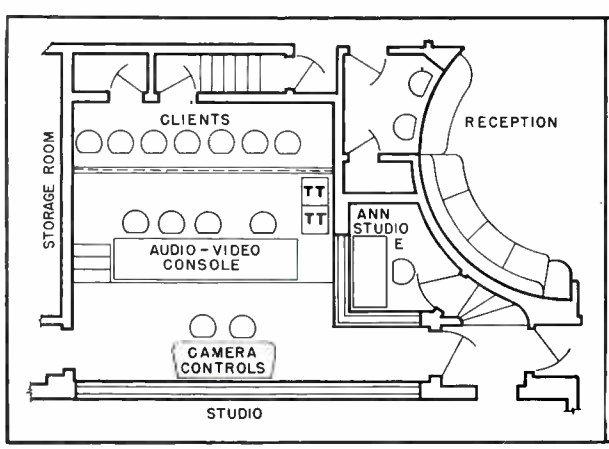


FIG. 3—Studio B control, showing location of technicians, directors, and clients

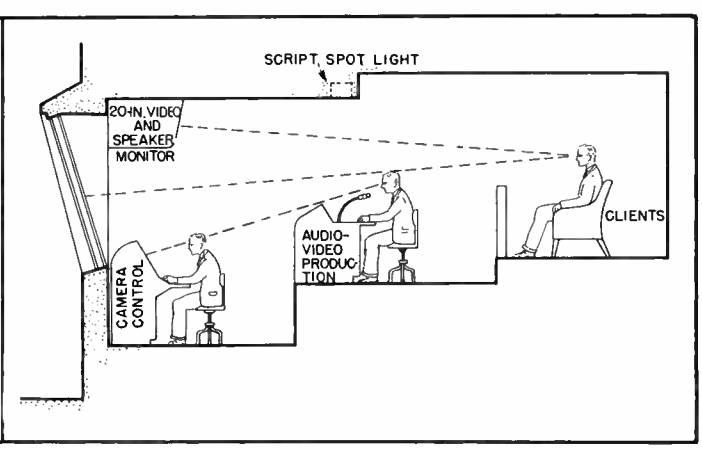


FIG. 4—Elevation view of a typical control room, showing sight lines for occupants. Video monitor indicates television action

system. For instance, coaxial jack panels, relays, amplifiers, and other equipment associated with the Studio A channel are not only isolated, but rack space is provided for additional units of each type used in channel A.

Announce Studio F is provided for sound commentary associated with film, slide, or other program material. The technical supervisor's office is conveniently located near the entrance to master control; and storage space is provided at the far end of the room for technical spare parts, test equipment, and other necessary supplies.

The master control room is the real center of the system. All video switching is done here. The individual camera lines from each studio camera control output appear on coaxial jacks in this room. However, these lines are normally jacked into the camera switching relays of the corresponding studio. The relays are controlled from pushbuttons on the program consoles in the corresponding studio control rooms. Four banks of interlocked relays are used, two banks for the program switching, fading, and lap-dissolving, and two banks for switching the preview monitors in the program console to any desired input signal. Camera control unit outputs can be patched from one studio to any other control room. In this way, the video switcher at the program console in Studio A control room can switch in cameras from Studio B and from film cameras, as well as from his own local cameras. The signals can be faded, lap-dissolved, or switched instantaneously, between any two of these sources, at the one studio control console.

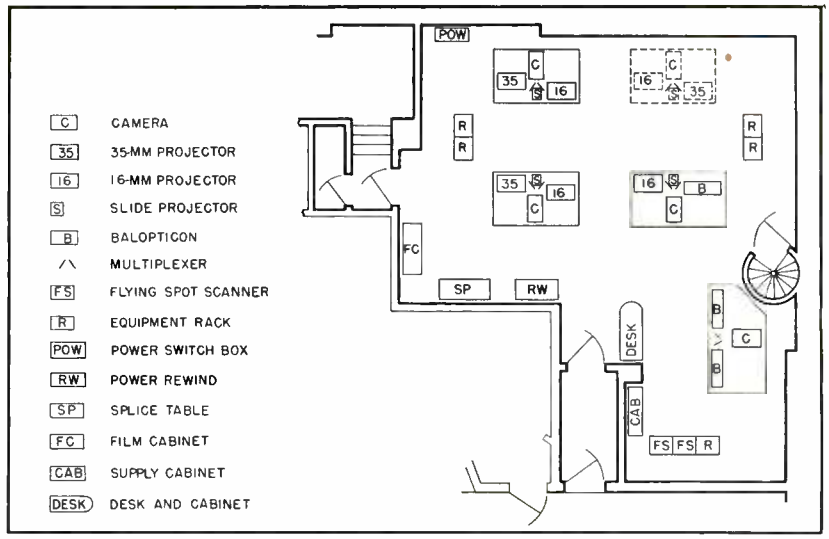


FIG. 6—Layout of equipment for telecine Studio C where motion pictures, transparencies, or opaque illustrations can be fed into the network

Remote or network signals can also be patched into any of the studio or film camera switching systems, thus making it possible to switch in remotes as part of a studio or film program if desired. It is possible to switch between local and remote signals but no provision is made for lap-dissolves under these conditions. It is expected that this shortcoming will eventually be eliminated.

The outputs of each group of studio switching relays are mixed in a fader amplifier which is remotely controlled from the corresponding studio program console. The fader amplifier feeds a stabilizing amplifier which clamps on the blanking level and removes switching transients or surges. In addition, synchronizing is mixed in this amplifier with the local camera signals. In cases where remote composite signals are switched in through this system, the local sync mixer is automatically biased off.

The output of each studio switching system is a complete composite signal available for switching to the transmitter or elsewhere. Each of these signals passes normally through jackboard contacts to the master control switching relays. The arrangement of these and associated facilities is shown in Fig. 8, a simplified master control video block diagram.

Three stabilizing amplifiers are used for handling coaxial and telephone line remote video signals. They are required to compensate for the different sync-to-picture ratios in the various incoming signals. In addition, they are useful for removing hum and bounce that may be mixed with the incoming signals. Each of these amplifiers has two outputs available on jacks for patching either into the master control film switching system or to either of the two other studio switching systems. The controls for each stabilizing amplifier are located on the master control console, providing convenient control over the sync and picture levels while monitoring the picture.

The master control switching

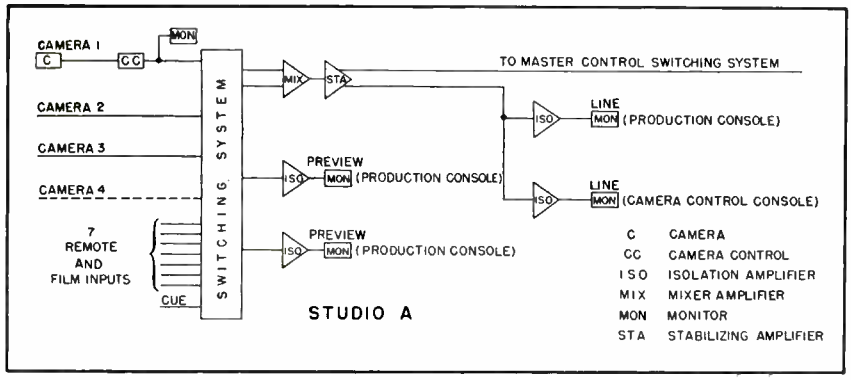


FIG. 5—Block diagram of video switching used in Studios A and B

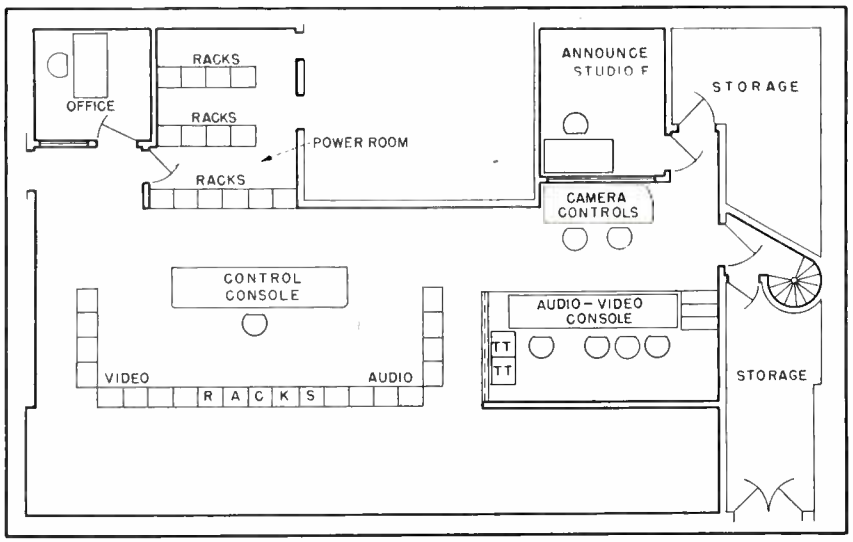


FIG. 7—WCBS-TV Master Control. Camera and associated controls are separated by curtains from main control activities at left

system is arranged so that the desired studio or other incoming signal can be selected to feed the transmitter or other points. This system consists of six banks of twelve interlocked relays each, thus providing for six outgoing circuits to be switched independently to any of twelve incoming signals. Two of these outgoing circuits are used to feed two preview monitors in the master control console. Future video monitors, if required, are indicated by broken lines on Fig. 8. The four remaining lines can be switched independently to any of the incoming circuits. One of these lines will be a network feed. By the use of additional distribution amplifiers, other lines can be fed in parallel with these circuits to take care of monitoring requirements in offices, viewing rooms, studios, and elsewhere. Contacts are available on these video switching relays for the control of simultaneous audio switching.

The master distribution switching desk also contains audio controls, waveform oscilloscopes, volume indicators, a PBX telephone switchboard, and other controls.

Two synchronizing generators are provided in the master control with a switch to select the desired generator for use. This generator feeds distribution amplifiers to supply the blanking, driving, and synchronizing signals to the various parts of the system. All synchronizing, blanking, and driving signal outputs appear on coaxial jacks. Spare outputs are also provided so that substitution can be made easily in case of failure of a distribution amplifier section.

This overall system is extremely flexible as it provides numerous combinations of camera facilities for programming and rehearsal. Cameras and remotes can be patched into any studio switching system so that the program director, at his console in a studio control room, has complete control over the switching of any studio cameras, film cameras, or remotes that he may require to make up a given program. A complete film program can be run entirely in master control if desired. Remote and network programs can also be run entirely by master control when so required. In this way the facilities of an individual studio can be used for rehearsals while another studio is put on the air. One film chain may be used for a program while another film chain is previewed, without interference. Almost any combination of facilities can be used to suit the particular requirements that may arise.

The generous use of coaxial jacks permits quick by-passing or substitution in case of failure of any part of the system. In order to obtain the high degree of operational flexibility described, more than 250 coaxial type jacks and 200 video relays will be employed in this system.

The master control room will be provided with an audio output switching system capable of handling, on a preset basis, the distribution of twelve sources of program to four outgoing circuits. It is complementary to the video switching but can be divorced therefrom if necessary. In addition, ample means will be provided for the equalization of incoming remote loops, for amplification and routing of remote programs, for feeding proper cue to the various studios, and for performing the other miscellaneous functions of a master control room.

Test and measurement equipment for properly determining and maintaining the electrical operating characteristics of all equipment in this new plant, to accord with established standards, is important.[1] Television test equipment presently available is comparable to that available to a-m broadcasting 15 to 20 years ago. Many of the typical laboratory type instruments do not lend themselves well to routine maintenance tests by personnel normally unable to devote full time to the use of such devices.

Test equipment, however, is being provided to enable routine measurements of the audio facilities in determining response-frequency, harmonic distortion, signal-to-noise ratio and signal level. In addition, more complex and expensive test equipment will be provided to enable measurement of video equipment and system performance. This new equipment will permit measurement of the video components and system, including such characteristics as resolving power, response-frequency, phase-frequency, transient response, transfer characteristic, signal level, signal-to-noise ratio, and sweep linearity. Means for accurately determining the timing of composite sync and blanking, and signal conformance with RMA standards, will also be available. It should be noted that only one signal source is necessary for audio performance

measurements and that eight different signal sources are necessary to determine properly the performance characteristics of video equipment and systems.

Sound Effects

Two sound isolated, acoustically treated and air-conditioned rooms, approximately 15 × 20 feet, each overlooking a studio, will be used for producing sound effects. Audio and video monitoring, communication, and special audio consoles including microphones and mixers, will be permanently installed here. Special power and utility circuits, variable speed turntables, and a record library will also be available. Water supply with necessary plumbing fixtures, and compressed air with necessary controls, will be furnished with which to produce special effects. Many types of physical props will be permanently installed in each room including doors, windows, dresser drawers, gongs, bells, and buzzers. The sounds produced here will be cued in and mixed with audio from studios or elsewhere as may be required. If desirable, the sound effects may be produced in the studio proper or may be reproduced there from loudspeakers. The production of effects in the sound room will be used as much as possible in order to decrease the amount of equipment and cables on the studio floor.

Other Facilities

The primary power supply facilities include approximately 450 kw, of both a-c and d-c power. The audio and video equipment requires about 60 kw of single phase a-c which is available on these premises from two sources. Direct-current power is used for studio and other lighting.

Experiments in studio lighting have gone forward for many months. Although the exact lighting requirements in terms of the new studio image orthicon camera tube, type 5655, have not been fully explored, considerable information has been obtained with five different stage sets in Studio A. This studio is now being operated with live-talent pickups using portable type cameras, and both portable

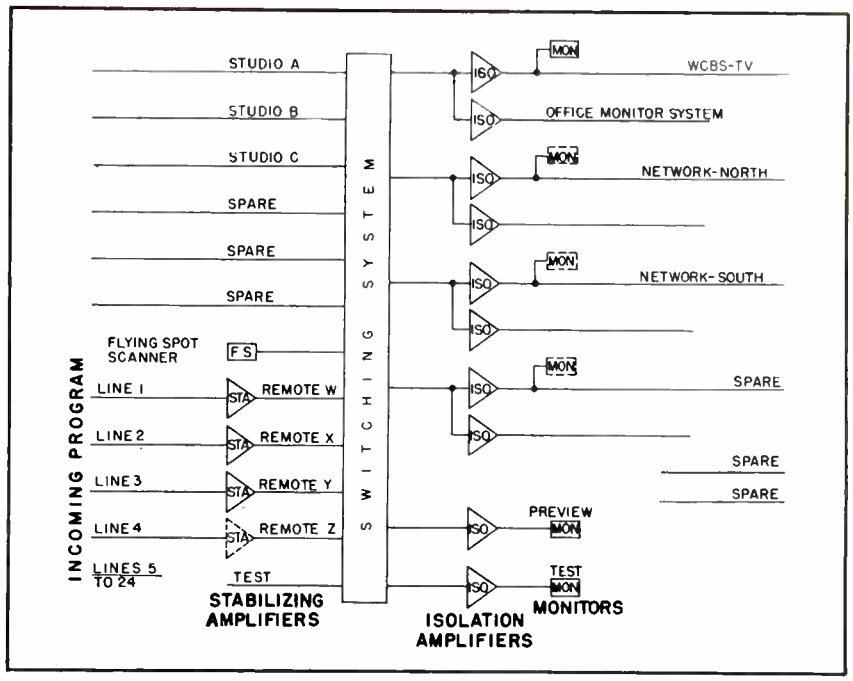


FIG. 8—Block diagram of Master Control video switching, showing mixing of studio and remote program for composite network output

and fixed synchronizing, switching, control and monitoring equipment. Best results to date have been obtained using fluorescent base lighting with about 50 to 100 foot-candles of incident light. This illumination is supplemented with incandescent flood and spotlights which are located for best modeling and high-lighting of the subject or subjects being televised. This high-lighting increases the incident light on the set from 200 to 300 foot-candles. On one particular experimental set, about 18 kw of lighting is used, most of the power being consumed by the incandescent floods and spots. Various types of fixtures and reflectors are used, the objective being to arrive at a standard fixture design which, with adapters, will accommodate various types and sizes of lamps. All fixtures can be elevated, tipped, or rotated by manual adjustment. Because proper set lighting plays an important part in the quality of picture which the televiewer sees, all types of studio lighting are being investigated. It is planned to arrive at a system that has equal flexibility with the audio and video facilities so that the producers of television programs will have available all of the tools necessary to do a first-class job. The lighting for all studio sets will be electrically controlled from a single point. Originally, it was planned to control the physical location of the various light fixtures from a single point. Although the plan has not been abandoned, experience thus far indicates that it may not be practical and economically feasible. All of the lighting facilities will be arranged so that they can be serviced conveniently. Experience indicates that the amount of lighting required will be considerably less than that formerly used with older type iconoscope cameras. This condition is fortunate when considering the comfort of performers and the air-conditioning problem. Studio control rooms and all other operating areas will be lighted with dimmers and spotlights wherever video monitors are located.

A television studio project of this magnitude requires several thousand engineering man-hours to plan and execute it efficiently. The audio and video engineering work is being performed by the CBS General Engineering Department under the direct supervision of Howard A. Chinn, Chief Audio-Video Engineer.

Reference

(1) D. G. Fink, "Avenues of Improvement in Present-Day Television", a paper delivered before the RMA-IRE Fall Meeting and before the IRE, New York Section.

Dynamic Relay Analyzer

Every aspect of relay action under any operating condition can be measured and analyzed. A cathode-ray display is photographed to obtain permanent records of operate and release time, contact bounce, or other characteristics

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Front view of the relay tester. Color-coded leads correspond to colored schematic engraved on panel

THE Relay Tester to be described is a versatile instrument that quickly measures the coil resistance, minimum operate current, drop-out current, and voltage drop across the coil of direct-current relays, in addition to the following time periods of the contacts:

(a) Closing time of the normally-open contacts
(b) Opening time of the normally-closed contacts
(c) Closing time, during drop-out, of the normally closed contacts
(d) Opening time, during drop-out, of the normally open contacts
(e) Transfer time of the moving contact, in the operate direction.

The time-check feature is of special interest to the electronic engineer, because it enables him to determine the relay action at the specific current or voltage to be used. By inserting the appropriate impedances or resistances in the relay circuit during tests the actual circuit parameters can be closely simulated.

The circuits incorporated in the relay tester to accomplish these tests are shown in block form in Fig. 1.

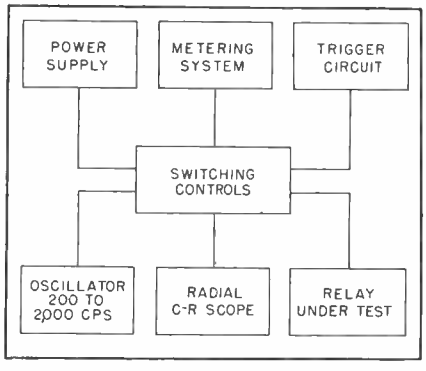


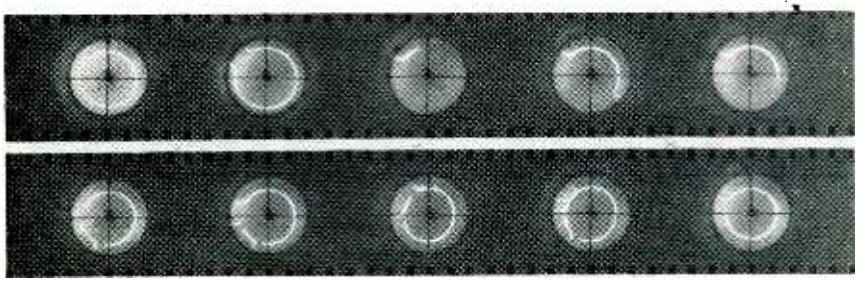
Fig. 1—Block diagram of the relay tester

Power and Metering

A conventional full-wave power supply is used to furnish relay operate currents up to 1 ampere at 270 volts d-c. A 30-second time delay switch is incorporated in the plate circuits to protect the 866-A rectifier tubes during the warm-up period.

The output of the power supply is fed to a voltage dividing system. By means of a selector switch no-load voltage ranges are available at 0 to 200 and 200 to 1,000 mv, 1 to 10, 10 to 90, 90 to 180, and 180 to 270 volts. Fine adjustments of the ranges are made possible by the use of two tandem arrangements of three 50-watt potentiometers.

The current meter is properly shunted to provide five ranges: 100 μa, 1 ma, 10 ma, 100 ma, and 1 amp. The high impedance voltmeter operates in the following ranges: 3 v (full scale), 10 v, 30 v, 100 v and 300 v. An ohmmeter for measuring circuit, coil, and contact resistance is combined with the voltmeter circuit and indicates resistance in six scale ranges up to 1,000 megohms. The half-scale



Upper oscillograms show closing time of normally-open contacts, opening time of normally-closed contacts, transit time of moving contact in operate direction, closing time of normally-closed contacts on drop out, and opening time of normally-open contacts on drop out. Lower strip shows various types of contact bounce

ranges are: 10, 100, 10,000 and 100,000 ohms, and 10 megohms.

Relay Timing Circuits

The basic timing circuit is shown in Fig. 2. This circuit, which measures the operate time of the relay, is constructed around the 3DP1 cathode-ray tube. The tube, a radial-deflection type developed for radar use, is similar to the 3AP-1/906-P1, and operates with comparable anode potentials. A 2.5 v filament is incorporated, however, and a radial control anode protrudes through the tube at the center of the screen surface for applying radial control voltages. This anode requires a positive potential from 50 to 75 v, in order to maintain a circular trace within the viewing area of the screen. This requirement is the basis of the timing circuit.

In Fig. 2A, a sine-wave voltage is continuously fed to the deflecting plates through the phasing system including C_1 and P_2. The source of the sine-wave voltage is a stable oscillator covering the range from 20 to 2,000 cycles. A resultant trace will be visible if the proper potential is applied to the central anode of the tube, and the trace will be circular if the phase control is properly adjusted.

A type 3C31 thyratron is utilized as a switch to apply the current to the relay coil and c-r tube anode. This arrangement has two desirable features: the current is applied to the coil instantaneously, without the interruptions that might be encountered if the chattering of a mechanical switch were involved; the thyratron is normally biased with a negative potential that prevents firing. The timing test is initiated when the test switch S_1 is momentarily closed. If the control P_1 is adjusted to a minimum voltage that will just cause firing of the thyratron, the starting point of the trace will repeat itself on consecutive tests. In view of the persistence qualities of the P1-type screen incorporated in the c-r tube, this feature assures ease in making visual observations.

In a test operation the relay is connected to the proper voltage point as shown in Fig. 2A. The oscillator is set to the lowest frequency, and the phase control adjusted to produce a perfect circle. (A continuous trace will be visible at any time the trace check switch S_3 is opened and the relay test switch operated.) This arrangement makes it easy to check the phase adjustment, which is not affected materially by small frequency changes in the oscillator.

With the relay coil connected to the proper voltage on the voltage divider, the test switch S_1, of the momentarily-on type, is closed. As the thyratron fires, voltage is applied simultaneously to the relay coil and the central anode of the c-r tube. This action causes a trace to appear. The length of the arc described will depend on the oscillator frequency and the time interval between the application of the voltage to the central anode of the tube and its removal, due to the circuit resulting when the normally-open relay contacts close. Let us assume, for example, that the arc appears to be about 180 deg. Because the ultimate aim is to apply a frequency to the c-r tube that causes the arc to close to a complete circle, the frequency is doubled and another trial made, after resetting the circuit by opening the reset switch S_2. This procedure is repeated until the trace just closes to a circle. In practice, this closure may be arrived at in about three trials from start, consuming less than a half minute of time.

It is apparent that the closing time of the normally open contacts, from the time that voltage was applied to the coil, was $1/f$ seconds, where f is the oscillator frequency in cps. It is therefore possible to calibrate the oscillator dial directly in time units, such as milliseconds.

A slight modification of the circuit shown in Fig. 2A, permits the transit time of the movable contact to be measured. The two stationary contacts are connected together as shown by the dotted lines, and during the test the trace will be visible only when the moving

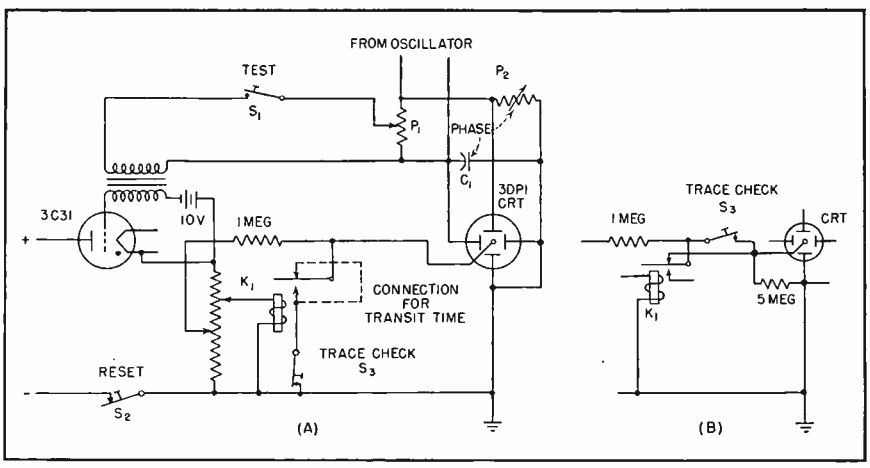


FIG.2—Circuit wiring for measuring operate time of normally-open relays (A), and opening time of normally-closed contacts (B). Transit time is measured by the dashed line modification of circuit A

contact is not touching either stationary contact.

Figure 2B shows another modification of the basic circuit that permits the opening time of the normally-closed contacts to be measured. The trace begins as voltage is applied and disappears when the moving contact of the relay breaks normal contact position.

When measuring the contact times during the drop-out period of a relay, two possible conditions must be considered. The first is introduced when the relay coil is de-energized by means of a series switch and opens into an infinite load where no shunt interferes with the collapse of the magnetic field. The other condition is the one most often encountered in electronic circuits, when the relay is connected in the plate circuit of a vacuum tube not operating with cutoff grid bias. The current through the coil never drops to zero, but varies sufficiently to operate the relay. Under these circumstances the drop-out time is increased. It is, therefore, desirable to be able to simulate either of these conditions when making drop-out time tests on a relay. The basic circuit shown in Fig. 3 makes this possible.

The position of the initiating thyratron V_4 has been changed from its former series connection. When the selector switch of the relay tester is set for closing time of normally closed contacts, voltage is applied to the bleeder to close the relay under test. When the test switch is closed, the thyratron triggers to operate the auxiliary relay K_2, which in turn disconnects the coil of the relay under test. In this manner, the starting point of the c-r trace is still under control. It should be noted that the inclusion of the initiating thyratron at no time introduces any delay in the timing considerations of the c-r trace and its relation to the closing or opening of the relay.

When the test switch is operated the initiating thyratron fires to energize the auxiliary relay K_2. The operation of this relay opens two circuits simultaneously; the grid bias is disconnected from the second thyratron V_3 which then fires to start the timing trace on the c-r tube; the current to the coil of the relay under test is disconnected. When the normally-closed contacts of this relay engage, the trace on the c-r tube is stopped to complete the described timing arc.

The auxiliary relay K_2 is a dpdt relay with adjustable contacts, set in a manner that causes the two moving arms to break contact simultaneously (within 4 to 10 microseconds). This small difference, as well as the delay of V_3 are of such small order as to be unimportant when considering times in the order of milliseconds.

The basic circuit modification shown in Fig. 3B is used to measure the opening time of the normally-open contacts during drop-out. This circuit is similar to Fig. 3A except the anode voltage to the c-r tube is removed, to terminate the timing trace, when the normally-open contacts of the relay under test open.

Binding posts are provided for connecting a series resistance in the coil circuit of the relay under test when the auxiliary relay K_2 operates. The value of this resistance will depend on the circuit conditions in which the relay is to be used, and will take into consideration the d-c resistance of the tube with which it is used, (the series resistance after drop-out), and the current still flowing in the coil.

The six-conductor cable used for connecting the relay to the relay tester is composed of colored wires and terminated in small clips which are convenient for attaching to the lugs of the conventional telephone type relay. A color-coded schematic of a spdt relay is attached to the panel of the tester, and is used as a reference in connecting the relay and in selecting the points desired for voltage and resistance measurements.

Timing Ranges

The oscillator circuit is a resistance-tuned type. Stability has been increased by the use of quality parts with ratings above requirements. The circuit is similar to the Hewlett-Packard 200 Series oscillator. Two frequency ranges are incorporated: 20 to 200 and 200 to 2,000 cps. The millisecond scale of the tester is graduated to read from 0.5 to 5 milliseconds on one scale and from 5 to 50 milliseconds when using the multiplying factor. Operational times from 0.5 millisecond, full trace, to 50 milliseconds, can therefore be read. The c-r screen is divided into four quadrants by means of ordinate lines, and an arc of 45 deg may be estimated, so that approximate readings down to about 60 microseconds can be read at the fast end of the range. Few relays now available will operate in less than 1 millisecond. There are many relays available however, that have operate times of over 50 milliseconds, the extreme limit of the range. If such relays are to be accommodated, the oscillator should have a third range of 2 to 20 cps. Relays with operate times of over one-half second can be tested conveniently on a clock timer.

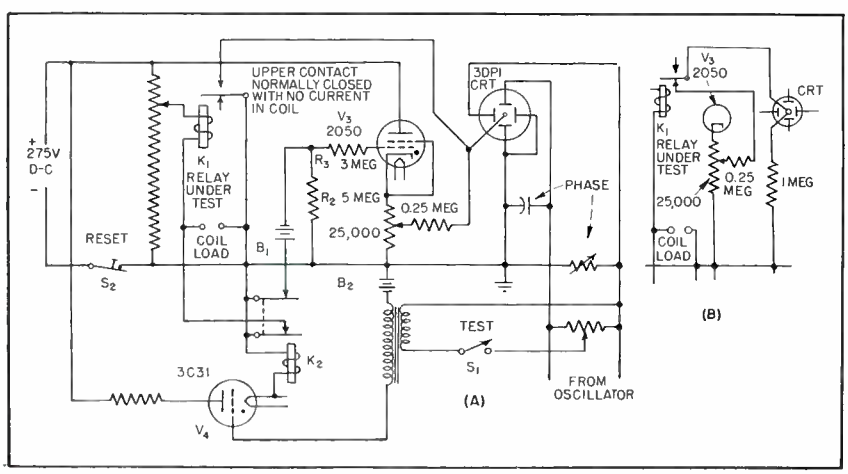
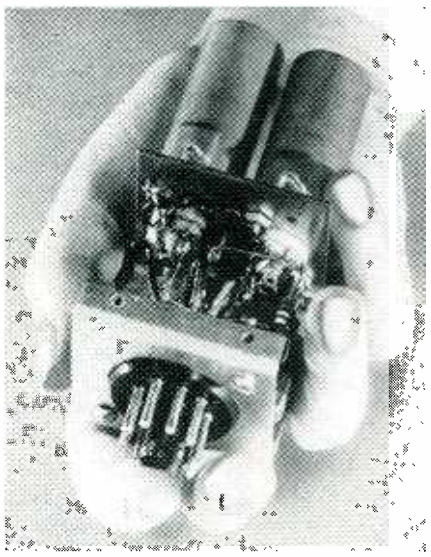


FIG. 3—Schematic circuit diagrams for measuring drop-out time of relays. Circuit A is for relays with normally-closed back contact, and modification B for opening time of normally-open contacts



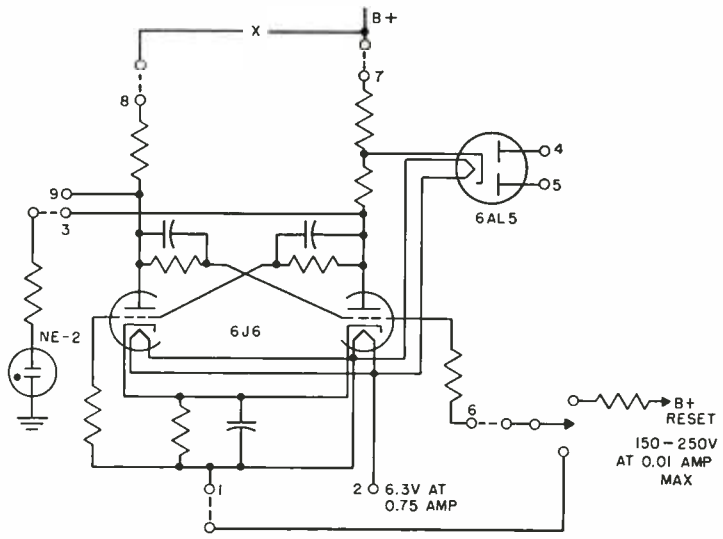


FIG. 1—Duoscale plug-in scale-of-two unit and schematic diagram. Numerals are pin connections for plug. Circuit is modified Eccles-Jordan trigger circuit using miniature tubes

Plug-in Scaler for

Basic scale-of-two counter mounted on nine-pin tube base simplifies design of high-speed counting equipment for industrial and research requirements. Unit can be connected to reset itself automatically on reaching a predetermined count

By CYRIL H. BROWN

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SCALING DEVICES are used as constant-frequency dividers in any electrical process where impulses are occurring at too rapid a rate to allow dependable actuation of a mechanical register. For instance, small machine parts moving into a packaging machine at the rate of 1,000 units per minute can be counted with an electromechanical counter having a maximum rating of 600 counts per minute by adding a scale-of-two circuit. This allows the register to run at 500 counts per minute, which is within its rating.

When an electromechanical counting device is used in conjunction with a Geiger-Mueller tube for measurements on radioactive materials, the problems posed by the existence of a maximum counting rate for the register become even more complex. The basis of these difficulties is the unfortunate fact that radiations from the nucleus occur, individually and collectively, at completely random intervals. Even though the average counting rate being measured is not excessive (equal to or less than the maximum rated speed of the register), a sequence of impulses may be received with too short an interpulse spacing to actuate the register. This loss due to random occurrence of pulses becomes serious at rates approximating the register rating.

The use of scaling stages between the Geiger tube and the register greatly improves this situation, since the use of a series of scales tends to decrease the spread or deviation of any individual interpulse space from the mean. It is desirable to use scaling stages even where the counting rate to be measured is equal to or even less than the maximum rated speed of the register, because a system can begin to lose counts well below the rated speed. In actual tests with random pulses, an electronic scaling system rated at 32,000 counts per minute (scale of 32, register maximum rate of 1,000) began to lose at 20,000 counts per minute. In these tests, the same register, when used with a scale of 8 (with rated system speed now 8,000 counts per minute) began missing at 4,000 counts per minute, comparatively a much higher loss.

Use of plug-in scaling circuits in an amplifier-scaler-counter unit for Geiger tubes permits replacing any scale at a moment's notice, without sending the whole chassis to the shop for repairs. A counting circuit used for such a scaling circuit was developed from the Eccles-Jordan trigger circuit by adding grid-plate capacitors between triodes to increase sensitivity and speed up the transfer of conduction from one

Top-of-chassis view of 64-count scaler using six scale-of-two plug-in units. Electromagnetic counter is at upper left

Bottom view of 64 scaler, showing simplicity of wiring. Arrows point to sockets of plug-in units

Industrial Counting

tube to the other. It uses the miniature type 6J6 dual triode, as shown in Fig. 1, with a minature type 6AL5 dual diode as the coupling tube. All electrical connections are made through a nine-prong plug. The scales may be reset in either of two ways: (1) a biasing voltage may be connected to the grid of the righthand triode at pin 6; (2) the plate supply voltage to either of the triodes may be interrupted at pin 7 or 8.

The circuit may be reset so that either the left or righthand tube is normally conducting, permitting use in a predetermined-type scaling circuit, where any number of counts from 1 to 2^n can be counted before the output circuit is actuated. In conventional counting circuits the righthand triode is usually reset to the conducting condition and a scaling ratio of 2^n is available (where n is the number of scales used).

These features, in addition to the fact that the resolving time is of the order of a few microseconds, combine to make this miniature tube plug-in scale useful for many problems of high-speed counting in industry as well as in the research laboratory, for incorporation in such widely varied equipment as scalers for radioactivity measurements and cosmic ray research, microsecond stopclocks using a crystal or tuning fork oscillator and a series of scales as frequency dividers, production line control equipment for counting such objects as machine parts or pills, and constant frequency dividers in any process where events occur too rapidly for direct actuation of a mechanical register.

MANUFACTURING TREND

- Acceptance of electronic equipment by industrial users is greatly increased by plug-in construction of critical sections, permitting instant replacement by unskilled help.
- Cost of keeping set of spare plug-in sections on hand is generally less than a single service call by a factory technician, and there is no machine idle time to be charged up to failure of an electronic component.
- Actual repair of plug-in section can be done at factory on semi-mass-production basis by skilled technicians, insuring effective repair at lowest possible cost.
- Use of plug-ins increases versatility of applications

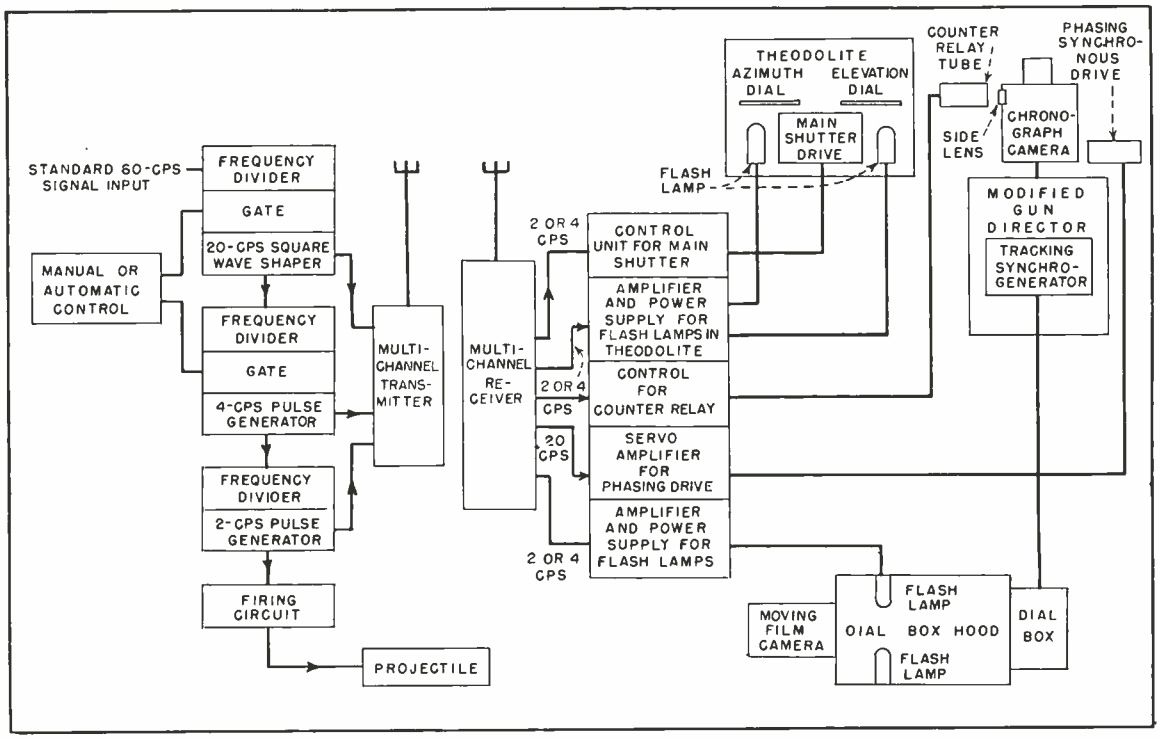

FIG. 1—Block diagram of the camera synchronizing system that is triggered when the projectile is fired. The camera station is common to two or more receiving locations. Position of the missile is recorded by the moving film camera by means of a linkage from the chronograph camera

Photographic Tracking

By L. M. BIBERMAN, S. E. DORSEY, and D. L. EWING

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PROBABLY the most widely used methods for studying the performance of projectiles and guided missiles are those based on various types of photographic recording. Through the use of a pair or more of camera stations a triangulation can be made to ascertain the position of the "bird" at the time the picture is taken.

It is apparent that any difference in the times at which exposures are made at the several stations will result in an error of computed position roughly proportional to the error in timing and the velocity of the bird, the proportionality being governed by the geometry of the installation. For this reason it was necessary to adopt a timing system for all equipment used in such dynamic triangulation.

Instrumentation

The major instruments concerned are cine-theodolites, which, in essence, are a form of a transit which records bearing-scale readings and the field of view of the telescope including the reference cross hairs. Many such theodolites exist, with varying degrees of accuracy and flexibility. Inasmuch as these instruments are normally tracked in a fairly smooth manner, the error in position determination caused by moderate errors in timing of the recording of the bird in relationship to the cross hairs will not be serious. This is because the cross hairs projected in space must travel at about the same rate as the bird being tracked and the tracking errors correspond to a phase-shift type error which slowly oscillates, so that a timing error of several milliseconds is not serious.

$$\Delta S_A = \left[\frac{ds_o}{dt} - \frac{ds}{dt}\right] \Delta t \qquad (1)$$

where ΔS_A is error caused in recording position of the bird relative to the cross hair by a timing error Δt, ds/dt is the angular rate of bird, ds_o/dt is the angular rate of the cross hair.

A necessary condition for keeping the bird in the field of the telescope is that ds_o/dt be approximately equal to ds/dt.

However, the same timing error applied to the recording of the bearing scales results in an error which is directly proportional to the tracking rate and to the error in timing.

$$\Delta S_B = \frac{ds_o}{dt} \Delta t \qquad (2)$$

where ΔS_B is bearing error caused by timing error Δt

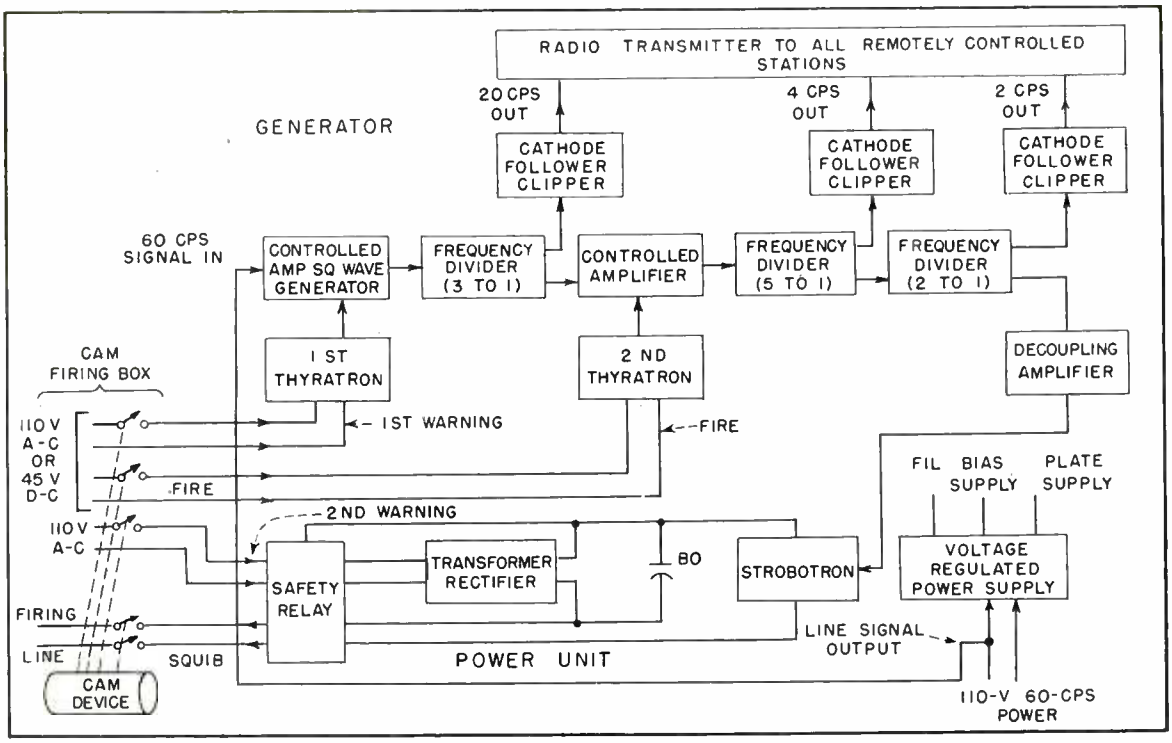


FIG. 2—Block diagram of the firing unit. Control signals are sent out by radio to receiving triangulation stations. Warning sirens at the firing grounds are actuated and the main firing line is open circuited until the safety sequence is complete

# of Guided Missiles

Optical methods used in triangulating on projectiles and missiles are synchronized by radio-links from a central timing standard. Complete automatic firing system including remote three-camera recording station is described

It may therefore be seen that the bearing error $(ds/dt)\ \Delta\ t$ must be made as small as is feasible by equipment design which will reduce Δt, since ds_o/dt is established by the flight characteristics of the missile.

It is this type of error that has been minimized by the use of a central timing source which transmits a series of timing pulses to the various units via a radio link system. A block diagram, Fig. 1, shows elements of the system.

Camera Equipment

The outputs of the receivers at the various stations are separated and fed through cathode followers to the individual control amplifiers, which are of two general types. One control amplifier operates the main field-camera shutter, recording the position of the bird with reference to the cross hairs of the instrument. The second type is a pulse amplifier for operating type FT-14 Edgerton flashlamps to illuminate the bearing scales and thus act as a precisely timed high-speed shutter.

The main field shutter controls are of two types. One amplifier operates the solenoid-activated, louvre-type shutter of the pulse-operated cameras, while the second is a servo amplifier for synchronizing and phasing the main field drive of the more usual motion-picture camera. An additional amplifier operates a counter at preset intervals to mark and identify the various frames on the camera. Thus a given record will indicate exact relative time at which the picture was taken, the azimuth and elevation angles of the optical axis of the telescope, and the angular position of the bird relative to telescope axis.

Timing Generator and Firing Unit

In order to insure the safety of all personnel concerned in the firing of ground-launched missiles a safety-interlock system is necessary. In addition, a warning is given and three supplementary warning horns are used for aural indication of the approaching firing. These devices are controlled by a cam system contacting snap-action switches in a given preset order. This same cam system can be used to energize camera motors when

precise timing is not required.

The general functions of the unit are shown in Fig. 2. One of the switches in the cam firing box, on momentary closure, injects an electrical impulse through the First Warning siren circuit into the grid of the first thyratron, causing it to start conduction. Conduction of this thyratron adjusts the voltages of the controlled amplifier-square-wave generator so that it amplifies and clips into square waves the 60-cycle signal that is fed into its input. These square waves, fed into the 3-to-1 frequency-divider circuit, emerge from its clipper-cathode follower output as 20-cycle rectangular positive pulses, with the same reference level of voltage (adjusted to zero volts) after the pulses have started as there was before. Another output of the 3-to-1 frequency divider feeds the second controlled amplifier.

Following the time sequence and the diagram, the second operation is the closure of the switch in the cam firing box which applies 110-volt a-c power to the Second Warning horn input. The application of power at this input actuates a safety relay, causing the transformer-rectifier combination to charge the 80 microfarad capacitor. It is the later discharge of this capacitor, through the Strobotron, that fires the projectile at the moment that the controlling impulse appears on the Strobotron grid.

When the firing of the round is desired, momentary closure of the firing switch either manually, automatically, or both in the cam firing box actuates the second thyratron through its input (Fire) terminals, causing the second controlled amplifier to become operative. Then when the next positive rise of the 20-cycle output occurs, the 5-to-1 frequency divider and the 2-to-1 frequency dividers operate simultaneously to give the first pulse on the 2-cycle and 4-cycle outputs. From then on, until the reset switches are operated to stop the counting sequences, the positive rises of the 2-cycle output occur simultaneously with positive rises of the 4-cycle output, which occur simultaneously with positive rises of the 20-cycle output. The 2-to-1 frequency divider also feeds through a decoupling amplifier to the grid of the Strobotron, causing it to discharge the 80-microfarad capacitor through the squib circuit at the moment of the start of the 2- and 4-cycle outputs.

Phasing Synchronous Motor Drive

A special drive system was designed to enable operation of several Mitchell chronographs in phase at a speed of 20 frames per second. Essentially this unit consists of a synchronous motor operating through a reduction-differential gear system with an output of 1,200 rpm. The output shaft carries a one segment commutator for generating a pulse approximately 15 electrical degrees wide. The output of the servo amplifier described below operates a reversible series motor which varies the output speed from 1,200 to some other value until the pulse from the commutator is in phase with the reference pulse generated by a centrally located pulse generator. When the pulses are in phase owing to the positioning action of the phasing motor, a brake is applied to lock the differential shaft in position. From this time on the phase is maintained by the synchronous motor operating at constant load. If a power-load change causes a line phase shift, the phasing action is resumed.

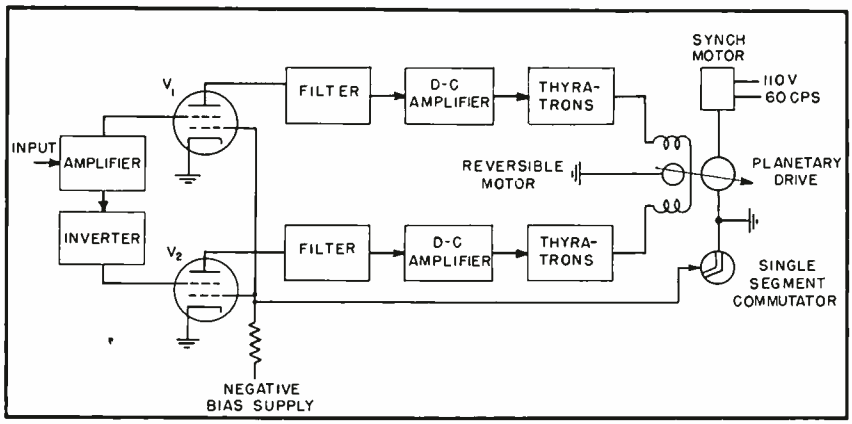


FIG. 3—Elements of the servoamplifier system used to synchronize cameras mounted on gun directors

Servo Amplifier

The basic divisions of the servo amplifier are shown in Fig. 3. The input signal, composed of 20-cycle rectangular waves transmitted to the device from the generator firing unit, is clipped, amplified, and applied to the second grid of the dual-grid mixer tube V_1, and passed through an inverter, so that its reverse is injected into the second grid of V_2. Within limits, the ratio of length of positive peaks to length of negative peaks is unimportant, as will be explained later. Excitation for the first grids of V_1 and W_2 is in the form of positive pulses, generated by the contactor and one-segment commutator mounted on the camera driveshaft. Since the contactor is connected through a high resistance to the negative bias supply and the segment is grounded, intermittent connection between the two for a few degrees of rotation creates these pulses.

The operation of the remaining portion of the amplifier is to cause the d-c motor to hunt for a phasing condition such that the center of the contactor pulse coincides with the positive rise of the input signal. Figure 4 shows graphically the various conditions imposed upon the mixer tubes. Where the pulse lags, as shown in condition 1, it is impressed on the first grids of the mixer tubes, while the second grid of V_1 is positive and that of V_2 is not positive. Since the second grids of these tubes must be positive if the tube is to conduct, V_1 conducts for the duration of the pulse but V_2 does not conduct at all. Conduction in the tube drops its plate voltage, as shown in the diagram. These pulses are averaged out by the filter circuit, the average value is amplified by the d-c amplifier, and the resulting positive rise of voltage is imposed on the grids of the thyratrons, causing them to conduct. The output of these thyratrons is connected to the d-c motor in such a

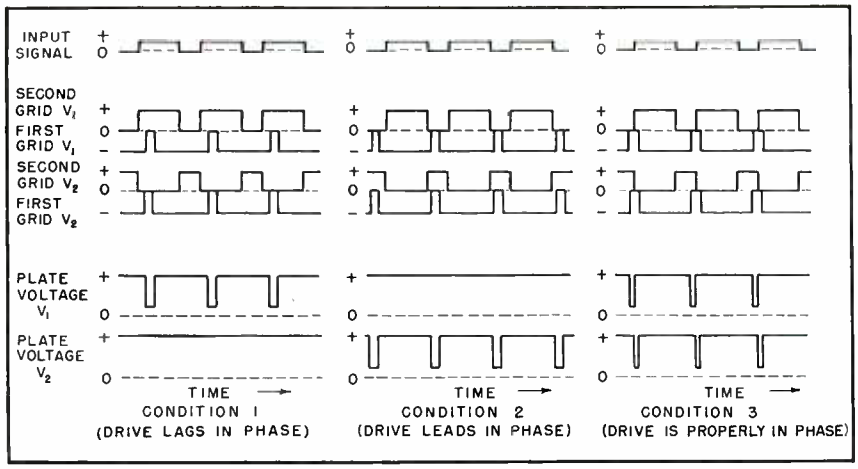


FIG. 4—Voltage patterns showing conditions that lead to automatic synchronism of tracking cameras

manner that it is driven in the direction which will correct the phase lag.

In condition 2, just the opposite is true: the contactor pulse leads the positive rise of the input signal, bringing about conduction of V_2 instead of V_1. The result is a positive rise in the grid voltage of the lower thyratrons. Conduction of these thyratrons drives the motor in the direction which will correct the phase lead.

In condition 3, the pulse is shown properly in phase with the positive rise of the input signal. The first half of the pulse causes conduction in V_1, the second half in V_2. The resulting pulses, after being integrated by the filter and amplified by the d-c amplifier, produce a signal not great enough to appreciably affect either thyratron circuit. Thus, the d-c motor, receiving insufficient current to be driven, is held locked by its brake into the proper position to phase the drive of the camera within a few degrees.

Power and Control

In the block diagram (Fig. 2) the plate and bias supplies, including the circuits necessary to bias the thyratrons properly, are not shown. There is also a circuit which prevents the application of voltage to the thyratrons and the synchronous motor until two conditions are met. Sufficient time must have elapsed for the cathodes of the thyratrons to reach operating temperature and there must be a signal on the input of the unit.

The counter relay tube (Fig. 1) contains a high-speed counter relay and a group of four 28-volt lamps in two circuits, each made up of two in series, and physically placed to illuminate the counter registers. This tube is placed so that the counter is photographed, when illuminated, by the chronograph lens of the Mitchell camera. The synchronization of film and lights is described below. The counter relay amplifier is connected to the radio timing receiver from which it is fed 2- or 4-cycle pulses. The amplifier sends out three pulses simultaneously, one to the counter relay and one to each lamp circuit. Since the chronograph is phased, the chronograph lens is open at the instant of flashing of the lamps. After the flashing of the lamp (owing to the small delay of the counter mechanism) the counter register advances one number, thus every tenth (or fifth) frame in the chronograph is numbered to furnish a definite reference for the film assessor.

The synchro dial box contains five type 5F servo motors, four of which are tied into the coarse and fine elevation, and azimuth synchro generators in the Mk 51 Mod 3 director. The synchro motors carry engraved dials mounted behind a mask to aid in assessing data. The synchro dial box is illuminated by two FT-14 Edgerton lamps powered by the flash-lamp amplifier. The flash-lamp amplifier is triggered by 20-cycle, 4-cycle, or 2-cycle pulses from the radio timing receiver. As a result, three recording ratios can be used: one, five, or ten frames of the chonograph to one frame of the dial box camera. This latitude allows detailed study of angular rates at 20 fps or angular positions at 2 fps along with the 20 fps chronograph record for study of round performance. Such a system allows a continuous-record film to be used for position data as well.

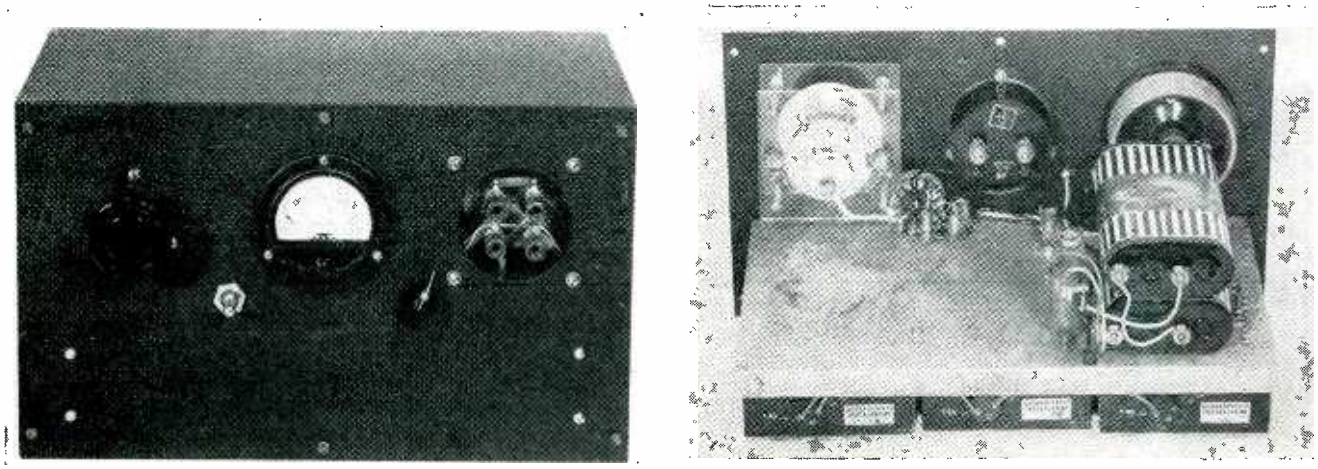
35-Mm Master Recorder

Another camera is designed to serve as oscilloscope recorder, dial box recorder, operations recorder, or combination dial box and operations recorder. This instrument is a continuous-drive 35-mm camera with interchangeable aperture plates for single and double-frame use. The aperture plate is mounted in a lamp house containing two neon lamps, each located behind a 0.006 in. hole centered vertically at the edge of the aperture plate. These lamps can be used to record as a series of dots on the edge of the film the operation of some two mechanisms connected through suitable amplifiers.

The Askania theodolite shutters are pulsed with an inherent delay of about 20 to 30 milliseconds because of mechanical linkages. The normal bearing-scale shutters and incandescent light which served to illuminate the bearing dials and expose them to the film at the proper time have been removed. In their stead is a flashlamp installation, which can be pulsed with resultant bearing-scale timing errors under one hundred microseconds.

Acknowledgments

The system has been used in part and as a whole for various guided missile and rocket studies carried on at this station for about a year. The system is part of a long development program carried on by the Exterior Ballistics Section. The authors acknowledge the close teamwork of Arden H. Milam, John DePangher, Norman Littrell and Joseph Hirsch in Mechanical Design. The recent electromechanical counterpart of the firing-pulse generator now commonly used and the radio link system were engineered by E. R. Toporeck and A. B. Vane of the Electronics section of this station. The general cooperation of N. A. Renzetti and J. Titus assisted the development considerably.



Front and rear views of the diode noise generator for receiver measurements

Noise Generator for

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TWO significant sources of noise are associated with a radio receiver. One is made up of all of those within the receiver itself, such as shot effect and partition noise. The other source is the thermal agitation (Johnson) noise supplied by the resistive component of the antenna impedance. The noise figure[1, 2] of a receiver is defined as the ratio of the sum of these two to the second, or,

$$F = \frac{P_r + P_a}{P_a} \qquad (1)$$

where P_r is the equivalent noise power output of the receiver referred back to its input terminals (that part in excess of thermal noise), and P_a is the thermal noise supplied to the receiver by the antenna. A perfect receiver would have P_r equal to zero, and the noise figure would be unity. This definition is not very explanatory; the reader should see the first two references for a full discussion of the subject.

It is easy to calculate P_a, but P_r is difficult to determine directly. However, the sum $P_r + P_a$ may be determined by a simple expedient. The noise power output of the receiver is measured when a resistance R_a, which is substituted for the antenna, is connected across the antenna terminals. Next, a temperature-limited diode is connected as shown in Fig. 1 and the direct diode current I is adjusted by varying the filament temperature to such a value that the noise power from the diode doubles the power output of the receiver.

Under these conditions, $P_{diode} = P_r + P_a$, and

$$F = (P_r + P_a)/P_a = P_{diode}/P_a \qquad (2)$$

It is now necessary to evaluate P_{diode} and P_a. The rms fluctuation current from a temperature-limited diode is[3]

$$i^2 = 3.18 \times 10^{-19} IB \qquad (3)$$

where i is the rms fluctuation current in amperes, I is the direct diode current in amperes, and B is the bandwidth in cycles per second. If the input resistance of the receiver is R, the diode sees a load resistance R_aR/R_a+R, and the diode delivers to the receiver a power

$$P_{diode} = 3.18 \times 10^{-19} IB \; (R_aR/R_a + R)^2 \, 1/R \qquad (4)$$

A resistance will develop a thermal-agitation voltage across its open-circuited terminals $e^2 = 4KTR_aB$, where K is Boltzmann's constant, 1.374×10^{-23} joules per degree Kelvin, T is the absolute temperature of the resistor in degrees Kelvin, and B is bandwidth in cycles per second. It is assumed that R_a is constant over this frequency band.

The resistor will deliver a power to the receiver

$$P_a = \frac{4KTR_aB}{R_a + R}\left(\frac{R}{R_a + R}\right) \qquad (5)$$

Substituting Eq. 4 and 5 in Eq. 2,

$$F = \frac{5.790}{T} IR_a \qquad (6)$$

For a temperature $T = 289$ degrees Kelvin, 19 C,

$$F = 20\, IR_a$$

Since the bandwidths cancel, noise figure measurements made in this manner are independent of the response curve of the receiver. Since quantity R, the input resistance of the receiver, does not appear, the measurements are not in error because of the mismatch between R_a and R, and the effects of such mismatch on noise figure can be studied.

The factor R_a in the expression requires some attention. A temperature-limited diode should, at first glance, appear to have an infinite a-c plate resistance. However, the work-function of the filament surface depends on the anode voltage[5]. The result is that emission in-

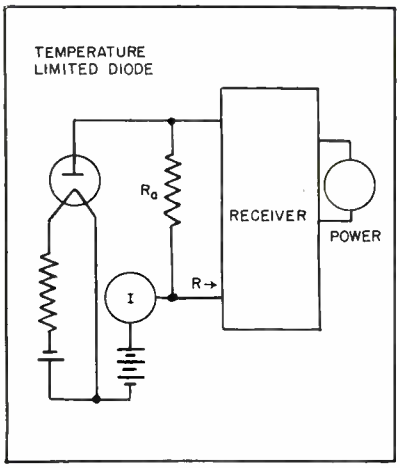

FIG. 1—Basic circuit for measurement of noise figure with a noise diode

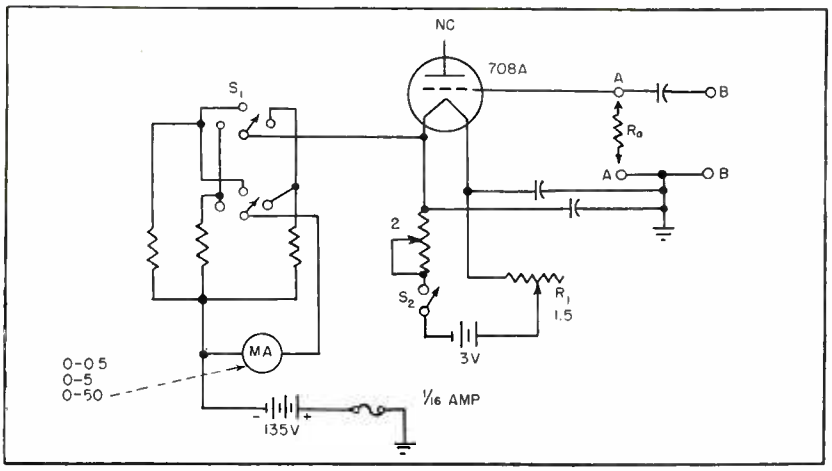

FIG. 2—Schematic diagram of the diode noise generator. The receiver connects to points *A-A* normally, to *B-B* if d-c isolation is required

Receiver Measurements

Diode noise generator permits simplified procedure in the measurement of noise figures and receiver input resistance. The receiver bandwidth need not be known and measurement is independent of the response curve of the receiver

creases with increased anode voltage, and the a-c plate resistance becomes finite. When high values of R_a are used, the plate resistance must be considered in parallel with it.

Resistance R must have the desired value, and must remain constant over the frequency range used. At the higher frequencies, the use of film-type resistors is desirable.[6] It has been found by slotted-line measurements that Allen-Bradley fixed resistors and Type J potentiometers of 1,000 ohms or less resistance are suitable at least as high as 400 megacycles.

Use of Diode Generator

It was stated that measurements are made by noting the diode current necessary to double the output of the receiver. Thus, the use of an output meter is indicated. However, calibration is usually necessary because of the nonlinearity of the detector. If a signal generator is available, it can be used. If not, the diode generator itself will serve the purpose.

The noise diode and R_a are connected to the receiver, and the diode itself is turned off. The r-f gain control of the receiver is turned down until the output meter nearly indicates zero. Under this condition the gain is so low that the noise power from the receiver and from R_a can be neglected, and the output power of the receiver will then be directly proportional to I.

The diode current I is then increased until some convenient output reading—say one volt—is obtained. The diode current I is then doubled, and the output reading is noted. If the detector is linear, the reading will be 1.41 volts. If not, it will probably be higher—perhaps 1.5 or 1.6 volts. The increase from 1 volt to the higher value does indicate a true doubling of the input power.

If the receiver has an a-f or video gain control, its setting must not be changed after this calibration is made, since it is necessary that the detector operate over the same part of its characteristic. It may be necessary to use a high value of R_a to obtain sufficient input to the receiver for this calibration.

The input resistance R of a receiver can be measured by a method given by A. van der Ziel.[7] A somewhat simplified version of his method follows.

The noise diode is connected to the receiver input terminals, with the diode inoperative, and with $R_a = \infty$. The receiver gain is decreased until the output indicator drops nearly to zero. The diode filament temperature is increased until a current I is obtained, and the output reading is noted. With reference to Eq. 3, the input power to the receiver is given by

$$P = 3.18 \times 10^{-19} I_1 BR$$

Next, a finite value of R_a is used, and the diode current I is adjusted for the same output reading as before. It will be necessary to use a higher value of I, I_2, because part of the diode power output is absorbed by R_a. The power input to the receiver is given by Eq. 3, and is the same as that obtained with I_1 when $R_a = \infty$. Equating the powers,

$$3.18 \times 10^{-19} I_1 BR = 3.18 \times 10^{-19} I_2 B \left(\frac{R_a R}{R_a + R}\right)^2 1/R$$

Solving for R,

$$R = R_a \left(\sqrt{\frac{I_2}{I_1}} - 1\right) \quad (8)$$

The procedure can be simplified if $I_2 = 4I_1$. Then $R = R_a$. In making the measurement in this manner, an output reading is obtained for a diode current I. The diode current is then increased to $4I$, and R_a is decreased to give the same output reading. Detector calibration is unnecessary for this test.

Noise Generator Design

In the noise generator circuit of Fig. 2 a type 708A triode is used as a diode, the control grid being used as the anode. The plate is not connected. The 708A was chosen because it has high grid-dissipation capabilities, low grid-filament capacity, and a thoriated tungsten filament whose temperature responds rapidly to changes in applied voltage.

Filament voltage is controlled by a rheostat R_1 which is used to set the diode current I to the desired value. In practice it may be necessary to measure noise figures as high as 50 with values of R_a as low as 50 ohms. This requires direct diode currents as high as 50 milliamperes. The meter was provided with shunts for full-scale currents of 50, 5, and 0.5 milliamperes.

The tube is mounted on an insulated panel with terminals for R and for connection to the receiver. Every effort has been made to keep the output capacitance as low as possible $-10\mu\mu f$ in this case. At frequencies where the reactance of this capacitance becomes comparable to R, it is necessary to tune it out by means of a coil or, at very high frequencies, a Lecher wire system.

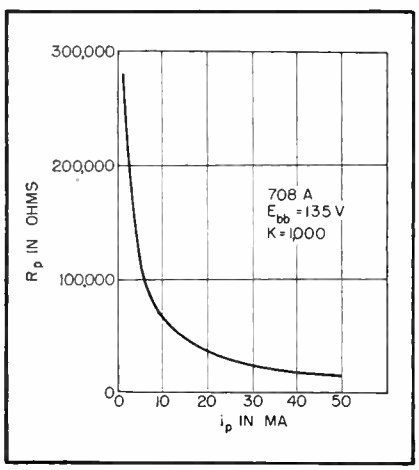

FIG. 3—Plate resistance versus plate current for the 708A tube

Figure 3 is a plot of R_p versus i_p for the 708A. It can be seen that R_p will be much higher than R_a under almost all circumstances.

Results

The choice of a diode for this use is a difficult one because almost all small diodes made in this country have oxide cathodes and are not suitable. It is to be hoped that a tube designed specifically for this application will be manufactured. A small diode constructed from the plate and filament of a 316A doorknob tube and mounted in a tubular envelope for probe use should be ideal for measurements, at least up to the vhf range.

The results of some measurements made with the diode noise generator are shown in Fig. 4A and 4B. The two amplifier circuits shown were used as preamplifiers for a Super-Pro receiver. The push-pull neutralized 6J6 gave the lowest noise figure; a ratio of about 1.2. This value is doubtful to about ±0.2 because of the external noise pickup. The minimum noise figure was obtained with a value of R_a less than the input resistance R; 150 ohms as compared with 200 ohms.

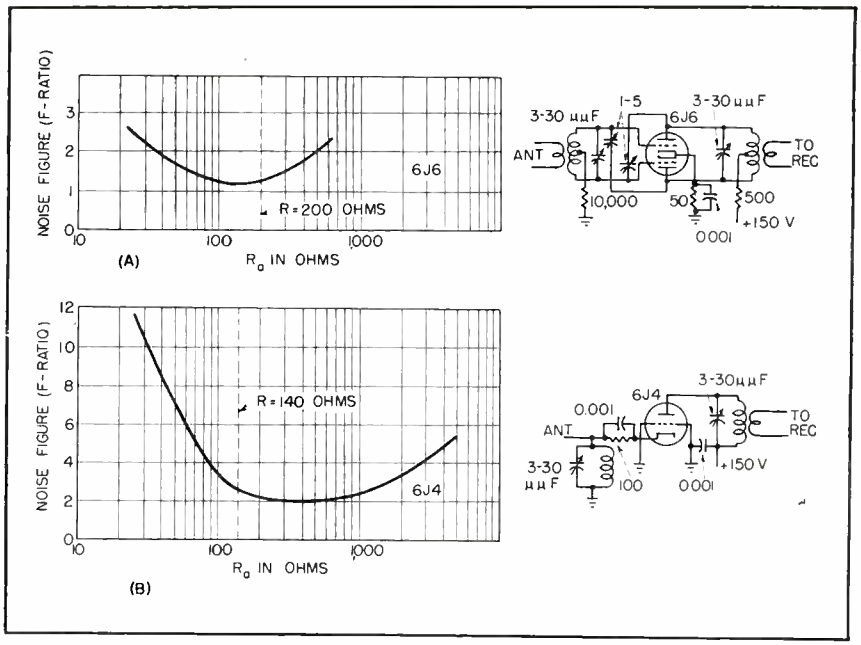

FIG. 4—Preamplifier circuits and measurements

The input resistance was measured by two independent means to provide a check on theory. The noise diode gave a value of 200 ohms; 220 ohms was obtained by substitution with a signal generator.

The 6J4 preamplifier shown in Fig. 4B gave a minimum noise figure of about 2. This is not quite as good as the 6J6, but the circuit has the important advantages that the tuning of the input circuit is not critical and neutralization is not required.

Input resistances of 140 ohms and 130 ohms were obtained with the diode and signal generator respectively. The measurements were made at 20 megacycles.

The assistance of Arthur H. Benner in the construction and measurements is gratefully acknowledged.

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Medical Stimulus Circuits

New electronic circuits for medical diagnosis and research include outline wave-shape generator that produces any desired waveform when its shape is cut from cardboard and placed between c-r tube and multiplier phototube. Recording circuits are also discussed

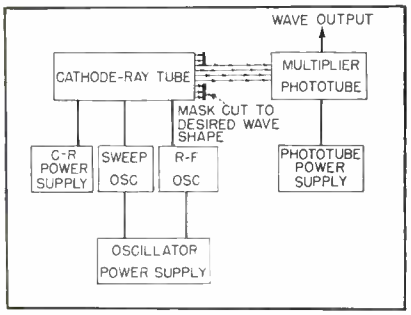

FIG. 1—Block diagram of system for generating stimulating current whose waveform is cut out from cardboard mask

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IN biological research it is frequently desirable to have available a source of stimulating current of unusual wave-shape, slope, and frequency. These characteristics are usually difficult or impossible to obtain by means of ordinary electronic circuits.

The device to be described was designed to provide either single or repetitive stimuli derived from a simple silhouette easily cut by following any desired curve drawn on cardboard or similar material. The mask so obtained is placed in contact with the screen of a cathode-ray tube having a short-persistence phosphor.

The block diagram of this variable wave generator is shown in Fig. 1. The beam of the cathode-ray tube is spread vertically into a thin line by a radio-frequency oscillator connected to the vertical deflecting plates. The line thus formed is caused to move from left to right between two definite end points on the silhouette. The motion is obtained by the relaxation oscillator circuit of Fig. 2, using fixed break-down point and a double-thyratron discharge path to provide a quick return. The accuracy of the break-down point at the right is obtained by a thyratron so biased and connected that it will fire when the voltage on the sweep capacitor reaches a predetermined point. This sends a positive pulse into the grids of the parallel sweep-actuating thyratrons, causing them to fire.

No special precautions are necessary to provide a stable end-point at the left as the voltage drop across the tube and the deionization voltage vary only slightly.

An RCA 931-A or similar multiplier phototube is placed about eight inches from the face of the cathode-ray tube. The amount of light which falls on the phototube is a function of the length of line which it sees at any instant and this is determined by the shape of the mask. The output of the phototube is approximately 10 volts with a 750-volt power supply and a 50,000-ohm load resistor.

The d-c power supply used consists of a half-wave rectifier (2X 2/879) and a pi-section filter using two 2-μf, 1,000-volt paper capacitors and a 300-henry audio choke with 1,600-volt insulation.

The light-sensitive surface of the phototube is of proper size so that no lens system is necessary to provide uniform output for a given length of line at any position between the fixed end points of the mask, provided the distance from the screen to the phototube is not less than eight inches.

The output of the phototube may be amplified by a d-c amplifier and applied to the organism, as desired. Examples of the wave shapes obtainable are given in Fig. 2.

The frequency so obtained is lim-

Square-wave stimulator, showing technician applying stimulus to muscles of forearm

* R. Pavlat of the University of Wisconsin Medical School is coauthor of the first portion of this article, covering the outline wave-shape generator.

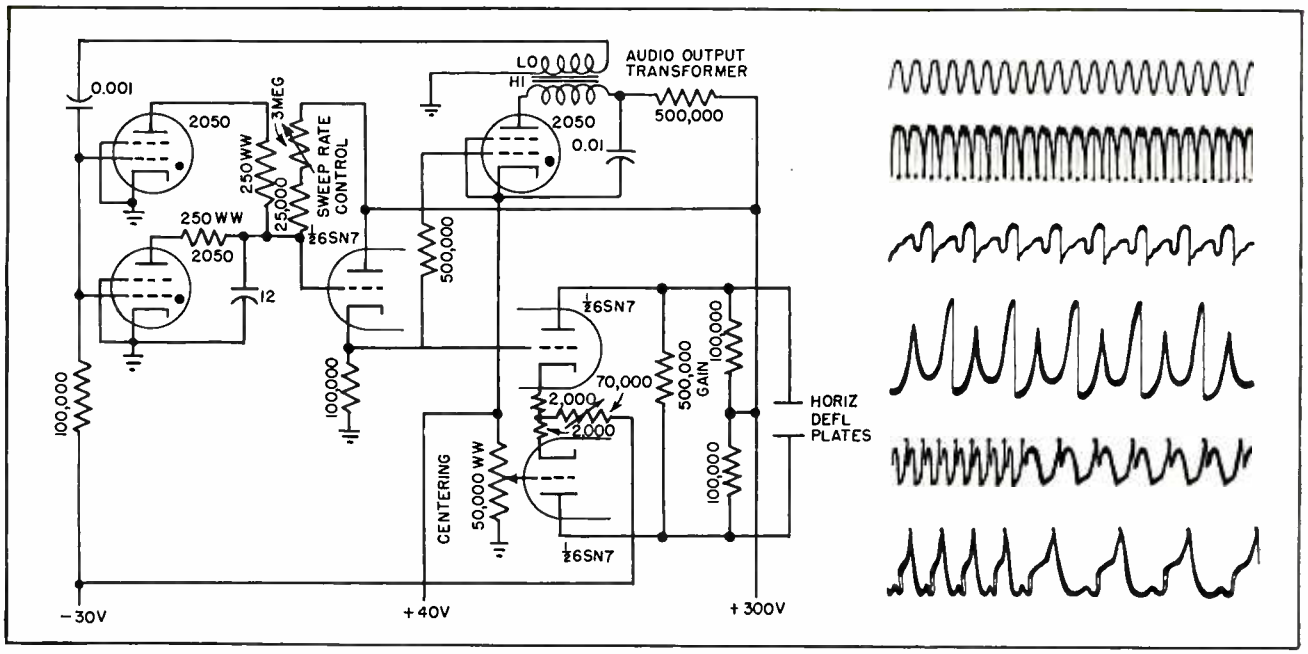

FIG. 2—Relaxation oscillator circuit used to sweep vertical-line trace across cut-out mask at desired frequency for generating medical stimulating current, and examples of waveforms generated. Lower two records show result of varying sweep rate

ited by the phosphor decay characteristics (the light output is down to 10 percent in 3.3 milliseconds with an RCA-11 phosphor). In the circuit used the lowest sweep frequency is about 1 in 10 seconds.

Square-Wave Stimulator

For purposes of diagnosis in nerve and muscle lesions it was desired to have available a square-wave stimulus with accurately preset current flow, independent of tissue and electrode resistance, and with separate adjustments for length of stimulus and frequency of stimuli. The latter adjustment appeared preferable to varying the interval between stimuli.[1]

The circuit of the stimulator is given in Fig. 3. Here T_2 and T_3 are connected as a one-shot multivibrator with T_3 normally fully conducting and its plate thus relatively negative. When a positive pulse is momentarily applied to the grid of T_2 it becomes fully conducting, and T_3 is cut off. Its plate then becomes relatively positive for a length of time determined by the size of the capacitor selected and by the 2-megohm resistor. The time in seconds is approximately equal to the value of the capacitor in microfarads.

The plate of T_3 is connected to the grid of T_6, the bias of which is varied by the *STRENGTH* control. In the normal quiescent condition T_6 is biased beyond cutoff, so little or no current flows. During the stimulus period the grid is less negative and current will flow, the amount depending on the setting of the *STRENGTH* control. Because of the current-regulating characteristics of T_6, the amount of resistance in the patient circuit makes little difference between 0 and 20,000 ohms.

The frequency of the stimuli is controlled by selecting capacitors in the plate circuit of T_1, which is connected as a relaxation oscillator. Each time the capacitor discharges through T_1, a positive pulse is transmitted to the grid of T_2 by the transformer in its cathode circuit. This triggers the one-shot multivibrator.

The frequency per second is equal to 1 divided by the capacitance in microfarads. Position 1 on the frequency control switch is for a single pulse provided by manual operation of the pushbutton. Because the 500,000-ohm resistor is connected to a less positive point than the 750,000-ohm plate resistor of T_1, the 0.1-μf capacitor will not become charged to the breakdown point of T_1. When the *MANUAL* pushbutton is pressed the bias on T_1 is momentarily removed for a period of time determined by the time constant of the resistor and capacitor in the grid circuit of T_1. This causes the tube to break down and provides a single square wave from the multivibrator.

The output of the stimulator may be connected either to a test resistor or to the patient. The approximate strength stimulus desired is usually set with the output connected to the resistor and with a long square wave so that the meter reading may be adjusted easily.

The output may be reversed by the reversing switch, so that either a negative or positive voltage is supplied to the active stimulating electrode.

In some cases it is desirable to surge the current applied to the patient, for automatically increasing and decreasing the stimulus. If the *SURGE* switch is turned on, the screen voltage of output tube T_6 will be controlled by relaxation oscillator T_7 through cathode-follower amplifier T_8.

Physiological Recording System

For recording circulatory phenomena in man it was desired to have a system capable of reproducing the electrocardiogram, the amount of blood in the ear, and several other graphs of physiological functions. The electrocardiogram could well be the standard 1 cm per millivolt size with an excursion of about 2 cm, but an excursion of several inches was necessary in order to show small variations in

ear volume. This made the use of a beam of light the method of choice. A camera using 12 or 18 inch-paper was devised in collaboration with J. S. Hipple.[2]

In order to simplify the optical system it was decided to use a galvanometer with a large mirror, eliminating the need of a high-intensity arc or incandescent light. The Sanborn Cardiette galvanometer proved to be satisfactory. It had a mirror approximately $\frac{1}{4}$ inch in diameter; when this was replaced by a Leeds and Northrup mirror of the same size, with a working distance of 1 meter, galvanometer lenses were not needed. This simplified construction and eliminated loss of light in the lenses.

The circuit of the direct-coupled amplifier used is shown in Fig. 4. This amplifier is suitable for operation with a photoelectric plethysmograph or photoelectric membrane-manometer.[3, 4] The amplifier is extremely stable as it incorporates a large amount of cathode degeneration. The operation is as follows: the input grid is connected to ground by means of switch *SW*. The gain control is turned to maximum and the center control adjusted so that the light beam is returned to approximately the same position it occupied before the amplifier was turned on. The gain may next be reduced and the grid connected to the input. The balance control is then used to balance the voltage drop in the phototube load resistor with the basal amount of light falling on the phototube. This brings the light spot back to approximately the same position. The gain may then be adjusted so that the desired deflection is obtained.

Figure 5 shows the electrocardiograph amplifier. It is a push-pull type, adapted to work with the Sanborn galvanometer. It is highly insensitive to a-c interference because of the large amount of in-phase degeneration provided by the large cathode resistors.

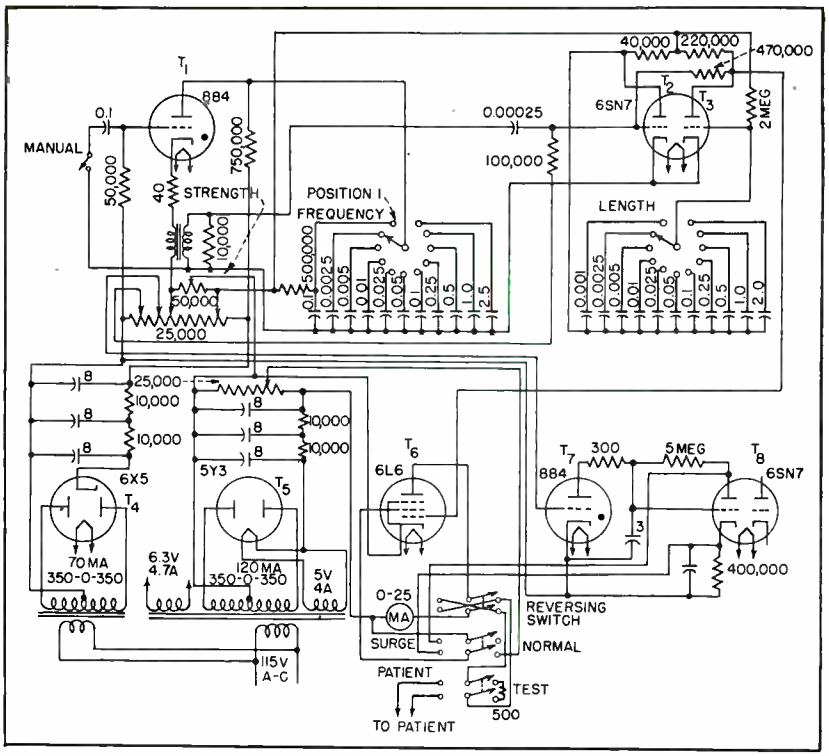

FIG. 3—Square-wave stimulator circuit providing separate adjustments for length and frequency of stimuli, along with constant preset current independent of resistance of patient

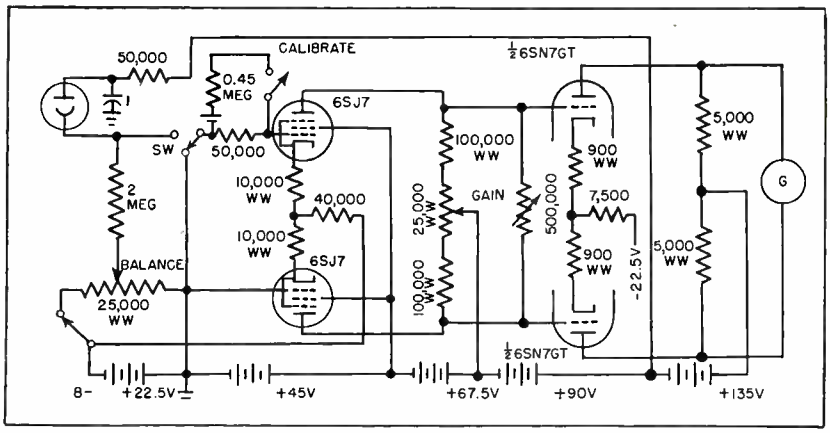

FIG. 4—Direct-coupled amplifier for driving recording galvanometer from phototube input

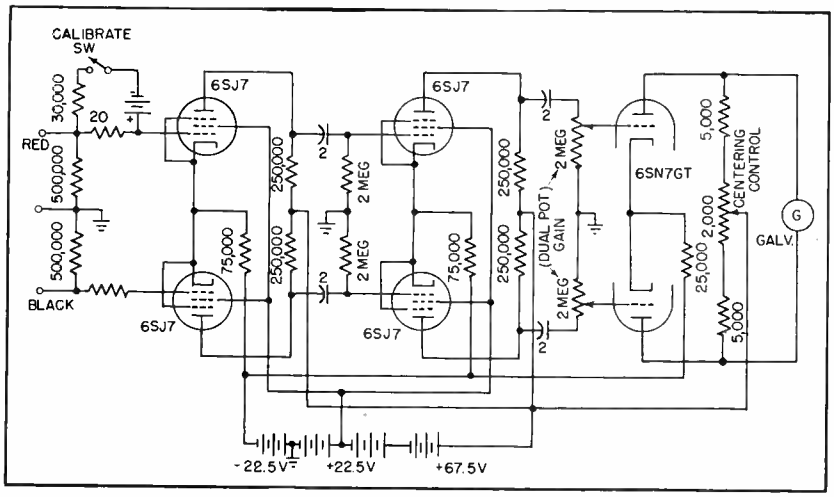

FIG. 5—Circuit of push-pull electrocardiograph amplifier adapted to work with Sanborn galvanometer

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(2) This camera is now made by Waters-Conley Co., Rochester, Minn.

(3) W. E. Gilson, Photoelectric Plethysmograph, ELECTRONICS, p 116, July 1944.

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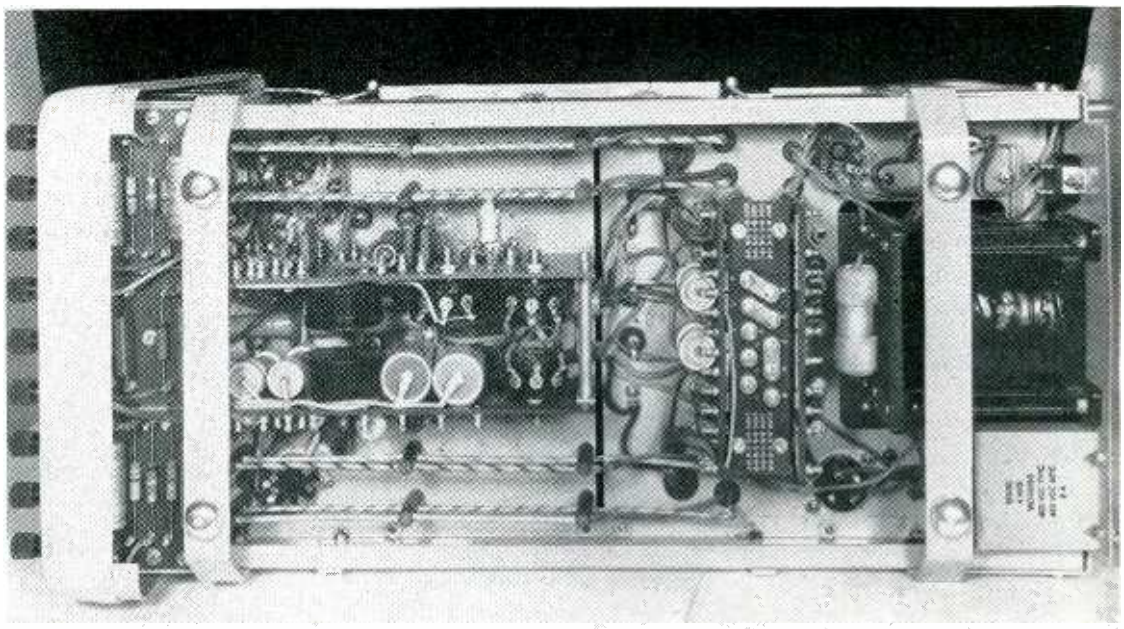


Under-chassis view of the oscilloscope showing preset amplifier controls (left of center) and spaced leads from front terminals to deflector plates

Direct-Coupled

THE requirements of modern servo technique and electromedical work call for the examination of very low frequencies. The use of conventional a-c amplifiers involves circuits having long time constants, but such circuits are seriously disturbed by transient impulses, which cause displacement of the image, often off the screen altogether, for periods lasting several seconds. The only real solution is to use a direct-coupled system. A further important requirement in a modern oscilloscope is that it shall be able to record potential differences between two points in a network, but should disregard fluctuations in the general level of network potential.

The instrument to be described achieves both these features in a practical fashion. The system is indeed so stable that it is not necessary to use stabilized power supplies. Although attention was primarily concentrated on the lower-frequency requirements, the circuits were found to be effective up to comparatively high frequencies. In the design of the finished instrument, therefore, attention was paid to constructional details and layout in such a manner as to maintain the frequency response substantially uniform up to 1 mc or, at some sacrifice of sensitivity, up to 3 mc. The amplifiers are provided with a simple link by means of which the user can choose whichever condition he wishes.

Special CRT

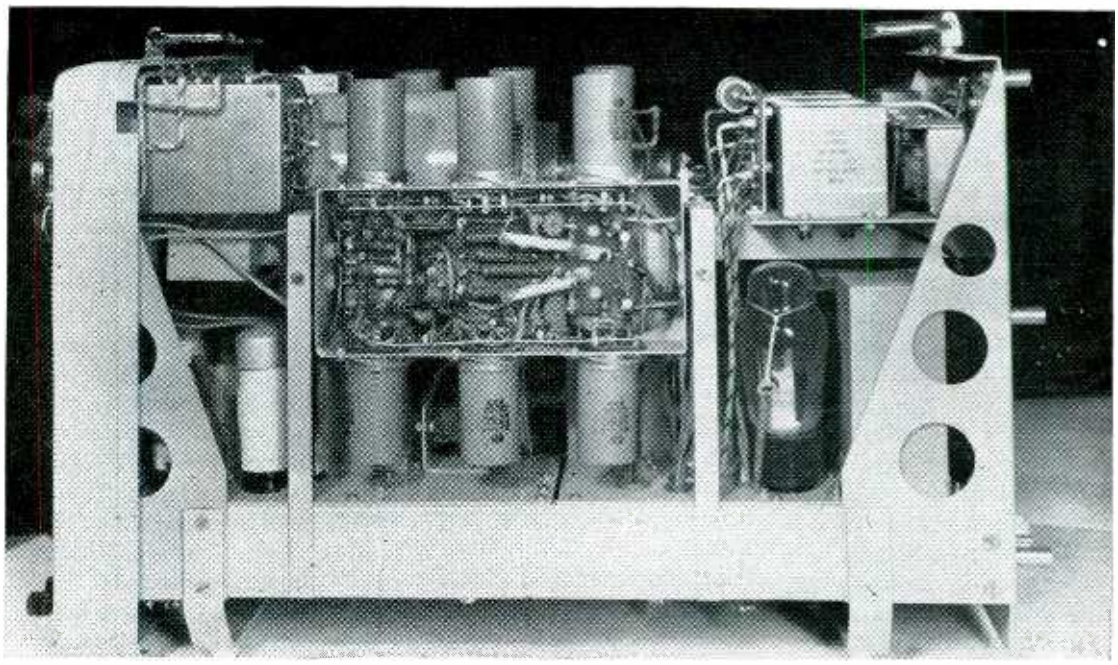
The instrument uses a cathode-ray tube of a type developed for radar. The particular tube has the merit of giving a brilliant trace and a sharply focussed spot with an anode voltage of only 1 kv. Because of this relatively low anode voltage the sensitivity of the tube itself is high. Electrostatic deflection is used, vertical deflectors having a sensitivity of 2.2 mm per v while horizontal deflectors are approximately half this sensitivity. The screen diameter is 3.5 in. with a nearly flat face. Four standard types of screen are available; blue trace with afterglow approximately 1 microsecond; green trace with afterglow approximately 1 millisecond; yellow trace with afterglow approximately 6 seconds; and blue trace with yellow afterglow lasting approximately 20 seconds.

Although the screen diameter is smaller than on many oscilloscopes the extremely small spot diameter (approximately 0.25 mm) at full brilliance results in such sharp traces that the effectiveness of the display is better than on many larger diameter screens.

The c-r tube sensitivity permits a high amplifier sensitivity to be obtained with a maximum gain of only 700. This condition results in a screen deflection of 1.5 mm per mv rms input to the amplifier. The sensitivity on the horizontal amplifier is only about half this figure.

The focus and intensity controls are independent and the focus is sharp over the whole screen. This effect is accomplished by the manner of connecting the deflector plates to the amplifying network, which ensures that the mean deflector potential is the same as the final anode voltage of the cathode-ray tube. This requirement is critical and provision for adjustment is explained later.

The two amplifiers, which are identical in all but minor particulars, each consist of three pairs of symmetrically arranged push-pull tubes. The basic circuit is shown in Fig. 1. The tubes V_1 and V_2 constitute a symmetrical cathode fol-



Side view of oscilloscope showing X-amplifier suspended from shock mounts. An identical 6-tube amplifier is suspended on other side of chassis

Oscilloscope

Examination of low-frequency phenomena encountered in servo techniques and electromedical work requires a high-sensitivity oscilloscope employing d-c amplifiers. Design considerations are given for a portable device useful in observation of waveforms up to 3 megacycles

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lower or "long-tailed pair". The anodes of the tubes are directly coupled to the grids of tubes V_3 and V_4 which are a similar long-tailed pair arrangement, and these anodes are again coupled directly through the grids of the final pair, which are simple separate cathode-follower stages, the voltage across the cathode resistors being fed direct to the deflector plates of the cathode-ray tube.

All three pairs of tubes are fed from the same supply line but the circuit is so arranged that the cathodes of the first pair are at a low potential, those of the second pair are at an intermediate potential, while in the third pair the whole of the signal voltage is developed in the cathode circuit, there being no anode resistor in either tube.

This symmetrical arrangement provides not only the discrimination previously mentioned but also contributes to the stability because there is no signal current in the B+ line. A symmetrically-applied signal to the input causes circulating currents around the network $V_1R_1R_2V_2$ and there is no signal current either in the high-voltage line or in the cathode resistor. The cathode resistor thus has no effect on the amplification for symmetrical signals, but to any asymmetrical signal it becomes operative and introduces heavy negative feedback; the resulting discrimination in the actual amplifiers is of the order of 1,000 to 1 at the maximum gain setting.

A similar action takes place in the second and third pair of tubes, though advantage of the symmetry here is more in the avoidance of signal currents in the B+ line, since these are now of greater magnitude. Because of this circuiting there is no interaction between one stage and the next or between one amplifier and the other and since, as will be seen later, the time base is operated on a similar principle, the whole instrument can be fed from a common power supply without any appreciable interaction among the circuits.

Since the whole network is directly coupled it operates from zero frequency upwards. Small corrector chokes are included in the anode circuit, so proportioned as to maintain the response level until

* c/o American British Technology, Inc., 57 Park Ave., New York, N. Y.

the cutoff point is reached after which rapid attenuation sets in.

Functional Controls

Figure 2 shows the amplifier network in greater detail. Variation in the sensitivity of the amplifier is accomplished by providing separate cathode resistors for the first two tubes and bridging the cathodes with a variable resistance. When this resistance is zero, so that the cathodes are connected together, the two cathode resistors operate in parallel and the circuit is effectively the same as that of Fig. 1 and develops its maximum gain. Increasing the value of the gain control inserts resistance into the circulating anode current ring, the voltage drop acting to oppose the push-pull component of the input signal and thus reducing the push-pull sensitivity of the stage. The push-push sensitivity is not affected and therefore the discrimination tends to fall off as the gain is reduced, but since maximum discrimination is required at maximum sensitivity this constitutes no serious disadvantage in actual practice.

The actual voltage on the anode of the tubes V_1 and V_2 is determined mainly by the voltage drop in the anode resisters R_1 and R_2. An additional source of voltage, however, is applied to these two anodes through a symmetrical network from another source, actually taken from the power supply unit a little earlier in the smoothing chain. This voltage is fed through buffer resistors having a high value compared with the anode resistors, so that the amplification of the network is not appreciably affected. It will be noted, however, that the potential is actually introduced via the slider of potentiometer P_1. At the midpoint of this potentiometer, the potential applied to each tube is the same, but as the slider is moved a condition of unbalance is introduced, which has the effect of making one anode slightly more positive and the other slightly more negative. This unbalance is transferred through the next two pairs of tubes and produces a shift of the spot on the cathode-ray tube screen irrespective of any movement which is being produced by the signal. A smooth and wide range of control is obtained by this means, the important feature being that the change of position is instantaneous so that the location of the image is both positive and rapid.

Bandwidth Adjustment

It has already been mentioned that at the option of the user the frequency response can be varied from 1 to 3 mc. The adjustment is accomplished in the second pair of tubes, the anode resistors for which are in two portions. When both portions are in operation the amplifier maintains its response level up to practically 1 mc, being actually only 3 db down at this frequency. If the link shown in the diagram is closed, however, the upper portions of the two anode resistors are short-circuited and only the lower portions are effective. Under these conditions the frequency response is maintained up to 3 mc but the gain of the stage is reduced by approximately three times. From the symmetry of the arrangement it will be seen that the link short-circuits two points at the same d-c potential so that no circulating currents result.

Figure 3 shows the performance of the amplifier with the link in the 3 mc position. It will be observed that the response is completely uniform from zero up to a frequency very close to the cutoff frequency, after which rapid attenuation occurs. There is no phase shift in the lower frequency portions but some phase shift becomes noticeable a little above 500 kc and the phase angle is approximately 75 deg at 3 mc. Because of this phase shift at the limiting frequency the locus of the operating point on the tube characteristics at this point is no longer a straight line but is an ellipse of fairly large eccentricity. Consequently the volt-ampere requirements are considerably greater than at the lower frequencies where there is no phase shift.

Because of this fact it is not possible to develop the full screen deflection at the highest frequencies and at 3 mc the maximum deflection obtainable is a little over 2 cm. The position rapidly improves as the frequency is reduced. About double this deflection is available at 1.5 mc and at a little under 1 mc the full screen can be filled. While this limitation might appear serious, in practice the need for a good high-frequency response is determined mainly by the need to handle the harmonics of a fundamental operating on a much lower frequency. The relative strength of these harmonics will, in any case, be small so that not more than about 10 percent of the screen will be required. Actually, approximately 25 percent of the screen can be filled even at the highest frequency and this amount is considered satisfactory.

Current-Forcing Circuit

In order to obtain the discrimination required in the input stage it is necessary that the cathode resistors of V_1 and V_2 shall be of high value. This would normally result in the cathode potential being appreciably positive to ground, so that if the grids on the first stage are operating near ground potential they would be so negative with respect to the cathode as to reduce seriously the effective conductance of the tubes V_1 and V_2. It is, therefore, necessary to maintain the

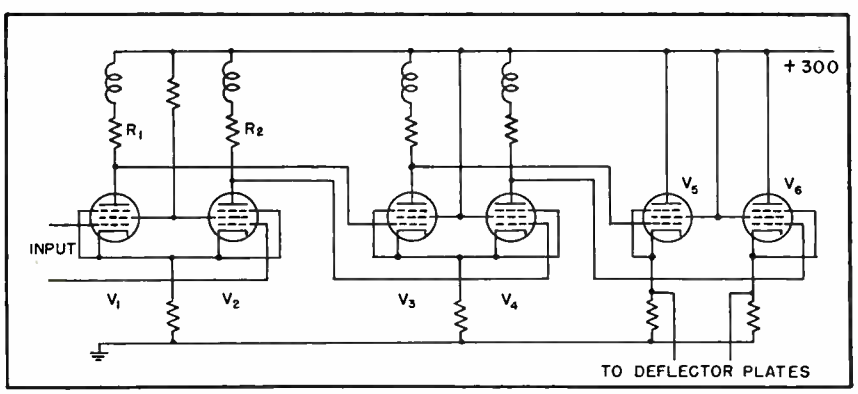

FIG. 1—Simplified schematic diagram of direct-coupled amplifier stages

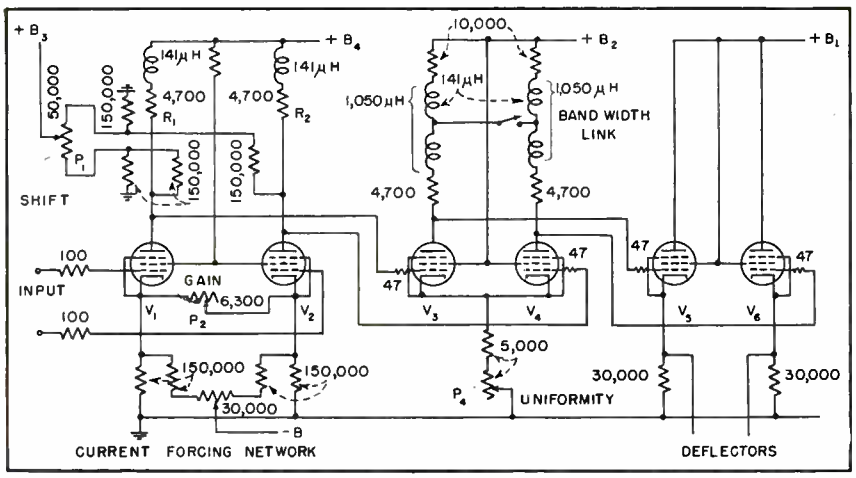

FIG. 2—Detailed circuit schematic of direct-coupled amplifier showing controls

anode current through V_1 and V_2 at a suitable value, and in order to accomplish this current is forced through the cathode resistors from a negative source of current. This supply is effectively a constant-current supply and forces into the network a current which divides equally through the two cathode resistors. The current is actually fed through the slider of a potentiometer. When the instrument is set up the slider is adjusted until the potential of the two cathodes, with the gain control at the maximum resistance, is equal. Without this adjustment operation of the gain control would produce a disturbance in the datum anode current that would be indistinguishable from a genuine signal.

To maintain sharp focus and freedom from astigmatism the final anode of the the cathode-ray tube must be at the same potential as the mean potential of both pairs of deflector plates. To achieve this condition the final anode of the cathode-ray tube is not solidly grounded but is connected to each of the four deflector plates through four equal resistors of 0.1 megohm as shown in Fig. 4. The mean outputs of the two amplifiers are then equated by appropriate adjustment of the anode current of the second stage in the amplifier at P_4. (Fig. 2). This adjustment is necessary on but one amplifier and is therefore incorporated in the horizontal amplifier only.

Time Base

A symmetrical construction is adopted in the time base which is shown in simplified form in Fig. 5. The capacitor C is charged through the pentode tube V_8. Across the capacitor is the discharge tube V_7, the grid of which is held at a potential determined by the network B, V_9 and D. When the capacitor C is discharged, the cathode of V_7 is near the B+ potential so that the grid of the tube is considerably negative with respect to the cathode and the tube is non-conducting. As the capacitor charges up, the cathode potential falls until it becomes only slightly positive with respect to the grid and the tube commences to conduct. As soon as current flows in this circuit a potential is developed across A which reduces the screen potential of V_9, causing a rise in anode potential which makes the grid of V_7 more positive. This change increases the conductance of V_7 so that the discharge is accelerated and a rapid flyback is obtained.

The action of V_7 and V_9 results in an effective transfer of the cathode current of V_9 from the anode to the screen so that the total drain from the supply line remains constant. This is an important feature since it not only avoids interaction between the time base and the amplifiers but it also renders the operation of the time-base circuit independent of the time-constant of the high voltage supply line. Because of this condition the circuit continues to function satisfactorily down to indefinitely low frequencies. Capacitor C is actually a series of eight of gradually increasing value in order to give discrete ranges of frequency, and for the sake of reasonable portability the largest capacitor is such as to provide a minimum sweep frequency of 2 cps. A two-pin socket is provided, however, to make the time-base voltage available externally, or for single-sweep operation as explained below. Additional capacitors can be added across the socket to extend the time base frequency downwards to at least to 0.2 cps.

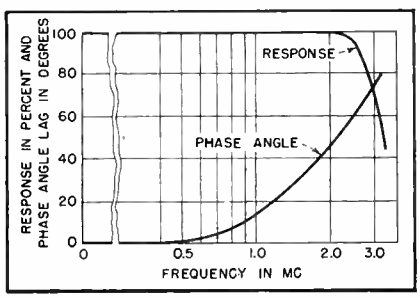

FIG. 3—Frequency response and phase angle of amplifier with link adjusted for 3-mc band

Fine control of the frequency is obtained by varying the current through the pentode tube V_8 via the grid potential. The voltage across the time-base capacitor is transferred through a high-resistance potentiometer to the input of the horizontal amplifier. This arrangement permits the width of the scan on the cathode-ray tube screen to be varied from about one half to five screen diameters. The highest time-base frequency is 150 kc and since the horizontal amplifier frequency response extends to at least ten times this value the saw-tooth waveform is satisfactorily maintained throughout the full frequency range. The potentiometer is compensated for stray capacitances so that the correct ratio is maintained throughout the full frequency range. To offset the d-c component of the time base signal the other X-amplifier input terminal is supplied with a steady voltage adjusted by the potentiometer P_5 to equal the mean d-c value of the signal.

Synchronism

The synchronism is automatic. Synchronizing signals are applied through the tube V_{10} to the grid of tube V_9. These signals control the current of V_9 and hence the grid potential of V_7. A positive synchronizing impulse will thus drive

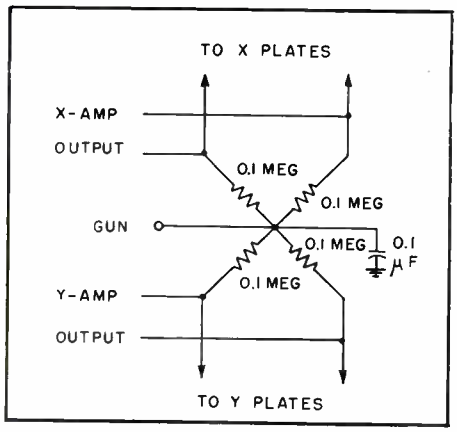

FIG. 4—Gun and deflector plate hookup

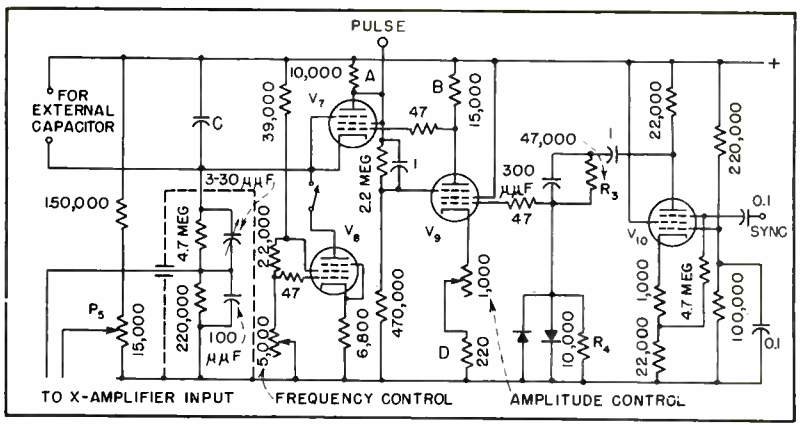

FIG. 5—Simplified schematic diagram of time base generator

the grid of V_7 positive and initiate the discharge.

The pulse of current through V_{10} does produce some slight modulation of the high voltage line but this is limited by the rectifier network in the bottom half of the potentiometer which transfers the voltage from V_{10} to V_9, and also by the inclusion of a high value of resistance in the cathode. As a result, the current of V_{10} is, in practice, substantially constant.

The main function of the two rectifiers just mentioned, however, is to limit the synchronizing pulse to a suitable value. The resistors R_3 and R_4 are so chosen that for small signals the rectifiers are of relatively high resistance. As the voltage on R_4 rises, however, the rectifiers begin to conduct and thus to shunt the bottom half of the potentiometer and limit the voltage applied to V_9. It is thus not possible to produce over-synchronism with consequent shortening of the time-base sweep. This feature is valuable in practice because with conventional methods a change in amplitude of the signal under examination causes a change in the point at which the time base triggers, with consequent unsteadiness of the image. With the present arrangement the image remains quite steady, irrespective of the changes of amplitude and the arrangement is so successful in practice that no synchronizing control is provided. It is merely necessary to apply to the sync terminal a signal either from the output of the vertical amplifier or direct from some part of the circuit under examination.

The negative pulse developed across A is brought to a terminal at the rear of the instrument and may be connected to the modulator grid on the cathode-ray tube, if desired. In this condition the spot is blacked out during the flyback.

Constructional Features

The power supplies and time-base components are mounted on the main chassis while the two amplifiers, which are assembled as separate units, are mounted in antivibration mountings on either side of the cathode-ray tube. All main controls are available on the front panel. The four deflector plates are connected to terminals along the bottom of the front panel and four switches immediately above permit each plate individually to be connected to ground, to the terminal either directly or through a capacitor, or to the output of the appropriate amplifier. The leads to the deflector plates are spaced from each other and from the chassis in order to reduce the stray capacitance. Where minimum plate capacitance is essential, however, connections can be made to four terminals at the back of the instrument. These terminals are normally strapped to adjacent terminals connected to the front terminals but by opening the links the additional capacitance of the wiring is removed. The gun and modulator electrodes are also accessible at the rear, together with the pulse output for flyback suppression.

Symmetrical input is provided on each amplifier with a ground terminal in between and each input is provided with a multiposition switch. This switch allows direct connection; direct connection through a resistance attenuator that reduces the sensitivity approximately fourteen times; and direct or attenuator connections including an isolating capacitor of 0.1 microfarad with 1.2 megohms to ground.

The horizontal amplifier switching has two additional positions. The first of these connects the amplifier input to the time base while the second is for single-sweep operation, the time base still being connected but the discharge tube rendered inoperative.

The single sweep referred to is not electronic in character. The time-base controls are set to operate at the required sweep speed and the time-base terminals are then short-circuited externally. On removal of the short-circuit the spot will sweep across the screen and will stay in its final position until restored by re-imposing the short-circuit across the capacitor. The d-c positioning of the spot and the gain control of the horizontal amplifier can be manipulated to include the whole of the sweep on the screen or any portions thereof. The internal time base is rendered inoperative when the amplifier is connected for external signals.

A graticule with millimeter rulings is located in front of the tube face, being held in position by a cover plate which incorporates a telescopic light shield. This cover plate can be removed completely and replaced by a camera, either for single shots or for continuous recording.

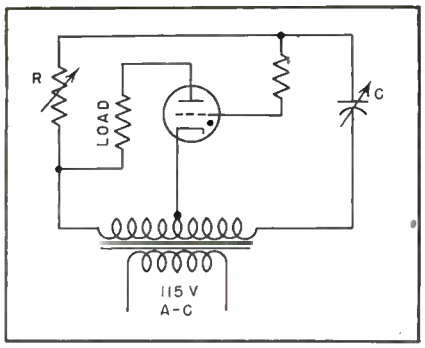

FIG. 1—Basic phase-control circuit using a single thyratron tube

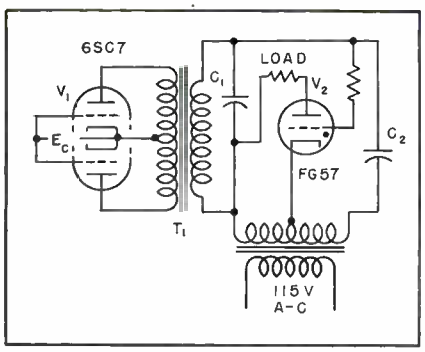

FIG. 2—Phase-control circuit with vacuum tubes as the variable parameter

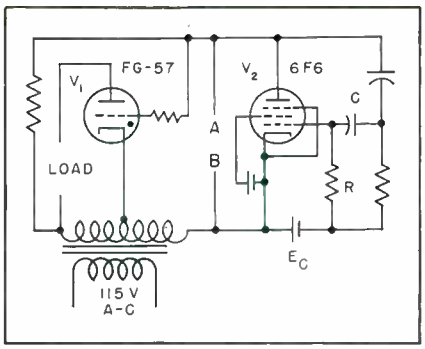

FIG. 3—Reactance-tube phase-control circuit that eliminates the transformer

Thyratron Phase-Control Circuits

Principles of operation, characteristics, applications and relative merits of several electronic circuits for controlling a large direct current by means of a small change of voltage

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NEED occasionally arises for a device to control a relatively large direct current by a small change of direct voltage. This result can be accomplished by incorporating one or more high-vacuum tubes in a thyratron phase-control circuit, as first suggested by Baker, Fitzgerald, and Whitney.[1]

Figure 1 shows the basic form of a commonly used phase-control circuit, in which the average anode current of the thyratron can be varied gradually from zero to its maximum value by changing the value of C or R and thus varying the phase of the grid voltage relative to the anode voltage.[2] The circuit can be controlled by means of direct voltage if the resistor R is replaced by two high-vacuum triodes, connected to the circuit through a transformer, as shown in Fig. 2.

A circuit of the form of Fig. 2 transfers the dynamic plate resistance of a vacuum tube into the phase-control circuit, and the magnitude of the transferred resistance is varied by adjusting the direct bias on the control tube. The vector diagram for this type of phase-control circuit is slightly different from that of the basic circuit of Fig. 1 because of the fact that the power factor of the varying parameter, as well as its magnitude, changes.

When the control tube is biased beyond cutoff, the inductance of the primary of the coupling transformer T_1 appears in the phase-control circuit.

At the other extreme, and with zero bias on the control tube, a relatively low resistance is transferred into the phase-control circuit. This situation is also complicated by the leakage reactance and internal resistance of the transformer. Thus, the vector diagram will not be of the circle type, as it is in the circuit of Fig. 1, in which the effective value of the alternating grid voltage is constant. This constant value is not a necessary condition, however, as long as the smallest value of the peak of the wave is always considerably larger than the critical grid voltage for the tube at the particular value of plate voltage used.

Range of Control

Control over almost 180 degrees may be gained by careful adjustment of circuit constants. It is advisable to adjust C_1 and C_2 by using decade capacitors. The main disadvantage of this circuit is that an expensive interstage transformer seems to be necessary to insure the

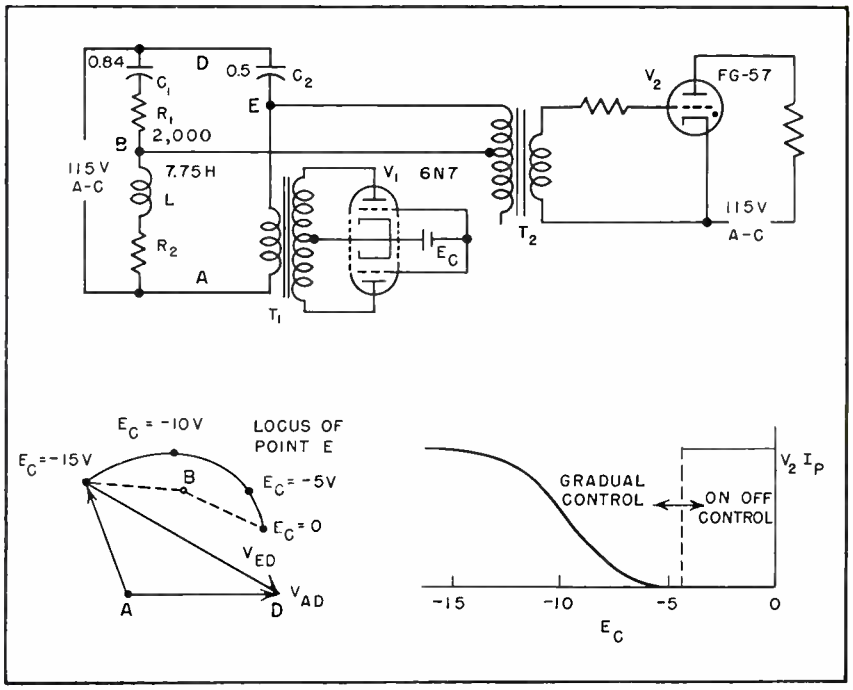

FIG. 4—Circuit for phase control with direct voltage. Transformer T_1 is a Stancor A-63C, and T_2 is a Thordarson T-33A91. Internal resistance R_2 is 75 ohms. Vector relations and control characteristics are included

desired change in effective transferred impedance for gradual control over the complete 180 degrees of positive thyratron plate voltage. Moreover, when bias E_c is zero, the resistance of the 6SC7 control tube is not so low as might be expected, because under this condition the alternating voltage fed into the 6SC7 plate circuit is low and thus the region of operation on the plate characteristic is such as not to favor low dynamic plate resistance.

If on-off control[2] is desired, the choice of coupling transformers is not at all critical.

The need for an expensive coupling transformer could be avoided by using the reactance-tube circuit shown in Fig. 3. In this circuit the 6F6 is operated in such a manner that it presents a capacitive reactance across points A and B. The shunt conductance is reduced to zero by proper choice of R and C. This circuit gave about 90 degrees of control of FG-57 current as a function of 6F6 control-grid bias.

The main difficulty seemed to lie in the fact that the alternating voltage fed into the reactance-tube circuit from the phase-control circuit varied considerably in magnitude and also was hard to keep undistorted. This circuit has the additional disadvantage that it requires a d-c supply for the reactance tube.

Use of Network

The need of the expensive coupling transformer in the circuit of Fig. 2, or of the d-c power supply in that of Fig. 3, was avoided by using the network and circuit of Fig. 4. Here the quality of the thyratron grid transformer T_2 is not important. Even the least expensive of the transformers tried worked well. It is desirable, however, that the transformer present as high an impedance as possible to the network and still provide a satisfactory magnitude of voltage to the thyratron grid. The transformer T_1 between the network and the 6N7 control tube is not at all critical.

The operation of the circuit depends on the fact that the potential of point E, with respect to point A, moves as shown in the vector diagram as the 6N7 bias is varied. If the values of R_1, R_2, L, and C_1 are adjusted in such a manner that the potential of point B lies as shown in the vector diagram, the voltage V_{BE} will swing more than 180 degrees. This voltage is fed into the thyratron circuit through the thyratron grid transformer.

It may be necessary to reverse the secondary leads of T_2 to obtain the proper phase relationship for gradual control. In order to avoid erratic operation, care must be taken in locating point B so that the voltage V_{BE} does not undergo extreme amplitude changes in addition to the phase shift discussed above. It should be noted that the voltage V_{AE} that is fed into the 6N7 plate circuit does not become extremely small as E_c is reduced to zero.

Control characteristics are also shown in Fig. 4.

Wider Range

Bancroft[3] describes a method of obtaining control over 90 degrees of the plate voltage cycle by adding an alternating voltage, whose magnitude can be controlled, to a fixed alternating voltage which has a 90-degree relationship to the variable

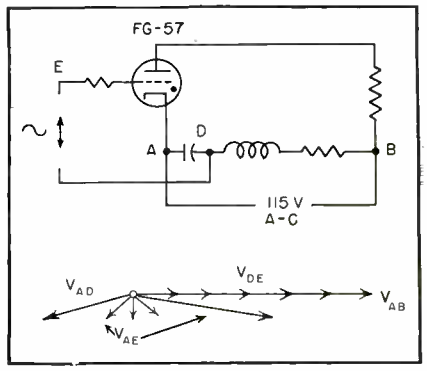

FIG. 5—Control is effected by changing the amplitude of an alternating voltage

voltage. Thus the resultant voltage varies essentially 90 degrees in phase as the magnitude of the variable voltage is raised from zero to a value considerably larger than the fixed voltage. An extension of this method allows control over 180 degrees or, if two thyratrons are used, over 360 degrees.

Figure 5 shows the basic circuit and the manner in which the phase of the grid voltage varies. The voltage V_{AD} must keep the thyratron from firing when V_{DE} is zero and must have enough vertical component to prevent erratic behavior when V_{AE} has its minimum effective value. The vector diagram shows that the alternating grid voltage V_{AE} swings from almost 180 degrees lagging to almost an in-phase position with respect to a horizontal reference. Control over the complete 180 degrees of positive half

cycle of plate voltage is obtained.

Figure 6 shows a form of the circuit of Fig. 5 in which the magnitude of voltage V_{DB} is varied by changing a direct voltage. The plate of the 6J5 is fed with raw a-c and T_1 is tuned to select the 60-cycle component. If the cost and space requirements do not prevent, the circuit can be made less critical as to circuit constants by the addition of a d-c plate supply in the circuit of V_1.

Complete Cycle

Figure 7 shows an interesting circuit which might have advantages in certain applications where control is desired over the complete 360 degrees. Individual thyratron current waves forms and the control curve are also shown. The circuit, in the form shown, may be used only when the flow of two or three milliamperes of 6N7 grid current is not objectionable.

Magnetron Flux Control

During a recent investigation it became desirable to limit surges in magnetron plate current and to control backheating. In this application, the drop across a resistor in the magnetron plate circuit serves as the bias on the control tube, which in turn shifts the phase of the voltage on the grid of the thyratron and thus controls the power delivered to the magnetron filament.

The circuits discussed here can be used to stabilize magnetron current more directly without relying on control of filament current. This can be accomplished by supplying the axial magnetron flux by means of electromagnets that are fed by thyratrons controlled, through the network of Fig. 4, by the magnetron direct plate current. The output of the thyratron must be filtered to reduce the ripple.

The circuit of Fig. 8 was found to deliver almost pure direct current to the field coils. Capacitor C and inductor L form a smoothing filter to eliminate ripple. The function of V_3, which is operated essentially as a diode, is to enable the coil current to continue after the instant in the cycle at which the main thyratron is extinguished. The action of the circuit is such that if, for any reason, the plate current of the magnetron tends to increase, the direct bias on the control tube is changed so as to cause the thyratron alternating grid voltage to be shifted in such a direction that the average magnet current, and thus the flux density, is automatically increased. The magnetron will therefore experience a smaller increase in plate current.

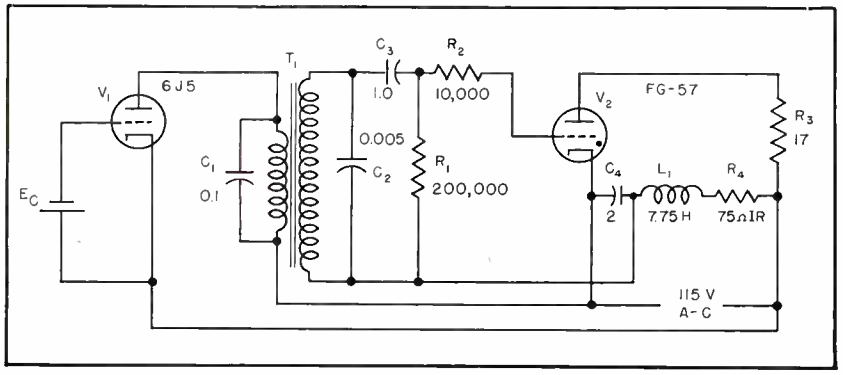

FIG. 6—Practical d-c phase control circuit using basic circuit of Fig. 5

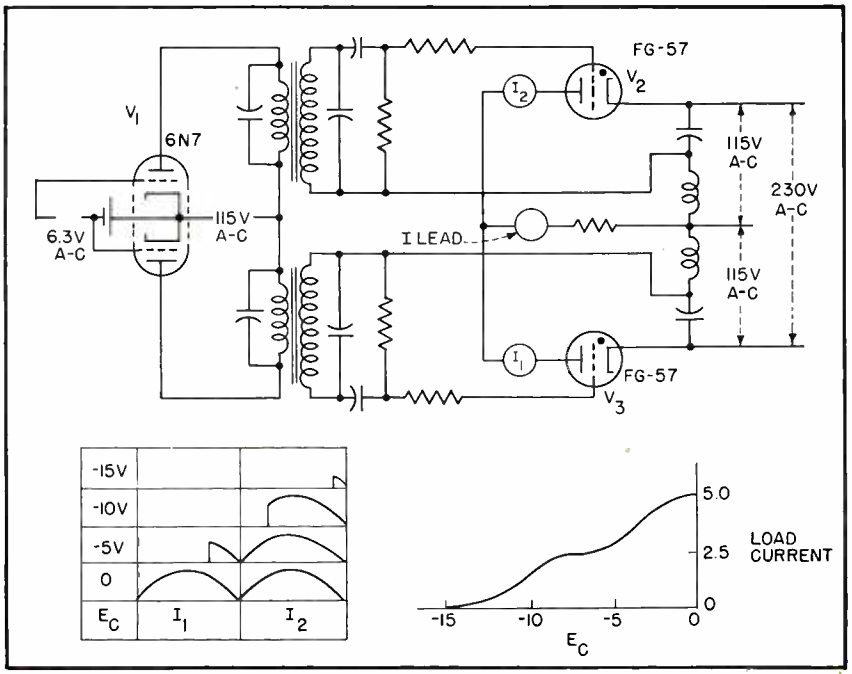

FIG. 7—Phase-control is provided over 360 degrees as illustrated by the waveforms

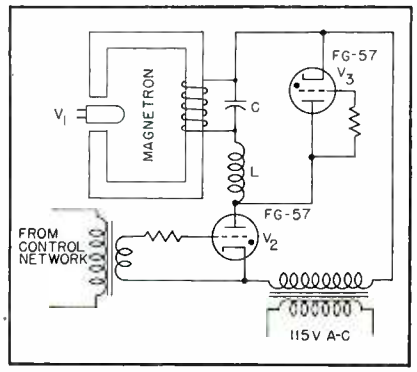

FIG. 8—Magnetron flux density is controlled by this circuit

Only a few of the practical applications of these circuits have been outlined. Although the gradual type of control has been emphasized in this paper, the circuits lend themselves to on-off control, which may be equally important in industrial applications.

The work that forms the basis of this paper was done in conjunction with a research project on magnetrons sponsored by the Office of Naval Research.

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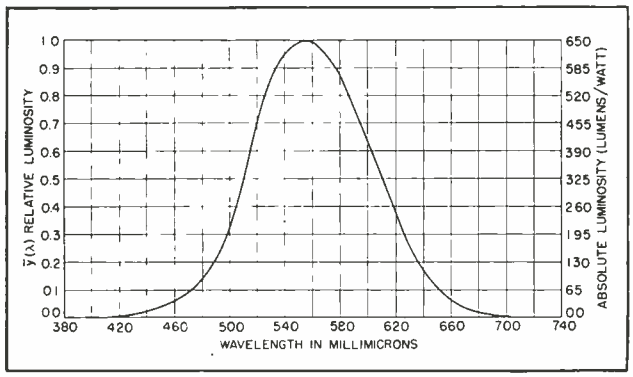

FIG. 1—Relative values (left) of luminosity curve apply to conditions met in television; absolute values (right) are used to determine luminous efficiency

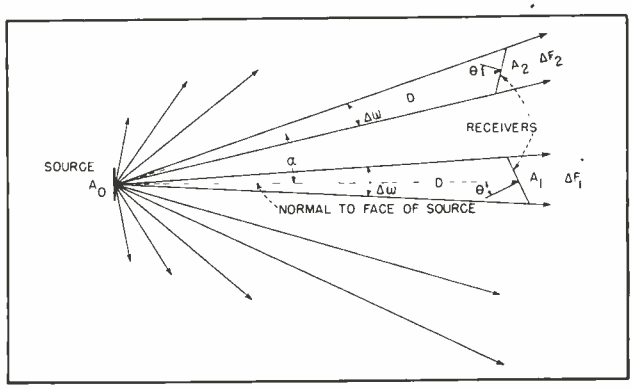

FIG. 2—Luminous intensity of the source is the flux emitted per solid angle. Illuminance of a receiver is the flux per unit area incident on its surface

PHOTOMETRY in Television Engineering

This introduction to fundamental photometric concepts and measurements provides an understanding of principles and methods whereby performance of television receivers may be evaluated. Quantities needing measurement and their interrelations are explained

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PHOTOMETRY is of considerable interest to television engineers because the engineering evaluation of television receivers depends to an important extent on photometric measurements. By making these measurements television engineers can accumulate objective data on the distribution of light output over the picture plane on which to base future designs of receivers.

Receiver Performance

Among the factors affecting receiver performance and in which photometry plays an important role are: (1) highlight brightness, (2) brightness range or large area contrast, (3) brightness gradation or gamma, (4) detail contrast, resolution contrast or sharpness, (5) ambient illumination, (6) directional characteristic of the emission, and (7) such other effects on the photometric performance of the receiver as hum and flicker. Although the relative importance of these factors for viewer satisfaction is determined essentially by experience in the field, it is only by possessing photometric data on them that this experience can be converted into specifications.

Photometry is concerned not only with the measurement and computation of the energy relationships in the emission process, propagation, absorption and reflection of radiant energy in the wavelength range of 380 to 765 millimicrons, but also with the quantitative evaluation of this radiant energy with respect to its capacity to stimulate visual sensations.

A luminosity curve shows as ordinates the relative effectiveness (plotted as the reciprocal of the required radiant energy) of various wavelengths of radiant energy to evoke, for a particular observer and under particular conditions, visual sensations of equal brightness. A luminosity curve may thus be considered as the relative response characteristic of the eye.

The difficulties encountered in attempting to make photometry an objective science are that the relative response characteristic of a given individual is different for different conditions of observation and that the relative response characteristics of different observers, under the same conditions of observation, are not identical.

The use of many luminosity curves would, obviously, lead to endless confusion and ambiguity in photometric measurements and specification. To avoid this, the International Commission on Illumination adopted in 1924 a standard luminosity curve. Figure 1 shows the standard I. C. I. luminosity curve which was obtained as an average of a reasonably large number of luminosity curves. It should be realized, that, (because a different average curve would have been obtained if a different group of observers or different conditions of observation have been used), the standard-luminosity curve is essentially an arbitrarily assumed standard for purposes of standardization and specification of photometric data and is not neces-

Table I—Standard Luminosity Function

λ in mμ	$\bar{y}(\lambda)$	λ in mμ	$\bar{y}(\lambda)$	λ in mμ	$\bar{y}(\lambda)$	y in mλ	$\bar{y}(\lambda)$
380	0.0000	480	0.1390	580	0.8700	680	0.0170
385	0.0001	485	0.1693	585	0.8163	685	0.0119
390	0.0001	490	0.2080	590	0.7570	690	0.0082
395	0.0002	495	0.2586	595	0.6949	695	0.0057
400	0.0004	500	0.3230	600	0.6310	700	0.0041
405	0.0006	505	0.4073	605	0.5668	705	0.0029
410	0.0012	510	0.5030	610	0.5030	710	0.0021
415	0.0022	515	0.6082	615	0.4412	715	0.0015
420	0.0040	520	0.7100	620	0.3810	720	0.0010
425	0.0073	525	0.7932	625	0.3210	725	0.0007
430	0.0116	530	0.8620	630	0.2650	730	0.0055
435	0.0168	535	0.9149	635	0.2170	735	0.0004
440	0.0230	540	0.9540	640	0.1750	740	0.0003
445	0.0298	545	0.9803	645	0.1382	745	0.0002
450	0.0380	550	0.9950	650	0.1070	750	0.0001
455	0.0480	555	1.0002	655	0.0816	755	0.0001
460	0.0600	560	0.9950	660	0.0610	760	0.0001
465	0.0739	565	0.9786	665	0.0446	765	0.0000
470	0.0910	570	0.9520	670	0.0320		
475	0.1126	575	0.9154	675	0.0232		

The commonly used units of wavelength are the micron (μ) = 10^{-6}meter, the millimicron (mμ) = 10^{-9}meter, and the Angstrom unit (A) = 10^{-10}meter.

Table II—Nomenclature and Symbols Used in Photometry

RADIOMETRY			PHOTOMETRY		
Name	Symbol	Unit MKS	Name	Symbol	Unit MKS
Radiant Energy	U	joule	Luminous Energy	Q	talbot
Radiant Flux	P	watt	Luminous Flux	F	lumen
Radiant Emittance	W	watt/m²	Luminous Emittance	L	lumen/m²
Radiant Intensity	J	watt/ω	Luminous Intensity	I	lumen/ω(candle)
Radiance	N	watt/ωm²	Luminance	B	lumen/ωm² (candle/m²)
Irradiance	H	watt/m²	Illuminance	E	lumen/m² (lux)
	m	meter		w	steradian

sarily the response of any normal or average individual. Table I gives the standard luminosity function, $\bar{y}(\lambda)$, at 5 millimicron steps.

Units of Photometry

Photometry has been complicated by nomenclature and systems of units. To alleviate this situation, the committee on Colorimetry of the Optical Society of America has recommended Table II, which gives the names, symbols, and basic mks units of radiometry and photometry. The term luminance in Table II replaces the older term brightness, which led to the confusion between the objective concept of brightness as a measurable quantity and the subjective concept of brightness which refers to the sensation in the consciousness of the human observer. It is recommended that the term brightness be used only in the latter sense.

Any radiometric unit in Table II is converted into the corresponding photometric unit by evaluating it with respect to the standard luminosity function $\bar{y}(\lambda)$. Thus, if $P(\lambda)$ be radiant flux (in watts per millimicron) distributed over the continuous spectrum extending between λ_1 and λ_2, then the luminous flux in lumens is given by

$$F = 650 \int_{\lambda_1}^{\lambda_2} P(\lambda)\, \bar{y}(\lambda)\, d\lambda \qquad (1)$$

where λ is measured in millimicrons. The ratio of any photometric quantity to the corresponding radiometric quantity in Table II is defined by the ratio

$$K = 650 \frac{\int_{\lambda_1}^{\lambda_2} P(\lambda)\bar{y}(\lambda)d\lambda}{\int_{\lambda_2}^{\lambda_1} P(\lambda)d\lambda} \quad \text{lumens per watt} \qquad (2)$$

and is called the absolute luminosity or luminous efficiency (expressed in lumens per watt) of the radiant energy. Thus one watt of monochromatic radiant flux of wavelength 555 mμ (peak of standard luminosity curve) is equivalent to 650 lumens, whereas one watt at 500 mμ is equivalent to $0.323 \times 650 = 210$ lumens. (The value of 650 lumens per watt has been adopted by the committee on Nomenclature and Standards of the Illuminating Society of America. However, as soon as the new proposed international photometric standard is adopted, this value will probably increase to 685 lumens per watt.

Luminous efficiency K should not be confused with the efficiency of a practical light source, which is the ratio of the total luminous flux to the total power input. The efficiency of a light source is less than K since generally only a fraction of the power input is converted into radiant flux.

Calculations

Referring to Fig. 2, let the small plane source of area A_0 emit P watts or $F = 650 \int_0^\infty \bar{y}(\lambda) P(\lambda)\, d\lambda$ lumens, and let A_1 and A_2 be the areas of two small receivers which subtend the same solid angle $\Delta\omega$ at the center of the source and are located at the same distance D from it. The luminous intensity or candlepower of a source is given by

$$I = \Delta F/\Delta\omega \qquad (3)$$

and is measured in candles or lumens per steradian. The number of lumens ΔF_1 and ΔF_2 contained in the solid angles $\Delta\omega$ will, in general, be different. Thus the intensity $I_1 = \Delta F_1/\Delta\omega$ measured in the direction normal to the source is different from the intensity $I_2 = \Delta F_2/\Delta\omega$ measured along a direction making the angle α with the normal. In specifying the intensity or candlepower of a source, it is therefore necessary to state the direction in which the intensity is measured or preferably to give a candlepower distribution curve. The directional characteristic of many extended sources, such as a luminescent screen of a cathode-ray tube, obey Lambert's law which states that

$$I_2 = I_0 \cos\alpha \qquad (4)$$

In the case of a uniform point or

spherical source, the intensity is independent of direction and is equal to $F/4\pi$. Table III shows the relationship between the three most frequently used units of intensity.

A surface of area ΔA placed in a field of flux F is said to be illuminated with the illuminance in lumens per square meter (in mks units) of

$$E = \Delta F/\Delta A \qquad (5)$$

where ΔF is the flux incident on the surface. The illuminance of receiver ΔA_1 (Fig. 2) is

$$E_1 = \Delta F_1/\Delta A_1 = I_0\Delta\omega/\Delta A_1$$
$$= (I_0/\Delta A_1)\,(\Delta A_1 \cos\theta)/D^2$$
$$= (I_0/D^2)\cos\theta \qquad (6)$$

The illuminance of receiver ΔA_2 is

$$E_2 = (I_2/D^2)\cos\theta \qquad (7A)$$

which, for a source obeying Lambert's law, is

$$E_2 = (I_0/D^2)\cos\alpha\cos\theta \qquad (7B)$$

In the case of normal incidence the illuminance of the two receivers

$$E_1 = I_0/D^2;\ E_2 = I_2/D^2 \qquad (8)$$

Equation 8 expresses the well known inverse square law of illumination. Equation 6 or 7 expresses the combination of two fundamental laws of illumination; the inverse square law and the cosine law. The inverse square law, which is the basis of most photometers, applies to large extended sources if D is considerably larger than the extension of the source. Thus, Eq. 8 holds to within about one percent if D is at least five times the greatest linear dimension (the diagonal of the raster on a cathode-ray tube screen) of the source. Equation 8, rewritten in the form

$$I_0 = E_1D^2;\ I_2 = E_2D^2 \qquad (9)$$

serves as a basis of determining the intensity of candlepower of extended sources if D is again at least five times the greatest linear extension of the source.

The luminance B of the surface A_0 (Fig. 2) in any direction α is the ratio of the intensity I_2 in that direction to the area of the projection of A_0 on a plane perpendicular to this direction so that

$$B = I_2/A_0\cos\alpha \qquad (10)$$

Luminance is measured in candles per square meter in mks units. If Lambert's law is obeyed, then

$$B = \frac{I_0\cos\alpha}{A_0\cos\alpha} = \frac{I_0}{A_0} = B_0 \qquad (11)$$

and the luminance of a surface is independent of α. The brightness sensation depends upon the luminance of the surface. Hence, if the surface obeys Lambert's law, its luminance is the same in all directions, and it will appear equally bright from all angles.

The luminous emittance L of a surface is the total luminous flux the surface emits per unit of area

$$L = F/A \qquad (12)$$

Luminous emittance is measured in lumens per square meter in mks units. The luminous emittance of a surface obeying Lambert's law is

$$L = \pi B \qquad (13)$$

Thus a perfectly diffusing surface with a luminance of B candles per square meter emits πB lumens per square meter. If the area of the surface is A square meters, then it emits πBA lumens.

Equation 13 is the basis for another unit of luminance called meter-lambert. One meter-lambert (equal to $1/\pi$ candle per square meter) is the luminance of a perfectly diffusing surface emitting, reflecting or transmitting one lumen per square meter. This lambert unit is extremely convenient when dealing with reflecting and transmitting surfaces which are perfectly diffusing. For, if these surfaces do not absorb any light, then the number of lumens incident on them is equal to the number of lumens transmitted or reflected, and the illuminance in lumens per square meter equals the luminance in meter-lamberts.

Besides the mks units given above, there are many others in widespread use. They differ from the mks units only in the fact that different units of area are used. Tables IV and V give the names and the relative magnitudes of the more commonly used units of illuminance and luminance.

Table III—Conversion Factors for Units of Luminous Intensity

UNIT	Int'n'l Candle	New Candle	Hefner Candle
One Int'n'l Candle	1	1.02	1.11
One New Candle	0.98	1	1.09
One Hefner Candle	0.90	0.92	1

Table IV—Conversion Factors for Units of Illuminance

Unit	Lumen/M² or Meter-Candle or Lux	Lumen/Ft² or Foot-Candle	Lumen/Cm² or Phot	Millilumen/Cm² or Milliphot
One Lumen/M² or Meter-Candle or Lux	1	0.0929	0.0001	0.1
One Lumen/Ft² or Foot-Candle	10.76	1	0.001076	1.076
One Lumen/Cm² or Phot	10,000	929	1	1,000
One Millilumen/Cm² or Milliphot	10	0.929	0.001	1

Photometric Measurements

The methods of light measurement may be divided into two classes: visual photometry, and physical photometry.

In visual photometry the human eye is used as the detector. Although the human eye is incapable of measuring, it is capable of fairly accurately judging the equality of luminances of adjacent areas. In a visual photometer, two adjacent areas of a screen are illuminated by a calibrated source and an unknown source. The observer adjusts the illuminance on the half-field produced by the calibrated source, (by varying the distance between source and screen) until he judges the two half-fields to be equally bright. The better visual photometers (such as the Macbeth Illuminometer) use a Lummer Brodhun cube to split the field. Relatively accurate measurements may be made with visual photometers only if the chromaticities of the calibrated and unknown sources are approximately the same. Although a series of fil-

Table V—Conversion Factors for Units of Luminance

UNITS	Candle per sq Cm	Candle per sq In.	Candle per sq Ft	Candle per sq M	Cm-Lambert	Foot-Lambert	Milli-Lambert	Meter-Lambert
One Candle/Cm² or Stilb	1	6.452	929	10,000	3.142	2,919	3,142	31,420
One Candle/In²	0.1550	1	144	1,550	0.4869	452.4	486.9	4,869
One Candle/Ft²	0.00108	0.00694	1	10.764	0.00338	3.142	3.38	33.82
One Candle/Meter	0.0001	0.000645	0.0929	1	0.0003142	0.2919	.3142	3.142
One Cm-Lambert	0.3183	2.054	295.7	3,183	1	929	1,000	10,000
One Foot-Lambert	0.000343	0.00221	0.3183	3.426	0.0010764	1	1.0764	10.764
One Millilambert	0.000318	.002054	0.2957	3.183	0.001	0.929	1	10
One Meter Lambert	0.0000318	0.0002054	0.02957	0.3183	0.0001	0.0929	0.1	1

Intensity (measured along line of sight) per unit of area (measured in plane normal to line of sight)

ters may be used to relieve this limitation, measurements upon sources of different colors (heterochromatic photometry) are generally subject to considerable errors unless a flicker photometer is used.

In physical photometry, the detector is generally a photovoltaic or photoemissive cell. A cell corrected with a suitable filter, so that its sensitivity throughout the spectrum is proportional to the standard luminosity curve will give standard photometric values regardless of the color of the light. The most important error in physical photometry is generally due to the difference between the spectral response of the cell and the standard luminosity curve. Other errors arise from the directional, temperature and fatigue characteristics of cells. Most commercial light measurements are now made using a photovoltaic cell with a correcting filter to give a response typical of the human eye.

Although physical photometry is obviously the ideal, visual photometry will continue to be used because no portable physical photometer has as yet been developed which is as universal a light measuring instrument as the Macbeth Illuminometer. It can be used to measure the light from small or large areas and, with suitable filters, covers a very wide range of intensities. For trained observers, the Macbeth will yield reasonably accurate and consistent results over a wide spectral range. The correct manner of using the Macbeth illuminometer is given in the instruction book issued by the manufacturer (Leeds and Northrup).

However, because of the spectral distribution of the light emitted by cathode-ray tubes and in the case of semiroutine measurements especially by nonspecialists, it is preferable to use a physical photometer. A barrier-layer cell photometer, such as a Weston Photronic cell with a Viscor filter, will, under the circumstances, often yield more consistent and more standard results than those obtained with a Macbeth if as much care is taken in its calibration and reasonable care is exercised in following procedure (such as that outlined by L. E. Barbrow, A Photometric Procedure Using Barrier-Layer Photocells, Jour. of Res. Nat. Bureau of Standards. 25, 703, 1940). However, the barrier-layer cell photometer is not very suitable for the measurement of very low intensities, or of the ratio of luminance of small areas, as is required in measuring contrast gamma and hum. Under these circumstances it may be necessary to use the Macbeth and, whenever possible, calibrated filters to match the color of the light from the luminescent screen should be used.

The measurement of contrast, gamma and hum involves primarily the measurement of light intensity ratios. The absolute value of luminance need not be known and the spectral characteristic of the light stays approximately constant throughout the measurement. It is believed that a physical photometer, such as a well stabilized vacuum photocell arrangement preferably with an optical system, and several field limiting apertures should be developed for the purpose.

The following procedure may be used for measuring with a barrier-layer cell the luminance (brightness) of a uniformly emitting area of a cathode-ray tube screen: (1) Place a good mask with an opening of accurately known area A over the tube face. (2) Locate the cell facing the tube and one foot away.

The luminance in foot-lamberts is then $\pi E/A$ where E is the reading of the meter in foot-candles. If the area (in square feet) of the aperture in the mask is standardized, then the factor π/A can be included in the calibration of the meter and thus the luminance in foot-lamberts may be read directly. The largest linear dimension of the aperture in the mask should be kept below six inches, if the error, due to the assumption that the inverse square law holds for extended surfaces, is to be less than about 0.06.

The same procedure may be adopted in the case of projection receivers, except that here the luminance should be measured at least in two directions: normal and where the luminance has dropped to a preassigned value.

Design Curves for Parallel-T Network

Chart presents generalized design curves from which transmissions at various deviations from resonant frequency can be read directly. Design equations are also presented, and conclusions as to properties of parallel-T networks under usual conditions are drawn

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PARALLEL-T NETWORKS are coming into common use because of their simplicity, economy and effectiveness. To simplify their design, generalized transmission curves for conditions ordinarily encountered are presented.

Characteristics of Network

Resonance equations for the general parallel-T network are given in Table I, which contains other pertinent equations and the circuits which they describe. The analysis need not be restricted to symmetrical networks in which $R_1 = R_2$ and $X_1 = X_2$ or even to the condition that $R_1 = X_1$ at resonance. For the general case the parameters m and k can be defined at resonance by the two relations of Eq. 2, and with the aid of Eq. 1 the relations of Eq. 3, 4, 5 can be derived.

The general expression for transmission through a parallel-T network is given by Eq. 6 where f is the operating frequency and f_0 is the resonant frequency of the network; the other terms are defined by the relations of Eq. 7. Usually the parallel-T network is made using capacitors for the reactive arms. The resonant frequency of such a network is given by Eq. 8; R_3 does not appear in this relation because it is uniquely determined by the other parameters. The arms of the capacitive network can be designed from the relations of Eq. 9.

Considerable information about the network can be obtained from an examination of part of Eq. 6

$$\frac{\alpha + \beta\gamma^2}{\alpha\beta\gamma} = \frac{1 + m + 2k}{k} \qquad (10)$$

which, for $m = 1$, reduces to $2(1 + k)/k$ and for $k = 1$ reduces further to $3 + m$.

These relations show that the larger the magnitude of Eq. 10, the less the selectivity of the network. Increasing m for a fixed value of k increases the value of Eq. 10, decreasing the selectivity, while increasing k causes Eq. 10 to decrease, approaching 2 as a limit, and consequently increasing the selectivity.

The effect can be seen in the design chart in which Eq. 6 is plotted for various values of k and m; only the low side of resonance is shown because the curves are symmetrical.

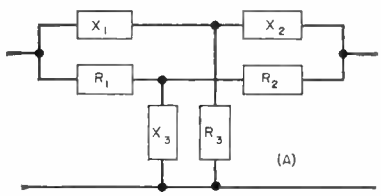
An approximate transmission formula when $k = m = 1$ for the frequency range from $f = 0.9f_0$ to $f = 1.1f_0$ is

$$T = j\,[(f/f_0) - 1]/2 \qquad (11)$$

This equation also illustrates the fact that there are approximately 90 degrees of phase shift near resonance, lagging at frequencies below, leading at frequencies above.

Table I—Design Equations for Parallel-T Network

General Parallel-T Network



General Resonance equations

$$X_1X_2 = (R_1 + R_2)R_3 \qquad (1A)$$

$$R_1R_2 = (X_1 + X_2)X_3 \qquad (1B)$$

Relationships between parameters

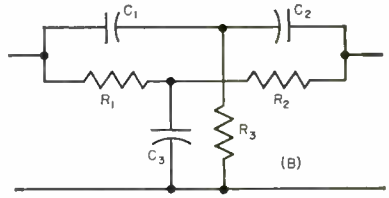
$$X_1 = mR_1;\ R_2 = kR_1 \qquad (2)$$

$$X_2 = kR_1 = kX_1/m \qquad (3)$$

$$R_3 = [mk/(1 + k)]R_1 \qquad (4)$$

$$X_3 = [k/(m + k)]R_1 \qquad (5)$$

Capacitive Parallel-T Network



Resonance frequency of network

$$f_0 = \frac{1}{2\pi[R_1R_2\{C_1C_2/(C_1 + C_2)\}C_3]^{1/2}} \qquad (8)$$

Design of capacitive network, all components related to R_1 or C_1

$$C_1 = 1/\pi f_0 mR_1 \qquad (9A)$$

$$C_2 = mC_1/k;\ R_2 = kR_1 \qquad (9B)$$

$$C_3 = (m + k)/2\pi f_0 kR_1 = m(m + k)C_1/k \qquad (9C)$$

$$R_3 = mkR_1/(1 + k) \qquad (9D)$$

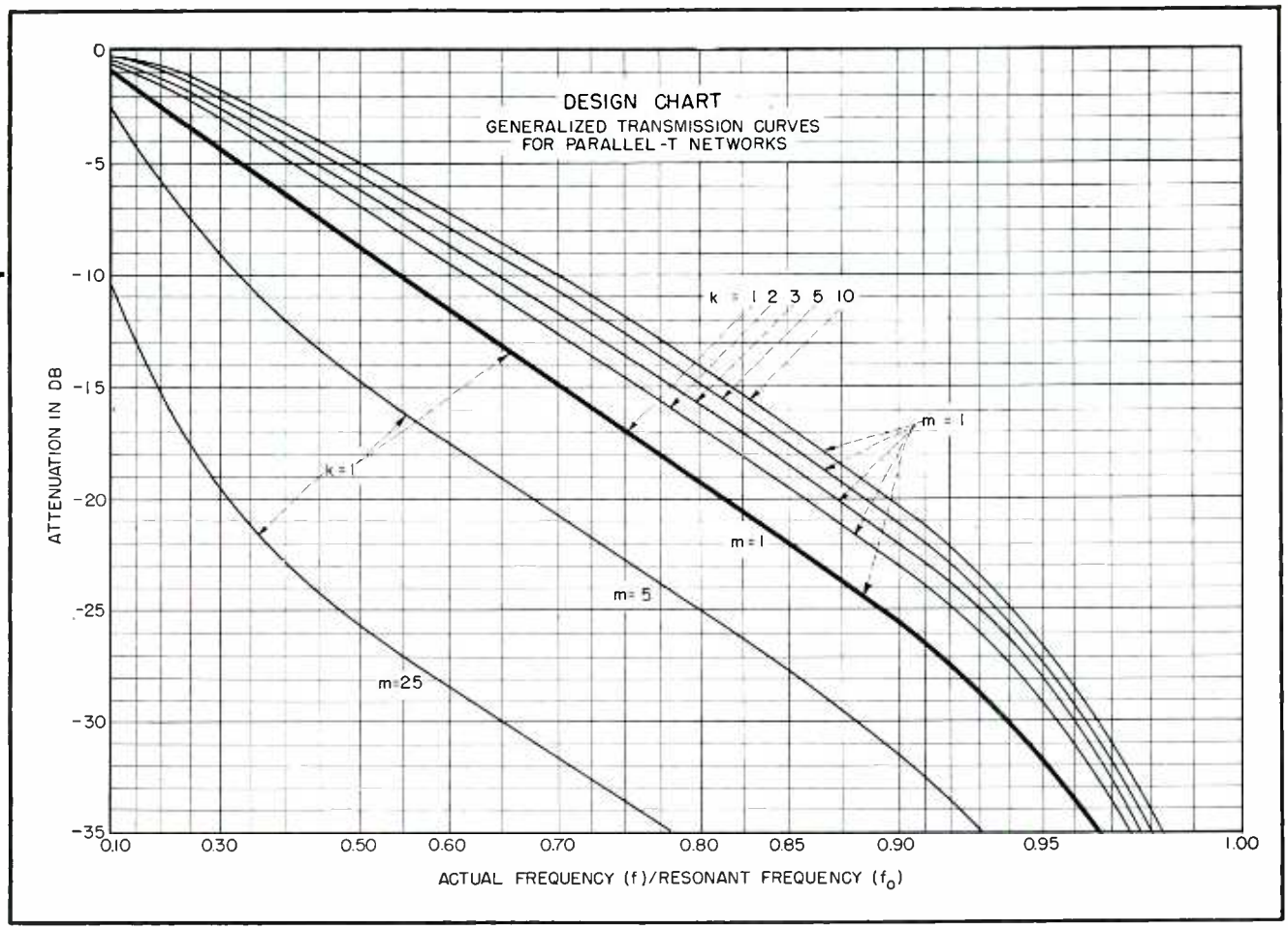
General expression for transmission through a parallel-T network

$$T = \frac{1}{1 + j\,\dfrac{(f/f_0)}{1 - (f/f_0)^2}\,\dfrac{\alpha + \beta\gamma^2}{\alpha\beta\gamma}} \qquad (6)$$

$$\alpha = \frac{R_2}{R_1 + R_2} = \frac{k}{1 + k} \qquad (7A)$$

$$\beta = \frac{X_2}{X_1 + X_2} = \frac{k}{m + k} \qquad (7B)$$

$$\gamma = \frac{X_1 + X_2}{R_1 + R_2} = \frac{m + k}{1 + k} \qquad (7C)$$



The parallel-T network loads the driving circuit at all frequencies, and at resonance presents an input impedance of $R_1/2$ for any value of k when $m = 1$. Below resonance this impedance increases and above resonance it decreases. Loading the output of the network with an external load reduces the transmission on both sides of resonance, although the effect is greater on the low-frequency side. However, loading with a value as low as $3(1 + k)R_1$ reduces the transmission less than a decibel in the region from $f = 0.5f_0$ to $f = 2f_0$.

Varying R_3 and either R_1 or R_2 allows sufficient adjustment to tune the network to resonance. Each component contributes approximately 0.5-percent change in f_0 for each 1-percent variation from the specified value. An adjustable element should have a range of ±4 times the individual element tolerance to assure the ability of resonating the network.

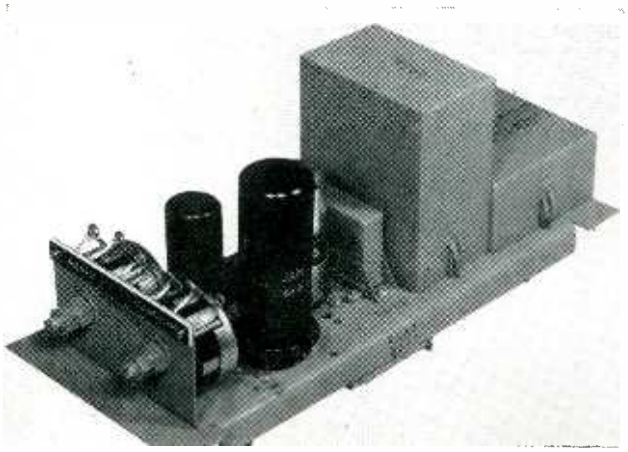
Table II—Comparison of Computed and Measured Transmissions

Frequency in cycles per second	Transmission in Decibels					
	k = 1 and m = 1				k = 1 and m = 5	
	Computed	Measured	Measured*		Computed	Measured
1,000	——	−65	(1,000	−65.7)	——	——
950	−31.6	−32	(1,053	−32.7)	−37.6	——
900	−25.6	−26.5	(1,110	−26.4)	−31.6	−33
850	−22.0	−22.1	(1,170	−22.3)	−27.5	——
800	−19.1	−19.4	(1,250	−19.2)	−25.0	−26.5
700	−14.9	−15.3	(1,430	−15.2)	−20.8	−22.0
600	−11.9	−12.0	(1,670	−11.8)	−17.5	−19.0
500	− 9.15	− 9.5	(2,000	− 9.4)	−14.8	−16.0
300	− 4.35	− 5.0	(3,300	− 4.8)	− 9.0	−10.0
100	− 0.7	− 1.9	(10,000	− 0.9)	− 2.5	− 3.0

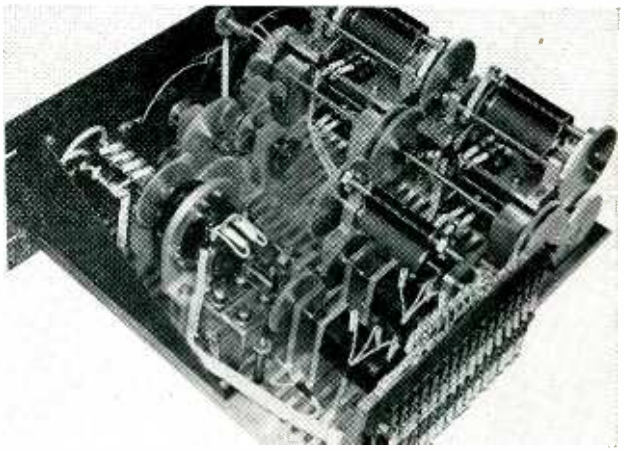
* These two columns give the symmetrical frequency on the high side of resonance as compared to the frequency of the extreme left-hand column and the corresponding transmission. The transmissions indicate the degree of symmetry of the response.

A parallel-T network resonant at 1,000 cps and with $k = m = 1$ was built from the foregoing equations. From Eq. 9 $R_1 = R_2 = 16{,}000$ ohms, $R_3 = 8{,}000$ ohms, $C_1 = C_2 = 0.01$ μf, and $C_3 = 0.02$ μf. With ±1-percent tolerance capacitors, actual values of the resistances required for resonance were $R_1 = 15{,}800$ ohms, $R_2 = 16{,}000$ ohms, $R_3 = 8{,}000$ ohms. The computed transmissions (from the design chart) and the measured values are presented in Table II. Results for a similar network, but for which $m = 5$, are also given in this table.

The measurements at resonance were remade by filtering out the second and third harmonics with parallel-T networks and rejecting hum frequencies with a high-pass filter. Under these conditions an attenuation of 115 db was measured.



Basic interchangeable amplifiers are used wherever possible



Servomechanism plates are built to high mechanical tolerances

Compact Analog Computer

Operation and facilities of a computer for obtaining dynamic solutions of the simultaneous differential equations usually encountered in design engineering. Here d-c amplifiers add and integrate, while servos multiply or divide variables and resolve or add vectors

By SEYMOUR FROST

Reeves Instrument Corp.
New York, N. Y.

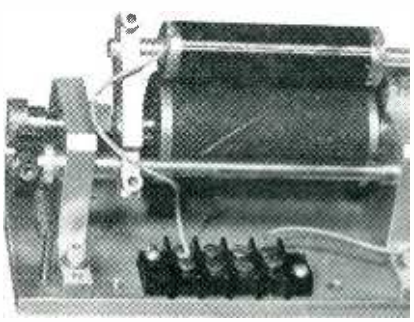
PROBLEMS can usually be stated mathematically but obtaining numerical solutions is often impractical because of the enormous amount of computation that is required. In the field of electronics, for example, the relationship between the current and circuit elements of a tuned plate oscillator is

$$\frac{d^2i}{dt^2} + \frac{di}{dt}\,\frac{r_P rC + L - \mu M}{r_P LC} + i\,\frac{r_P + r}{r_P LC} = 0$$

Most of us find it easier to build such an oscillator and use cut and try methods in selecting its components than to solve this second order linear differential equation.

If the equipment is goal, this approach is satisfactory, but when a fundamental design principle is being studied the exact solution is required.

The REAC (Reeves Electronic Analog Computer) can solve such problems, and more complex ones, in a relatively short time. Once the problem has been set into the REAC, the effects upon oscillation of different values of the circuit parameters can be obtained simply by turning a dial; solving the equation is thus simpler and neater than changing components on a breadboard.

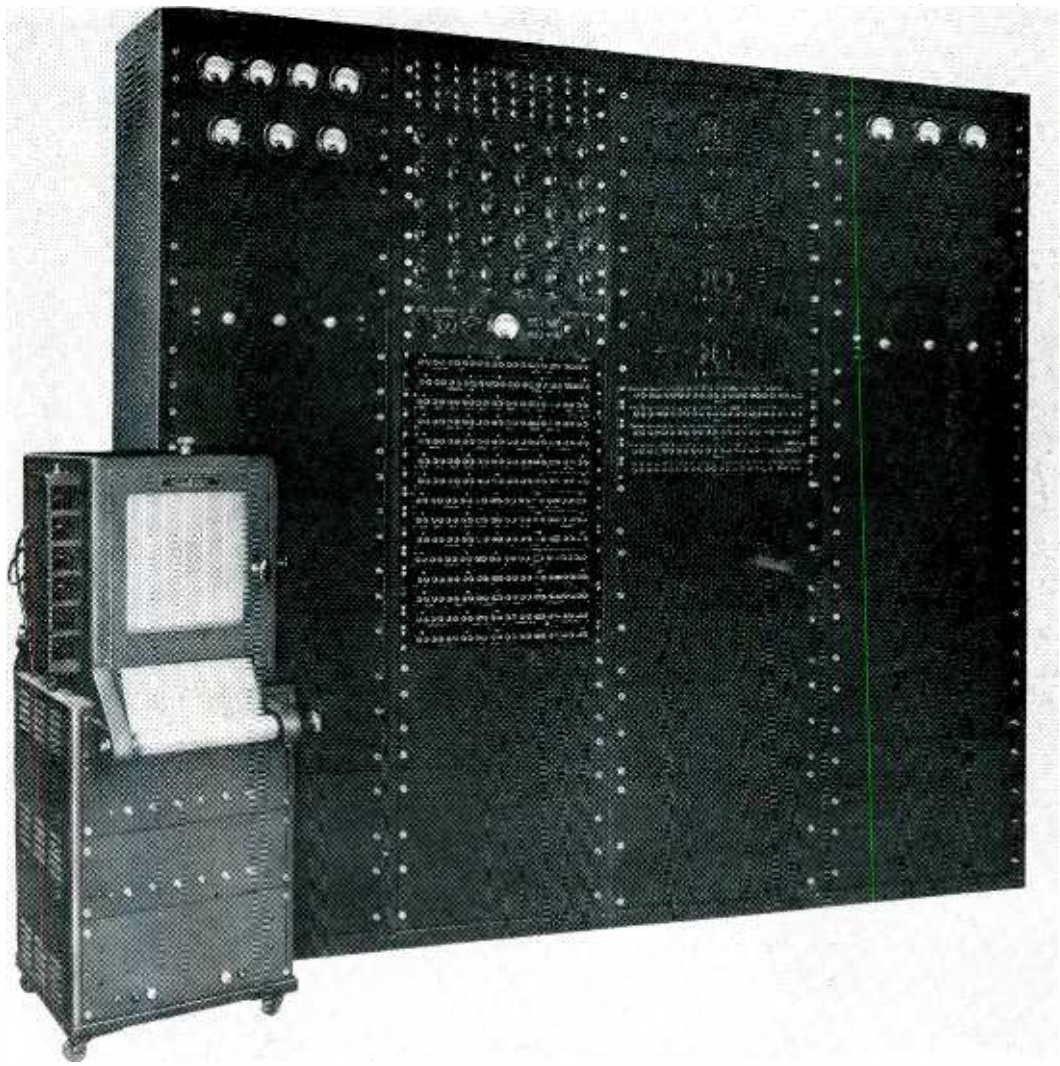


Interchangeable cylinders carrying spiral contacts provide the special functions

Computer "Turns the Crank"

What is actually done when an equation is set into the REAC is to simulate the system to which the equation applies. For example, using aerodynamic relationships expressed in terms of ordinary, initial valued, linear and nonlinear simultaneous differential equations, the REAC can be set so that it simulates the flight of an aircraft. The effect of contemplated design changes or the design that will give optimum performance can be determined without actually building an aircraft or model. Control equipment can be tested by using the REAC to simulate an aircraft. Similarly, chemical and other industrial processes can be simulated and controlled.

The REAC was developed for the Special Devices Center of the Office of Naval Research as a gen-



Elements of computer are interconnected by plugging into jacks at a common patch bay; recorder plots solution

eral-purpose analog computer. Using it on problems submitted by various airplane manufacturers and universities, it was found that the REAC cut the cost of computation 95 percent and produced answers as adequate as those resulting from hand computation by experts. Extensive use of the machine on problems shows that it reduces the man-days required to obtain solutions to about a thirtieth of that required by hand methods using desk computers.

The standard REAC consists of the Computer Unit, the Servomechanisms Unit, a Recorder Unit, and associated power supplies. Because the power supplies do not contain computing controls they need not be located with the other units in which all the computing elements are mounted.

The computing elements generate and operate on direct voltages that are proportional to the terms in the mathematical problems set into them. There are seven summing amplifiers, seven integrating amplifiers, four limiters, six initial condition potentiometers, twenty scale factor potentiometers, and automatic balancing and overload relay units. The principal elements are shown diagrammatically in Fig. 1.

Summing Amplifiers

The function of a summing amplifier is to furnish an output voltage whose value is the negative of the algebraic sum of several input voltages. Connection to the seven inputs of each amplifier is by means of telephone jacks on the patch bay in the front panel. One of the inputs has an amplification of ten, two have amplifications of four, and the rest have amplifications of one. Two volts applied at the amplification-ten input, for example, would produce and output of −20 volts.

This operation is accomplished as follows: Figure 1A is a block diagram of the summing amplifier with two inputs, where R is the value of the feedback resistor of a high gain d-c amplifier and R/A and R/B are the values of the input resistors. Assuming no grid current, the following five equations can be written where $-\mu$ is the gain of the amplifier without feedback, e_1 is the first input voltage, e_2 the second, e_g is the grid voltage into the amplifier proper, e_o is the output voltage from the amplifier, I is the current through R, I_1 is the current through R/A, and I_2 is the current through R/B, consequently

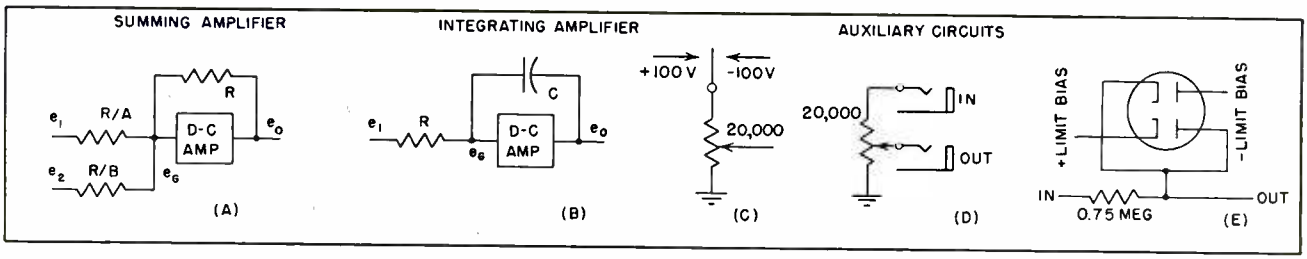


FIG. 1—Computer includes (A) summing and (B) integrating amplifiers, (C) initial condition and (D) multiplying pots, and (E) limiters

$$I = I_1 + I_2 \quad (1)$$

$$e_1 - I_1R/A = e_G \quad (2)$$

$$e_2 - I_2R/B = e_G \quad (3)$$

$$e_O = -\mu e_G \quad (4)$$

$$e_G - e_O = IR \quad (5)$$

From Eq. 1 and 5 comes the following

$$-e_O = IR - e_G = RI_1 - RI_2 - e_G \quad (6)$$

and from Eq. 2 and 3

$$I_1 = (e_1 - e_G)A/R \quad (7)$$

$$I_2 = (e_2 - e_G)B/R \quad (8)$$

therefore from Eq. 6, 7, and 8

$$e_O = e_1A + e_2B - e_GA - e_GB - e_G \quad (9)$$

From Eq. 4, $e_G = -e_O/\mu$, so Eq. 9 is

$$-e_O = e_1A + e_2B - e_O(1 + A + B)/\mu \quad (10)$$

The gain of the amplifier is about 75,000, hence

$$e_O(1 + A + B)/\mu \cong 0 \quad (11)$$

and can be neglected with little resulting error, so that Eq. 10 may be written

$$e_O = -(e_1A + e_2B) \quad (12)$$

Equation 13 states that the output voltage equals the negative sum of the input voltages each multiplied by a multiplication factor determined by the ratio of the feedback resistor to the input resistor.

The schematic of the summing amplifier is shown in Fig. 2. It is a three-stage d-c amplifier with a one-megohm feedback resistor from the plate of the final stage to the control grid of the input stage. The variable resistor in the cathode of the input stage is provided to stabilize the gain of that stage. The stage gain is stable when the fixed cathode resistor equals $1/g_m$ of the 6SL7. To achieve this condition, the bias of the tube is varied by means of the Compensate resistor. The compensated condition corresponds to the condition of maximum gain in the amplifier, which fact is used to indicate the correct setting.

The bias of the second stage is also adjustable (the grid resistor leads to a bias source in the automatic balancing system; see below) by means of the Balance potentiometer. This spot is used to adjust the gain so that, with the input to the first stage open-circuited (by the zeroing relay), the output of the amplifier is zero. Because maintaining the balance condition is important for accurate results an automatic balancing system is provided that balances all the amplifiers sequentially in about a minute.

The accuracy of the amplifier's operation is limited by the tolerances of the components. The input and feedback resistors, which determine the multiplication factors, have a tolerance of 0.1 percent and all other resistors, with the exception of those in the filtering networks which are not critical, are temperature compensated and have tolerances of 1 percent.

Integrating Amplifier

The integrating amplifier provides an output voltage equal to minus the time integral of the algebraic sum of several input voltages, each of which is multiplied by a fixed factor as in the summing amplifier. This is achieved by the arrangement shown in the block diagram in Fig. 1B. The following relations in the circuit can be written, again assuming no grid current and using the symbols as before

$$e_O = -\mu e_G \quad (13)$$

$$e_1 - e_G = IR \quad (14)$$

$$e_G - e_O = (1/C)\int_o^t e_1dt + e_{IC} \quad (15)$$

where $e_{IC} = -e_o$ at $t = 0$, or the initial voltage from which the integration takes place. Eliminating I between Eq. 14 and 15 gives

$$e_G = e_O + (1/RC)\int_o^t e_1dt - (1/RC)\int_o^t e_Gdt + e_{IC} \quad (16)$$

Combining Eq. 16 and 13 gives

$$e_O + (e_O/\mu) + (1\ \mu RC)\int_o^t e_Odt = -(1/RC)\int_o^t e_1dt - e_{IC} \quad (17)$$

Because μ is very large, Eq. 17 can be written

$$e_O = -(1/RC)\int_o^t e_1dt - e_{IC} \quad (18)$$

If two input voltages are applied, the output voltage is

$$e_O = -(1/R_1C)\int_o^t e_1dt - (1/R_2C)\int_o^t e_2dt - e_{IC} \quad (19)$$

where R_1 is the input resistance through which e_1 is applied and R_2 is that for e_2.

The integrating amplifier is the same as the summing amplifier (Fig. 2) except for the replacement of the feedback resistor by a feedback capacitor and by the use of two dpdt relays in the input circuit instead of one spdt relay for the summing amplifier. When one of the two relays for the integrator is energized, the inputs to the amplifier are disconnected so that connections can be made while setting up a problem. When the other relay is energized, the integrating amplifier is connected as a summing amplifier with a multiplication of one. The input to the amplifier in this condition is only the initial condition voltage taken from a panel-mounted initial condition potentiometer (Fig. 1C) and applied at the amplifier's initial condition input. This input determines the voltage across the capacitor from which the integration starts. When both relays are energized, the feedback capacitor and resistor are shorted out and the input to the amplifier is open-circuited, the conditions necessary for balancing the amplifier.

There are seven integrating in-

puts and one initial condition input for each integrating amplifier. Because the multiplying factor for each integrator input equals $1/RC$ (Eq. 19), by using different input resistors with a fixed one-microfarad capacitor, different multiplying factors are obtained. For example, the input with a multiplication factor of ten consists of a 0.1-meg resistor; with the 1-μf feedback capacitor. This give $1/RC = 1/(10^5 \times 10^{-6}) = 10$. The multiplying factors of the integrating amplifier are the same as those of the summing amplifier; connections are also made by jacks on the patch bay.

Auxiliary Circuits

As shown by the above discussion, the summing and integrating amplifiers develop outputs that are opposite in sign to their inputs, and offer only fixed multiplications of 10, 4, and 1. These limitations are overcome by the inverting amplifiers, each of which is simply a summing amplifier with a multiplication factor of unity to provide a means of changing sign when necessary and scale factor pots.

The scale factor potentiometers (Fig. 1D) make intermediate multiplication factors available. Each of the 24 scale factor potentiometers is a linear ten-turn 20,000-ohm Micropot controlled by a dial on the front panel of the computer unit. For each scale factor pot there is mounted on the patch bay an input jack that is connected to one end of the pot and an output jack connected to the tap; the other end of the pot is grounded. If it is desired that a signal input to an amplifier be multiplied by three, the signal is connected to the input jack of a scale factor potentiometer that is set to 0.75 and then applied to a multiplication by four jack of a summing amplifier. (The same result could be obtained more directly by another design for the computer, but this method provides considerable flexibility, which is essential to a general-purpose machine.) The whole range of the scale factor potentiometer is covered by ten turns of the panel dial, which has 100 divisions. This gives three-place accuracy in the setting of the potentiometer, but the linearity of the pot has a tolerance of 1%.

In many problems certain variables cannot exceed certain known limits. Four limiters (Fig. 1E) are provided to keep the signal voltages corresponding to these variables between the known upper and lower limits; for example, the limits of motion of a shaft between two stops. Each limiter consists of a pair of biased diodes back to back that clamp the signal at the preset limit if it tries to exceed it. The resistor (0.75 meg) in series with the output affects the multiplication factor of any summing amplifier input to which the limiter is connected by increasing its effective input resistance. For example, if a voltage is connected through a limiter to the multiplication by four input of an amplifier, the total input resistance will become one megohm, giving unity feedback to input resistance ratio.

In addition to the computing elements, there are also an automatic balancing unit (mentioned previously) and an overload relay in the computing unit. The automatic balancing unit is provided so that the operator can balance a selected amplifier or all of them in sequence by simply setting a switch on the front panel. When the switch is set to the number indicating a particular amplifier, the input to that amplifier is opened and the output connected to a servo that adjusts the bias of the second stage of the amplifier until its output is zero. When that amplifier is balanced, if the switch is set in the automatic position, the balancing unit steps itself to the next amplifier in the balancing sequence, balances it, and continues until the sequence has been completed.

The overload relay unit is incorporated to indicate to the operator when and what amplifier is operating outside the limits at which it will produce accurate results (between plus and minus 100 volts). The output of each amplifier is connected to a relay in the overload unit that is energized whenever the output of that amplifier exceeds the 100-volt limit. If a relay is tripped it ignites a red light on the panel indicating which amplifier has been overloaded and sounds a warning gong.

Using the Computor

The computer unit alone can solve ordinary initial-valued linear differential equations up to the seventh order. The equation for an oscillator presented at the introduction of this article is typical. Figure 3 shows the basic oscillator circuit to which this equation applies and the computer set up to solve it for the case that

$$(r_P rC + L - \mu M)/r_P LC = 16$$
$$(r_P + r)/r_P LC = 6.25$$

and the current i is represented by the variable y with the initial conditions at zero time of $y = 0.5$ and $dy/dt = 0$.

To set up the computer the elements are connected as shown by means of patch cords joining the proper inputs and outputs through the patch bay. All amplifier inputs are disconnected by means of the relays on the amplifiers while the problem is being set up and the initial conditions prepared. When the circuit has been completed, the first initial condition set at 0 volt and the second at 5 volts, a switch is thrown setting the relays in the operating positions. The solution then takes place and is recorded by picking off voltages at the outputs

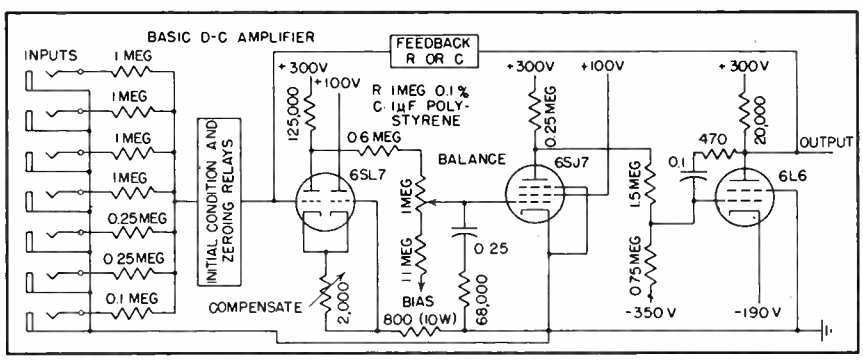


FIG. 2—Basic high-gain directly coupled amplifier used in computer

of the appropriate amplifiers. When the solution is no longer of interest, the switch is thrown back, opening the inputs and resetting the initial conditions. To obtain families of solutions the potentiometer settings are changed to the next set of conditions and the next solution obtained without disturbing the connections. In this way a large group of solutions can be determined in a very short time.

Servomechanisms Unit

The function of the servomechanisms unit is to multiply and divide two or more variables, multiply by trigonometric and special functions, and resolve and add vectors. This unit contains two multiplying servos and two resolving servos.

The multiplying servo block diagram is shown in Fig. 4A. The d-c signal servomechanism amplifier contains a vibrator in its input that converts the d-c signal to a-c. The rest of the amplifier consists of three stages of push-pull amplification. The a-c output drives the 10-watt Diehl induction motor whose shaft is coupled to the input of the follow-up potentiometer, which is a linear Helipot whose output is coupled back to the input of the servo amplifier. As long as there is any difference between the signal voltage and the follow-up voltage, a driving a-c voltage will be delivered to the servo motor with such phase as to drive it to the position at which the follow-up voltage equals the signal voltage. In this way the setting of the follow-up pot and the servo motor is determined by the d-c signal input. The tachometer that is also coupled to the servo motor produces a d-c voltage that is fed back to a network in the servo amplifier so as to damp the response of the servo system to prevent hunting and oscillation (on the rest of Fig. 4 this has been omitted for simplicity). Also coupled to the servo motor is the multiplying pot. This basic arrangement is employed for multiplication and division.

Multiplication is obtained with the servo when it is patched to the computer unit as indicated in Fig. 4B. The output voltage z of the multiplying pot is proportional to its angular rotation and to the variable voltage applied across it (y voltage). The action of the servo and follow-up pot is such that the voltage is proportional to the angular rotation determined by the x voltage and the fixed 100 voltage applied across it, therefore $z = xy/100$. A typical multiplying servo has one follow-up potentiometer, four multiplying pots, and accommodations for one functional pot.

The functional potentiometer is used to produce a special complex relationship between a dependent and an independent variable that cannot be produced otherwise. These relations are frequently empirically derived functions that are too complex to be stated analytically. The functional pot consists of a stationary linear card and a rotatable cylindrical form on which is glued a wire that makes contact with the linear card. A voltage is connected across the linear card and the cylinder is rotated by the servo motor so that its rotation is a function of the input to the servo amplifier. The curve that the wire makes around its cylinder is calculated to reproduce the desired function.

Division is accomplished with the multiplying servo and two inverting or summing amplifiers in the computer unit, which are patched to the servo as indicated in Fig. 4C. The input consists of K_1x and K_2y where K_2y does not approach zero too closely (that is, does not decrease below the noise level of the amplifier). The tap voltages are controlled as for multiplication, but the electrical connection is such that the output of the multiplication pot is

$$[(H - h)/2H]\, 2K_3(x/y) = (1 - K_2y/100)\, K_3(x/y) = K_3(x/y) - K_3K_2y/100$$

where H is the total displacement from the center to one end of the pot and h is the displacement from center to the actual position of the movable contact. Thus $K_2K_3/100 = K_1$ and hence $K_3 = 100(K_1/K_2)$. From Fig. 4C it can be seen that there are two outputs containing x/y.

Vector Resolution

The resolving servo also provides convenient vector component resolution and vector addition. The block diagram of this unit is shown in Fig. 4D. The type of operation is determined by the position of the switch. With the switch thrown to the left as shown, component resolution is obtained; with it to the right, vector addition is obtained.

For component resolution when three inputs x, y, and θ are fed into the servo, ($y \sin\theta + x \cos\theta$) and ($y \cos\theta - x \sin\theta$) appear as outputs. The heart of this manipulation is the magnetic resolver which uses only a-c signals. To convert the d-c input signals to a-c signals whose amplitudes are proportional to the inputs, the x and y signals are fed to potentiometer follow-up servos such as the one used in the multiplying servo. The shaft of the servo motor is coupled to a linear pot across which is 30 alternating volts. The output of the x pot is $z = x(30/100)$ alternating volts.

The outputs of these potentiometers are fed through isolating amplifiers to the two primary (stator) windings of the magnetic resolver. These windings are in space quadrature and each signal produces a quadrature magnetic field proportional to its amplitude. On the rotor of the resolver are wound the two secondary windings, also in space quadrature. The position of the rotor is controlled by the θ signal through another potentiometer follow-up servo. The voltage induced across the one secondary is $E_1 = K_1x \sin\theta + K_2x \cos\theta$ and across

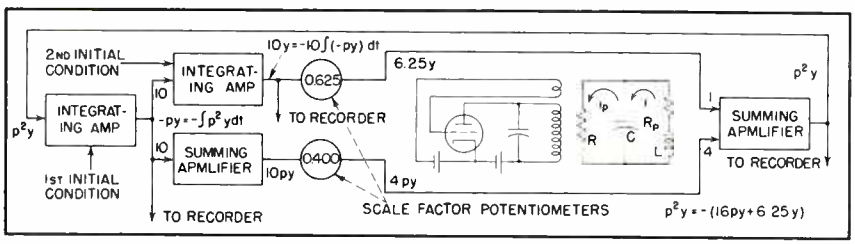
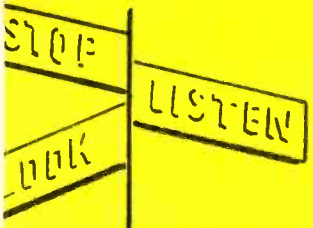


FIG. 3—Computer set up to solve equation of oscillator current



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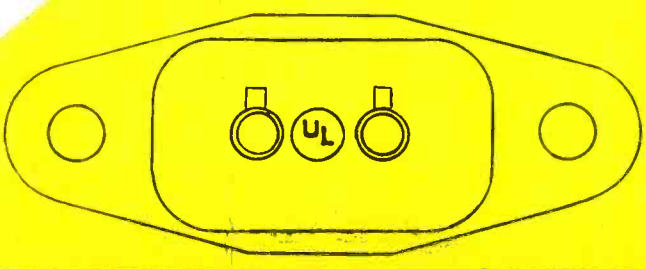

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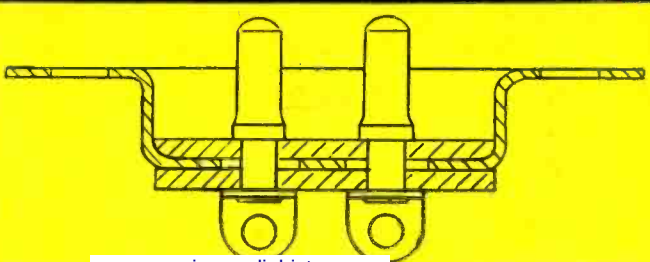

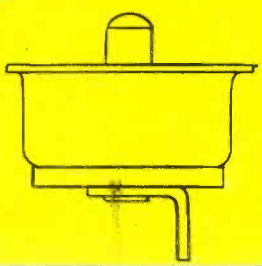

the other it is $E_2 = K_1 y \cos\theta - K_2 y \sin\theta$.

These are a-c signals, however, and must be demodulated before they can be used in the computer unit. The E_1 output is fed directly through the linear Y-demodulator and a filter network to give one output component. The E_2 output is connected to the linear X-demodulator and its filter through the switch to give the other component output. The system is so designed that K_1 and K_2 both equal unity and the outputs are as desired. If only $y \sin\theta$ and $y \cos\theta$ are desired, the x input is grounded so that x terms drop out.

Vector Summation

In this operation two signals x and y are fed into the servo and $(x^2 + y^2)^{1/2}$ is produced as the output. The θ input is not connected, which leaves it grounded. The x and y signals are fed in as before. However, because the switch which is now to the right, the x component out of the magnetic resolver is connected to the X-demodulator, through an avc amplifier and back to the input of the rotor positioning servo. This feedback drives the magnetic resolver rotor until the output of that winding is zero, and thus $\tan\theta = K_1 y / K_2 x$. Therefore

$$E_1 = \frac{(K_1 y)^2}{[(K_1 y)^2 + (K^2 x)^2]^{1/2}} + \frac{(K_2 x)^2}{[(K_1 y)^2 + (K_2 x)^2]^{1/2}} = [(K_1 y)^2 + (K_2 x)^2]^{1/2}$$

as the output from the remaining secondary of the magnetic resolver. This signal is fed through the Y-demodulator and filter so that the output is $(y^2 + x^2)^{1/2}$. The avc amplifier is provided to make the response of the servo independent of the level of the signals.

The recorder unit consists of a direct-inking six-channel oscillograph with a synchronous motor drive. Each channel has a d-c amplifier whose gain is variable in discrete steps so that the pen deflection is variable from 0.1 volt per division to 10 volts per division. The frequency response of the pen motor is essentially constant from zero to 30 cps. The equivalent of higher frequencies is obtained by extending the time scale. For example, to record a 30-kc signal, a second of recorder time is set equal to a thousandth of a second of real time and $0.001t$ is substituted for t in the equations to be solved. The recorder unit contains its own power supply.

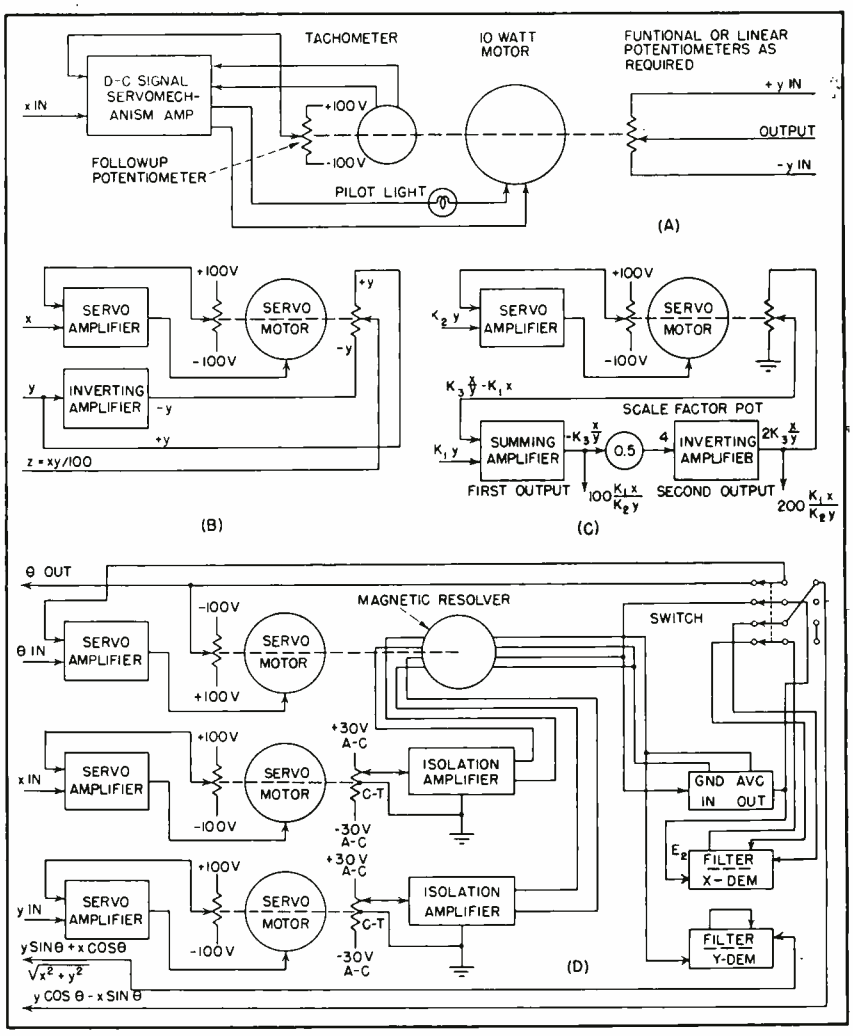

FIG. 4—Servomechanisms manipulate variables and vectors

The separate power supply cabinets for the computer and servomechanism units contain the rectifiers and regulators to produce the closely regulated voltage required. All voltages supplied to the d-c amplifiers in the computer unit are direct including the filament voltages. The power supply cabinets need not be close to the other units; the only controls on them are the power switches.

While the REAC is not the only computer capable of solving differential equations, it is the first successful commercial electronic computer of this type. The accuracy of the REAC is comparable with that of the highest grade of electromechanical systems. Besides, because it employs electronic circuits, it has many advantages over electromechanical analyzers. The REAC is produced at a twentieth of the cost, occupies a twentieth the space, and operates about twenty times faster than a comparable electromechanical computer. All the controls and interconnections are on the front panel of the equipment. There are no gears or parts to change in setting up a problem. Additional units can be connected to extend the capacity of the system. The amplifiers are mounted on separate chasses that are plugged into the computer; they are interchangeable so that if one fails it can be quickly replaced by a spare. Models of the REAC, operated for more than a year, have been out for repair and maintenance less than five percent of the time.

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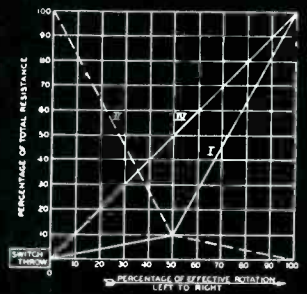
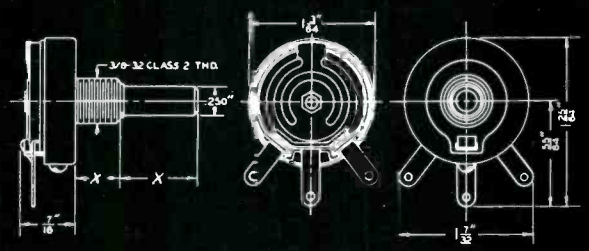
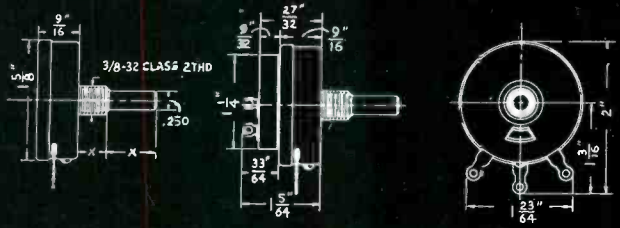
1. Resistance values: Type M—½ ohm to 70,000 ohms; Type C—6 to 10,000 ohms (linear); Type E—100 to 150,000 ohms.
2. Standard resistance tolerance: ±10% (special tolerances available)
3. Tapers: See curve
4. Rheostat (Types M & C): With or without "off" position
5. Wattage rating (Type M): 4 watts

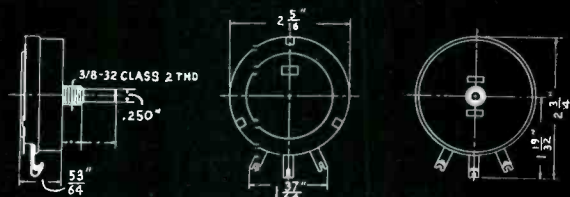




TYPE C IS A SMALL 2 WATT UNIT, USED AS A METER COMPENSATOR, MINIATURE MOTOR CONTROL AND LIGHT DIMMER.



TYPE M IS USED WHERE POWER DISSIPATION UP TO 4 WATTS IS REQUIRED.



TYPE E, RATED AT 7 WATTS, IS WIDELY USED IN PRECISION INSTRUMENTS, RESISTANCE BRIDGES AND OTHER CIRCUITS REQUIRING ACCURATE SETTINGS.

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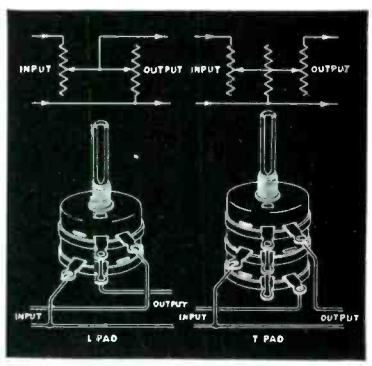
Both "standards" and "specials" are made according to Mallory's high standard of accuracy, and required to pass the rigid inspection checks that continuously maintain the dependability of Mallory Approved Precision Products.



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TUBES AT WORK

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Edited by VIN ZELUFF

Single-Signal Single-Sideband Adaptor 124
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X-Raying Flier Reactions 158

Single-Signal Single-Sideband Adaptor

BY E. W. ROSENTRETER

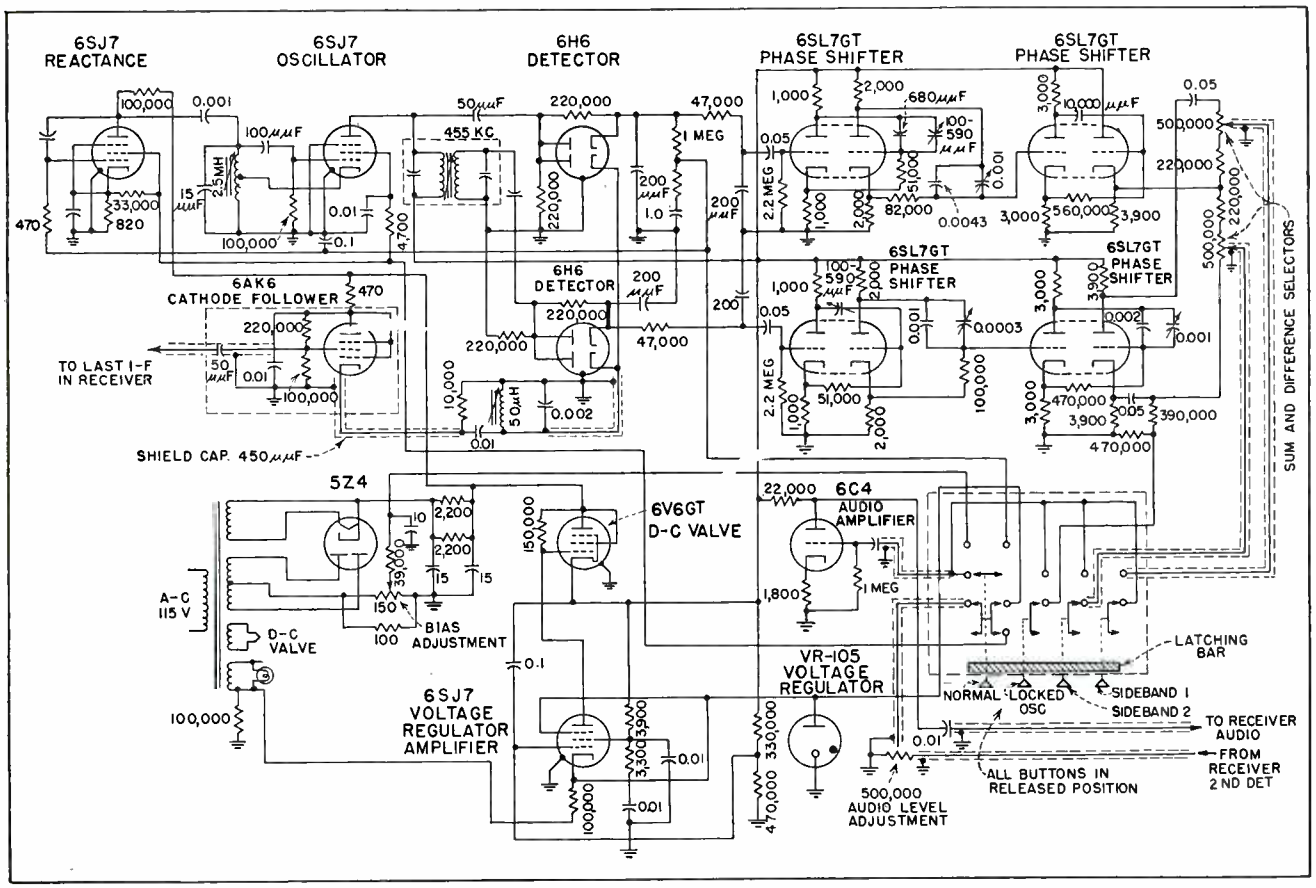
Specialty Division
General Electric Co.
Electronics Park
Syracuse, New York

An ordinary superheterodyne receiver will demodulate a single sideband signal and its accompanying carrier so long as the ratio of carrier amplitude to sideband amplitude is kept sufficiently large, though not without distortion. If, however, the carrier is attenuated below a critical value, complete unintelligibility will result. Commercial single-sideband transmitters now in operation attenuate the carrier 20 db below the sideband level to conserve power and simplify equipment.

If a communications type of receiver is used to demodulate this type of signal some means of carrier reinforcement in the receiver is necessary. This can be done conveniently at the intermediate frequency by using the receiver's beat frequency oscillator to exalt the carrier. Exact tuning is required, as well as excellent stability of transmitter frequency, receiver local oscillator frequency and beat frequency oscillator. If the frequency of any of these varies, an audio beat will be produced.

If the carrier is completely suppressed, then the received single-sideband signal can be satisfactorily demodulated only if the beat frequency oscillator supplies the missing carrier. The critical value between the synthetic carrier and the signal must be maintained or exceeded for acceptable results. Since it is difficult to control accurately the frequencies of the oscillators in both transmitter and receiver, other arrangements usually are resorted to in conventional single-sideband receivers.

Figure 1 shows in block form a simple receiver system using low-frequency filters. With this ar-



Complete circuit of the General Electric Selector for single sideband reception with a conventional communications receiver

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rangement, double conversion is necessary to change the higher radio frequencies used for communications down to the frequency of the filter.

The purpose of the two oscillators is to enable the pass-band filter to accept the desired side-

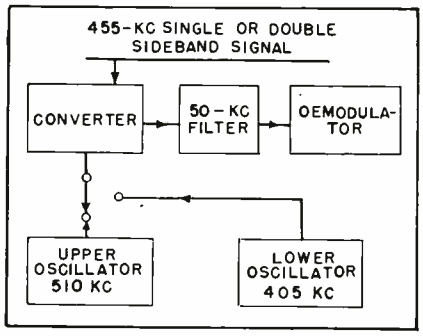


FIG. 1—Filter type of single-sideband receiver

band, whether it be upper or lower. This is done by switching one or the other oscillator into the second converter circuit.

Another single-sideband system, relatively simple in circuit elements, is shown in Fig. 2. This arrangement is used in the General Electric Single Sideband Selector. Reception of a single-sideband signal with or without carrier, and selection of one or the other sideband in a conventional a-m signal, are among the types of transmission which the system handles.

Principle of Operation

Assume that a conventional a-m, double sideband signal is being received. Referring to Fig. 2, the signal from the receiver i-f channel, containing carrier and both sidebands, is fed into two special detectors; 1 and 2. Voltage from an oscillator operating at the same frequency as the i-f channel is also fed into the two detectors. A fixed phase shift of 90 degrees exists between the oscillator voltage applied to detector 1 and detector 2.

The oscillator voltage, or synthetic carrier, is many times greater in magnitude than the incoming signal voltage. Thus the two detectors demodulate the incoming signals at an effective low modulation factor and distortion products are small. Identical audio signals, corresponding to the sideband intelligence are obtained from the two detectors, except for a 90-degree phase difference between them. The amplitude of these signals is directly proportional to the amplitude of the sideband intelligence.

The audio voltages are fed into phase-shift networks A and B, where they undergo an additional 90-degree relative phase shift. The two outputs are fed into a sum and difference circuit, where they are added or substracted algebraically. It can be shown that the sum contains only upper sideband information, for example, and that the difference contains only lower sideband information. (See: Simplified Single-Sideband Reception O. G. Villard, Jr. ELECTRONICS, May 1948.) Selection of one or the other is easily done by a switch, which selects the additive or subtractive process. The same switch also selects an output containing both sidebands.

Lattice Networks

Since the oscillator operates at one frequency only, it is quite simple to create and maintain a 90-degree phase shift of its voltage for application to detector 2. To be of any practical value, the sidebands must be wide enough to carry the desired intelligence. Suppose for instance that an audio voice frequency range of 100 cycles to 4,000 cycles is desired. Then the two sidebands will each be up to 4,000 cycles wide, so that the A and B networks must maintain a 90-degree phase difference over the full 100 to 4,000-cycle audio band. The wideband phase-shift networks were devised by R. B. Dome, and were described in detail in ELECTRONICS, December 1946. Briefly, the manner in which they function is that phase shift increases nearly linearly with the logarithm of the frequency. Thus

$$\text{Phase A} = K + \log f$$
$$\text{Phase B} = K + \log tf$$

Substracting phase B from phase A

$$\phi A - \phi B = K + \log f - K - \log tf$$
$$= \log f - \log f - \log t$$
$$= -\log t$$

where K and t are constants and f is the frequency. Thus the difference in phase shifts between A Network and B Network is a constant, regardless of frequency.

With two networks composed of three RC lattices as shown in Fig. 3 and through proper choice of component values, a frequency coverage ratio of 100 to 1 may be accomplished. Figure 4 shows that although the applied voltages undergo total phase shifts up to several hundred degrees, depending on frequency, the difference in phase shift between the two outputs is approxi-

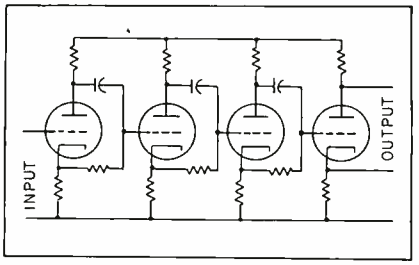


FIG. 3—Three-lattice A or B phase-shift audio network

mately 90 degrees over a very wide range. This difference can be made to extend from 50 to 5,000 cycles per second, or it may be from 250 to 25,000 cycles per second, for example.

The choice of frequencies of say 50 to 5,000 cycles per second does not mean that the phase-shift networks will not pass frequencies beyond this range (higher or lower in frequency). It means simply

(continued on p 140)

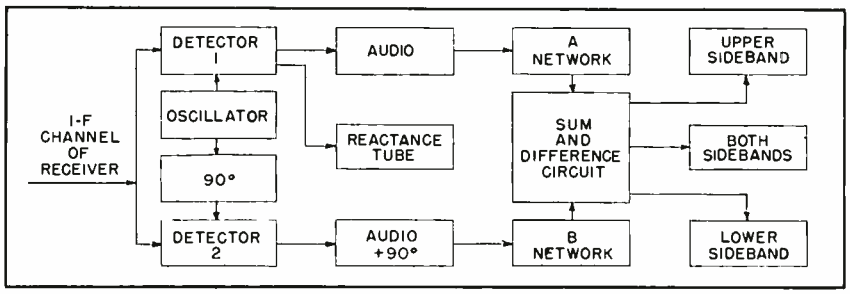
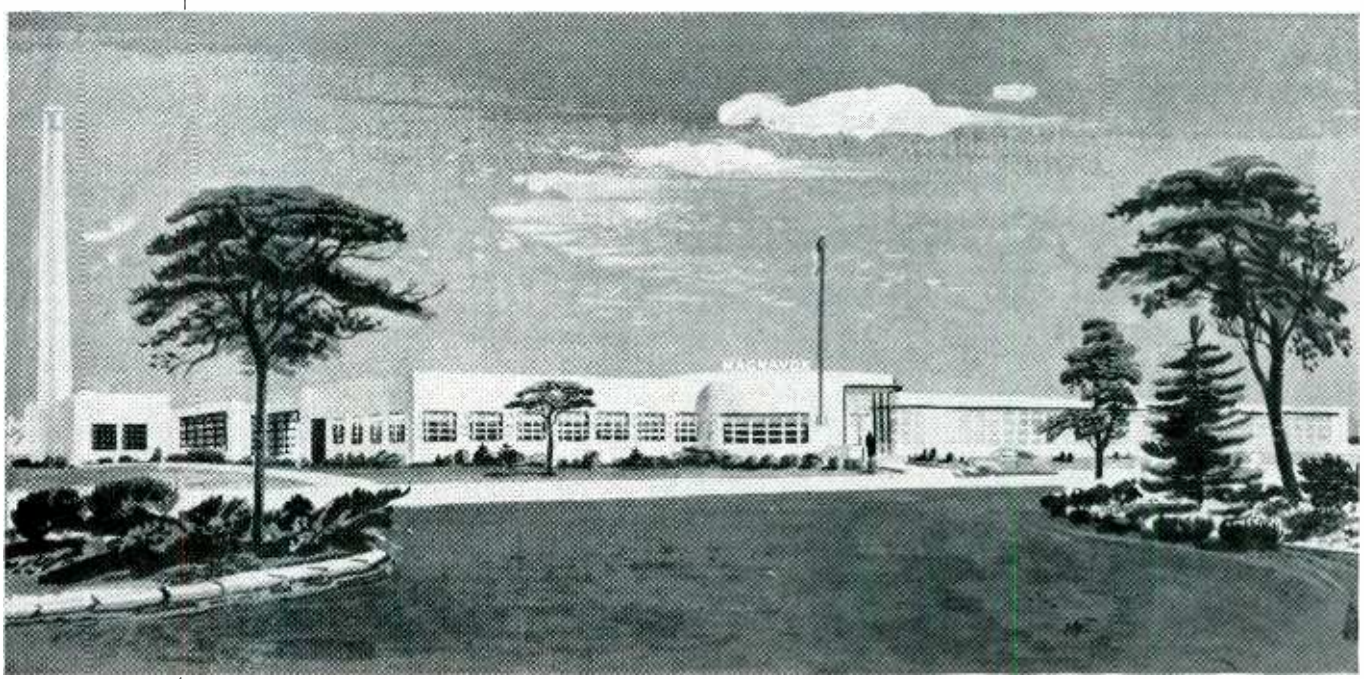


FIG. 2—Stage arrangement of the General Electric Selector unit for adding to a conventional communications receiver

Magnavox Opens Modern New Loud Speaker Factory In Paducah, Kentucky



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THE ELECTRON ART

Edited by FRANK ROCKETT

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Properties of Electromechanical Ceramics

By HANS JAFFE

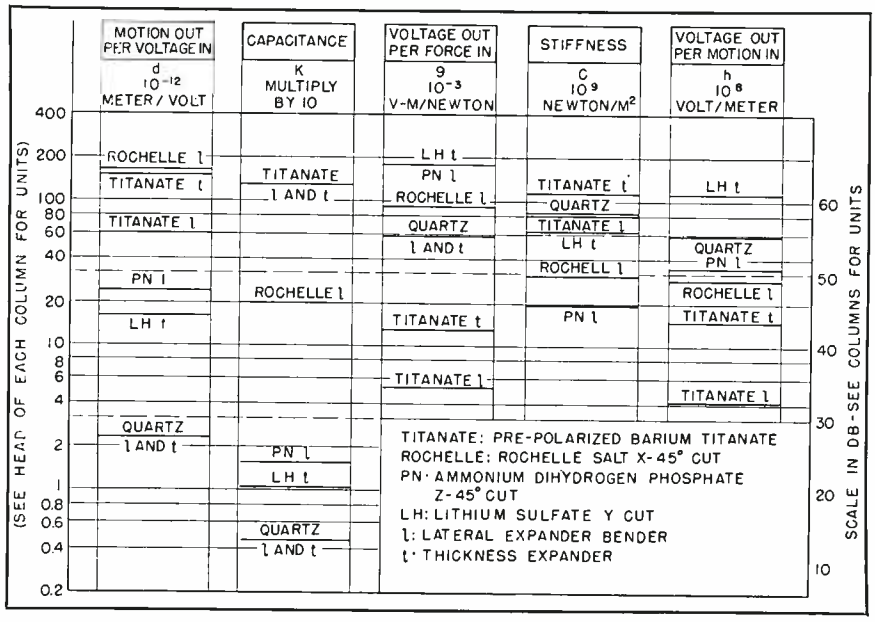
Head, Crystal Research Department
The Brush Development Company
Cleveland, Ohio

A SIGNIFICANT recent development in the capacitor field was the discovery[1] of barium titanate ceramics with a dielectric constant (specific capacity) of 1,500 which can be raised to 10,000 by the addition of strontium titanate, at the price of large variations with temperature[2]. Small single crystals of barium titanate have recently been grown and shown to be piezoelectric[3], but they are a highly refractory material melting near 3,000 F, and their commercial production seems remote. The following discussion will show that barium titanate nevertheless is a promising new material for electromechanical devices.

"Piezoelectric" Ceramics

Ordinary piezoelectricity is associated with single crystals, but in ceramic materials consisting of many randomly oriented small crystallites, a deformation proportional to the square of an applied field and a dependence of capacitance on the applied field can be expected. Usually these electrostrictive actions are minute, but in the titanate ceramics they become usefully large.

If such ceramics are maintained under electric bias they will show a linear electric response to a vibrating force and also a lienear mechanical response to an electrical signal superimposed on the d-c bias. For instance, a barium-strontium titanate plate of dielectric constant 5,000 maintained under 2,000 volts per inch raised by one-millionth of its thickness when a signal field of 800 volts per inch was superimposed over the bias field. A similar experiment carried out with essentially pure barium titanate leads to a significant result: If the biasing voltage is sufficiently high, (about 30,000 volts per inch), the medium will remain in its polarized state after the bias field has been removed[4]. It then shows a "piezoelectric" activity like a piezoelectric crystal element.



Comparison of electrical and mechanical properties of piezoelectric materials

Unfor-

TECHNICAL BIBLIOGRAPHIES

Bibliographies of technical subjects are available from several sources. These bibliographies can save much time in making literature searches and in conducting investigations related to other work the results of which have already been published.

A pool of unpublished bibliographies has been collected by the Special Libraries Association. These bibliographies, compiled by technical librarians, are on diversified subjects in both scientific and engineering fields. A complete list can be obtained from R. H. Hopp, chairman of the SLA Bibliography Committee, at the Bettelle Memorial Institute (Columbus, Ohio) where the bibliographies are housed; he is also interested in other unpublished bibliographies that could be included in the pool.

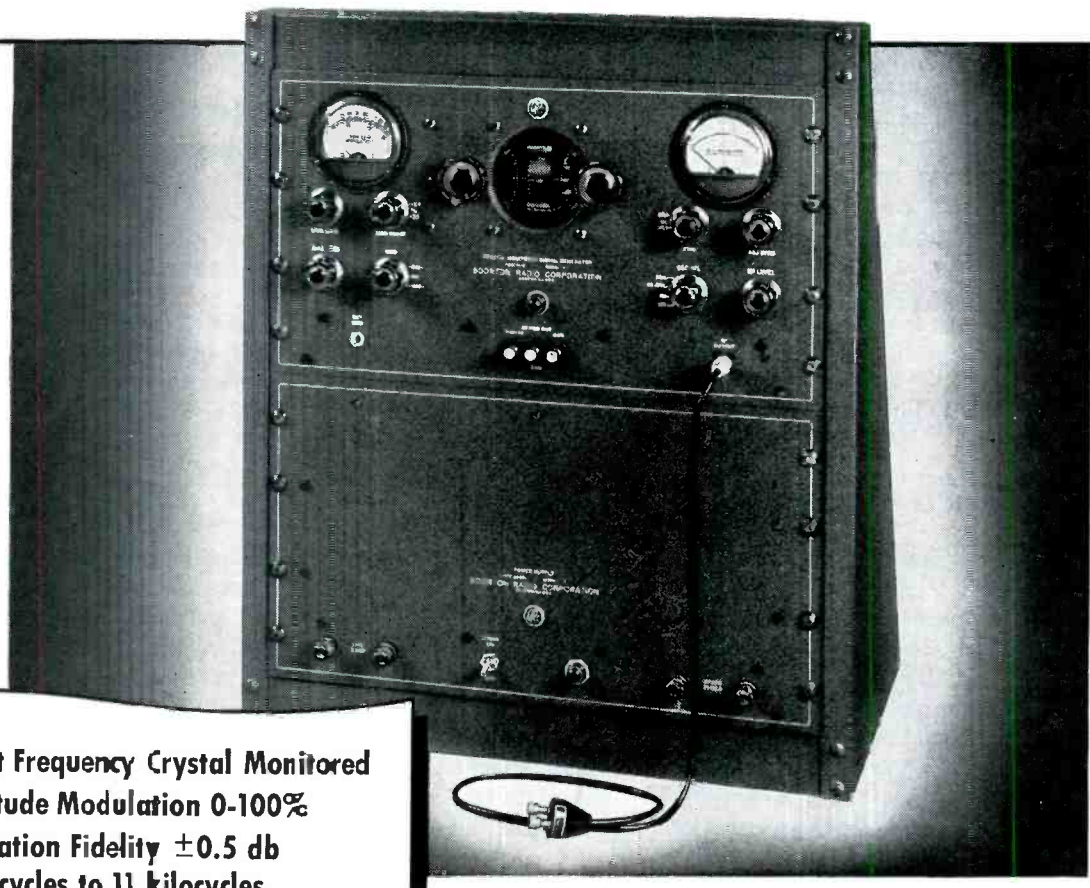
The Office of Tech. Services, U. S. Dept. of Commerce (Washington, D. C.) has available a 1,200 item bibliography and index of reports based on field investigations of German science and industry (PB-86000, mimeographed $5.00), a 523 entry bibliography of declassified American and British reports on atomic energy (PB-87782, mimeographed $0.75), and numerous other bibliographies, which are available free of charge, on such subjects as ceramics, infrared devices, magnetic wire and tape recorders, pyrometers, and selenium rectifiers.

The Engineering Societies Library (New York City) and other technical libraries make literature searches and compile bibliographies on order as a regular part of their service to industry. Such bibliographies provide a key to the wealth of knowledge that has been accumulated in recent years.

The appreciable electromechanical effects in barium titanate, in combination with its other properties, offer an inviting field for engineering endeavor. The ceramic shows a general chemical stability and resistance to moisture comparable to other good ceramics. It withstands extreme temperatures without chemical change or physical destruction. Temperatures above 250 F remove remanent polarization but higher temperatures can be used in constructing transducers before they are polarized.

A NEW AMPLITUDE MODULATED SIGNAL GENERATOR

Type 211-A • Frequency Range 88-140 Megacycles



Output Frequency Crystal Monitored
Amplitude Modulation 0-100%
Modulation Fidelity ±0.5 db
30 cycles to 11 kilocycles
Negligible Spurious FM

SPECIFICATIONS

FREQUENCY RANGE: Master Oscillator: 88-140 megacycles in one range. Vernier frequency dial has 100 divisions and is coupled to the main tuning capacitor through a 120:1 gear drive. Each vernier division is equivalent to a 10 kc. change in frequency.

Crystal Controlled Frequencies: Either of two crystals 110.100 mc. and 114.900 mc., accurate to ±0.0035%, may be selected by a switch for use individually or in combination with the master oscillator to standardize its output frequency.

AMPLITUDE MODULATION CHARACTERISTICS: Two amplitude modulation ranges, 0-30% and 0-100%, are provided for use with the internal oscillator or a low distortion external oscillator. Distortion is 5% or less at 95% amplitude modulation.

Internal Audio Oscillator: Two modulating frequencies, 400 and 1000 cycles.

Modulation Amplifier: The internal modulating amplifier has the following characteristics:

Uniform response within ±0.5 db. 30 cycles to 11 kc.
Uniform response within ±0.1 db. 90 cycles to 150 cycles.
Uniform response within ±0.1 db. 9500 cycles to 10.5 kc.

Phase Distortion: (up to 60% amplitude modulation.)

Less than 0.25 degrees at 30 cycles.
Less than 10 degrees at 11 kc.

AUDIO TEST VOLTAGE: This instrument contains a demodulator or detector which supplies to front panel terminals a portion of the demodulated carrier.

SPURIOUS FM: Less than 1 kc. at 60% AM.

OUTPUT ATTENUATOR: Single ended piston type, adjustable from 0.2 volt to 0.1 microvolt. Output impedance as seen looking in at terminals of output cable is 26.5 ohms.

The Type 211-A Signal Generator is specifically designed for the testing and calibrating of omni-range radio receiving equipment. It is also well suited for laboratory and development work where a precision type amplitude modulated R.F. signal source is required.

Careful consideration has been given to the location of panel controls with respect to function and degree of use. The main frequency dial is located in the center of the panel, with the vernier dial to the left in close proximity, utilizing the same fiducial for simplicity and ease of operation. Symmetrically located to the right of the frequency dial is the output attenuator dial, directly calibrated in microvolts. The center panel enclosure embodies those controls which the operator will have the greatest occasion to use, permitting rapid, accurate settings to be made with maximum convenience.

The calibration accuracy of the frequency dial settings is ±0.25% at any point; however since crystal controlled frequencies are also available within the instrument, zero beats may be obtained from which the output frequency may be standardized to an accuracy of about ±0.025% by slipping the vernier frequency dial with respect to the main frequency dial. This feature permits the identification and checking of channel frequencies differing by as little as 100 kc.

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tunately the material is rather fragile in thin shapes.

Comparison of Piezoelectrics

Polarized barium titanate has two important piezoelectric modes. One is a compressional mode parallel to the electric field suitable for producing and detecting ultrasonic waves much as quartz X-cut. The other is a lateral compression mode which can be used in bending assemblies similar to Rochelle Salt bender.

The diagram gives operating values referred to unit size of fully polarized barium titanate compared to crystals now in use. In current output for a given applied force barium titanate is ahead of quartz by a factor 70, but in open-circuit voltage it is lower by a factor of five. Rochelle salt is ahead of barium titanate in all three piezoelectric coefficients shown, but the gap is rather small in open-circuit voltage output for given motion input, as in a phonograph pickup with good mechanical coupling. Design of titanate transducers must take account of these properties. A phonograph pickup element for instance should be made narrow to balance the high stiffness coefficient. The high dielectric constant assures adequate capacitance.

Novel shapes of transducers not procurable from conventional crystals may be made of barium titanate by forming before firing[5].

Much remains to be learned about the control and the stability of the titanates as transducer materials, but they are on their way to become an important addition to the family of piezoelectric materials.

(1) Titanium Alloy Mfg. Co., Electrical Reports No. 8, 9 (1942) and 10 (1943) by E. Wainer and co-workers.

(2) A. von Hippel R. G. Breckenridge, F. G. Chesley, L. Tiza, *Ind. Engr. Chem.*, p. 1097, 38, 1946.

(3) B. Matthias, *Nature*, p. 325, Feb. 1948.

(4) S. Roberts, *Physical Review*, p. 890, 71, 1947.

(5) W. L. Cherry, Jr., and R. Adler, *Physical Review*, p. 981, 72, 1947.

Phototube Amplifier for Measuring UV Radiation

By C. M. Rively

Vapor Lamp Engineering
Lamp Engineering Dept.
Westinghouse Electric Corp.
Bloomfield, N. J.

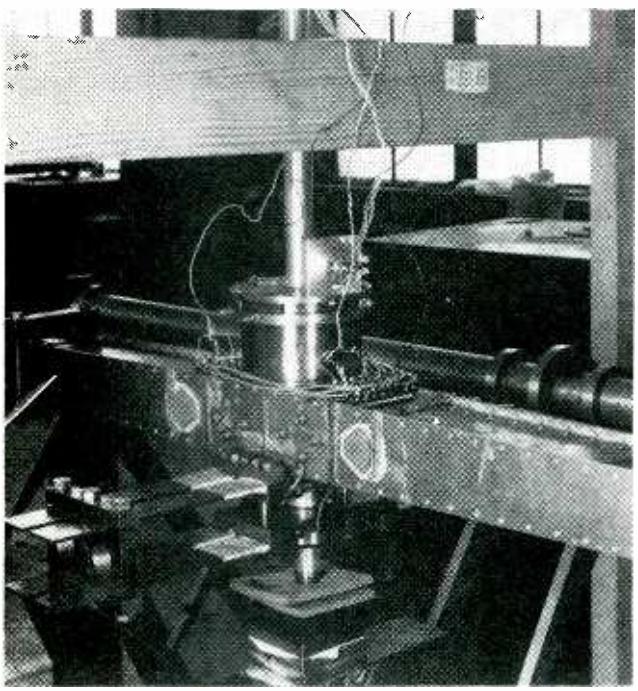
In quality control of ultraviolet lamps and in grading quartz tubes and flats for transmission, the radi-

(continued on p 162)

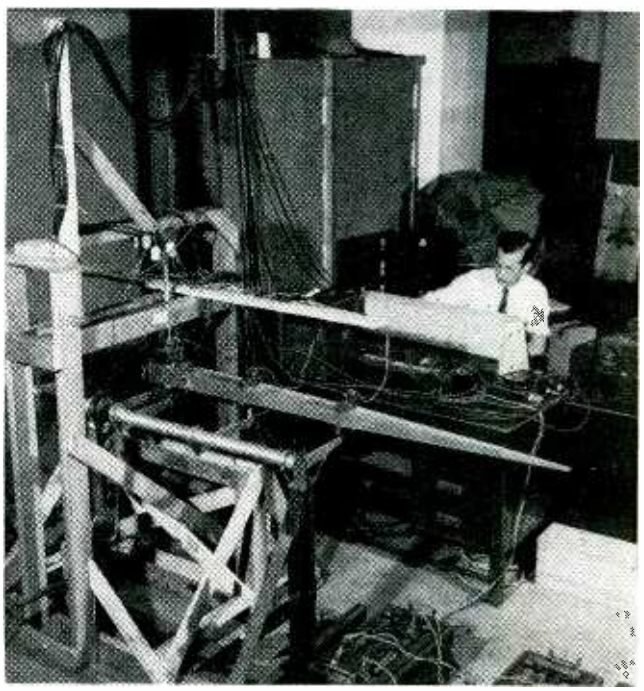
Acceleration and Strain Measurements Made on Laboratory Model Airplane

Vibrations in airframes are difficult to evaluate; it is not certain whether they are responsible for failures in wing and tail assemblies or not. Small aircraft are designed by being treated as rigid bodies. However, the transient vibrations excited by landing impact and which involve the many natural modes of vibration of the airplane are so violent in large aircraft that their flexibility must be taken into detailed account in their design.

To bridge the gap between theoretical analysis of simple structures and practical experience with actual aircraft, measurements on simplified models under controlled conditions are being made. The models consist of small scale structures that simulate the essential mechanical elements of an airplane: long flexible wing loaded at several points with massive fuselage and engines. Models are made to have a similar distribution of mass and flexural rigidity as existing airplanes. The model is released from a support that holds it in a strain free condition; it falls onto a simulated landing field to produce the impact. Strain gages and electronic accelerometer tubes mounted on the model produce signals that can be compared to similar values from theory and experience.

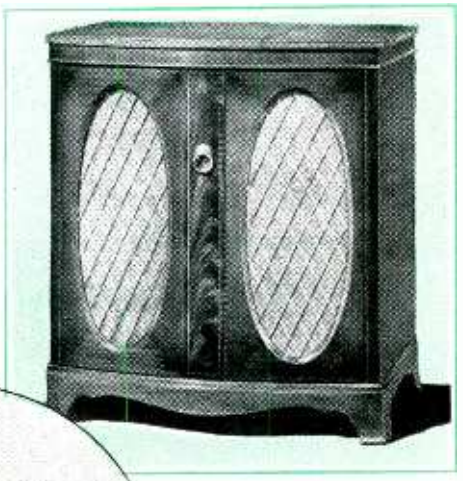


Acceleration tube, base of which can be seen projecting from its support, and gages attached to sides of simulated wing record vibrations produced by landing impact

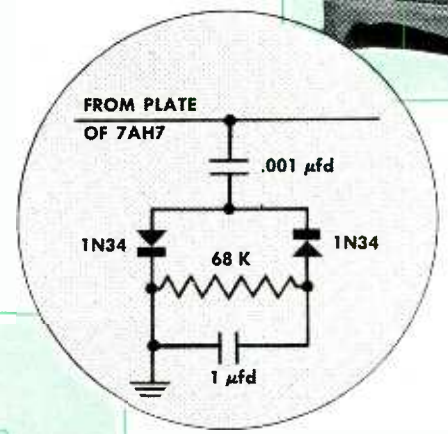


Effects of impact produced in model plane when its landing pin strikes rubber pads representing the airfield are being measured by Walter Ramberg at the National Bureau of Standards

Sound Gate lengthens range of *Bendix* FM Radio 1217-D



Circuit uses two Type 1N34 SYLVANIA germanium crystal diodes to divert overstrong signals from nearby transmitters



THE ABOVE RECEPTION RANGES SHOWN FOR ORDINARY INSTALLATIONS OF BENDIX FM RADIOS HAVE BEEN INCREASED FOR MODEL 1217-D

Advanced engineering design gives the Bendix Model 1217-D FM a range extending far beyond normal reception limits.

An important factor in this extended range is a Sound Gate circuit utilizing two Type 1N34 Sylvania Germanium Crystal Diodes. This circuit functions to divert over-strong signals from nearby FM transmitters and permits higher sensitivity for efficient reception from more distant stations.

The Bendix Sound Gate is one of many novel circuits developed to improve equipment performance or simplify design—through the use of Sylvania Germanium Crystals. Sylvania has prepared a catalog giving complete specifications on diodes and duo-diodes; a booklet of circuit suggestions made by "hams"; and two Engineering News Letters on usage and applications. This literature is yours for the asking.

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

NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

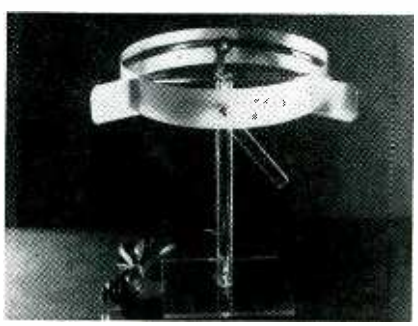
Television Generator

HICKOK ELECTRICAL INSTRUMENT CO., 10527 Dupont Ave., Cleveland 8, Ohio. Model 610 television generator enables the operator visually to align receivers to any of the present channels from 44 to 216

mc, also to align i-f stages and to insert an accurate marker at any point along the i-f response curve. Self-contained marker frequencies are directly calibrated on a 9½-inch dial.

Indoor T-V Antenna

BURNETT SERVICE CO., 178 W. 168th St., New York 52, N. Y. The Visibeam is a newly developed indoor television antenna now available for use with all television receivers. The unit is 12 inches in diameter



and is made of polished lucite. It is tunable to all stations.

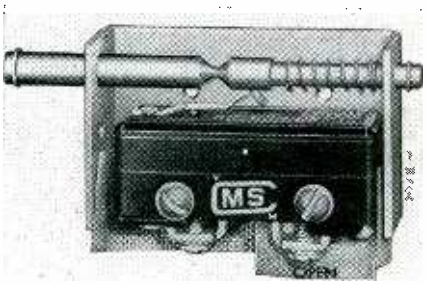
Projector Assembly

RADIO CORP. OF AMERICA, Camden, N. J. Type TP-35A sound motion picture projector employs an electronically-triggered, high-intensity "gap-lamp". The periodic lamp flashes coupled with a special film

drive mechanism make it possible to project 35-mm pictures directly on to the pickup tube of a television film camera for conversion to video signals. Monitor and change-over control are housed in a standard cabinet rack.

Cabinet-Door Switch

MICRO SWITCH, Freeport, Ill. The type 1AC1 interlock door switch, designed for use on h-f radio equipment cabinets, and all types of electronic controls, is single pole double throw. It automatically cuts off the power circuit when the cabinet door is open. Switching element is of the leaf actuator design. Circuit can be closed manually for



equipment servicing without hazard of forgetting to reposition the switch for normal protection.

Beam Power Amplifier

HYTRON RADIO & ELECTRONICS CORP., 76 Lafayette St., Salem, Mass. Type 3B4 is a miniature beam pentode for use in vhf portable mobile equipment as a Class-C

oscillator, frequency multiplier and r-f amplifier where it is desired to eliminate filament drain during standby periods. It employs a 1.25 or 2.5 volt filament for instant-heating and can be used at full ratings to 100 mc. Bulletin E-133 gives complete technical data.

Panel Instruments

GENERAL ELECTRIC CO., Schenectady 5, N. Y. Designed for better readability, the type DO-71 line of 3½-inch internal-pivot panel instruments are suitable for use in radio,

B-36A's are equipped with M-H's E-6 Autopilot Amplifiers Using RAYTHEON 2C50 and 2C52 Tubes

Minneapolis-Honeywell uses RAYTHEON 2C50 and 2C52 Tubes for control operations because these tubes feature reliability and stability as a result of proven design and careful manufacturing control including:

1. Operation of every tube for several days as a routine part of the manufacturing process.
2. Use of the Raytheon Bantal* construction features a flat glass button stem, standard Dumet metal-glass seal, and heavy stiff support wires above and below the button. This construction was pioneered in millions of Raytheon receiving tubes manufactured since 1945 and has been adopted for many military ruggedized tube types.
3. Careful welding technique combined with internal mechanical features such as grid side rod clips, tungsten heaters, and mica eyelets on plate side rods, provide the extra strength needed for reliable aircraft service.

*®

Write for Detailed Information on RAYTHEON Special Purpose and Subminiature Tubes

B-36A is the new U.S.A.F.—Consolidated Bomber—The World's Largest.

M-H is, of course, Minneapolis-Honeywell Regulator Company, makers of the famous M-H Control Systems. Their Aeronautical Division provides the Autopilots for the B-36A's.

Type 2C50 is a low mu double triode used as the output tube in servo-amplifiers which control small reversible motors or relays. Low mu and ample cathode area permits higher currents at lower operating voltages and simplifies impedance matching. Voltage breakdown at high altitudes is reduced by ample spacing between leads in both the Raytheon Bantal* stem and melamine base which has barriers between pins.

Type 2C52 is a high mu double triode used as a voltage amplifier in this equipment.

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Newton 58, Massachusetts

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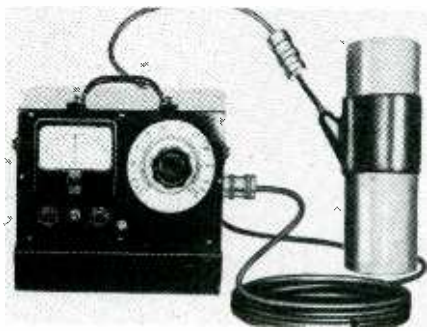
power supplies, transmitters, amplifiers and aircraft. High torque, provided by a high-strength Alnico magnet, makes for quick and accurate following of voltage and current changes.

Electronic Scale

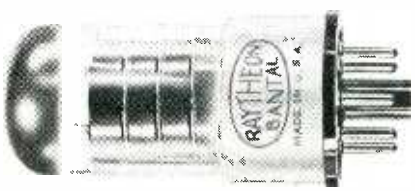
BAKER OIL TOOLS, INC., P. O. Box 2274 Terminal Annex, Los Angeles 54, Calif. Model 500A electronic weight indicator is designed for measuring any operation in which



the tension load does not exceed 75 tons nor the compression load 150 tons. It operates on the null balance principle and translates electrical impulses into weight readings within 2 percent of full-scale load.

Eight-Pillar Tubes

RAYTHEON MFG. CO., Newton, Mass., has announced a new series of Bantal tubes with a 8-pillar support construction. Other engineer-



ing features are wide lead spacing, glass-to-glass seal, standard octal base and short leads direct to base pins.

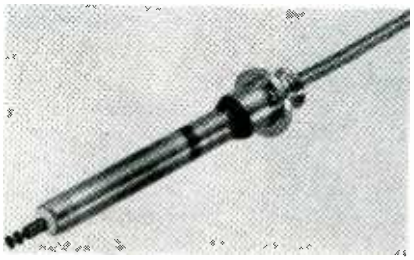
Midget Mike

RADIO CORP. OF AMERICA, Camden, N. J. The type KB-2C miniature velocity microphone shown on the left weighs only 12 ounces and fits

in the palm of the hand, making it ideal for use at remote pickups. A built-in swivel permits tilting forword or backward through an angle of about 30 degrees.

Thermocouple

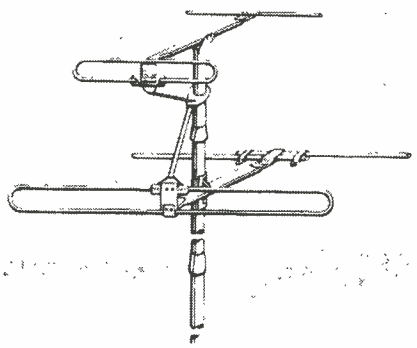
MANNING, MAXWELL & MOORE, INC., Bridgeport 2, Conn., introduces a new thermocouple for gas turbines. Time constants of better than 1.2



seconds are measured at gas velocities of 250 feet per second, with a life expectancy of 200 hours at 1,600 F.

Sectional Antenna

TECHNICAL APPLIANCE CORP., Sherburne, N. Y. Type 465 television antenna comprises a low-frequency



folded dipole and reflector assembly surmounted by a smaller high-frequency similar assembly, both mounted on a sectional aluminum tubular mast and connected together by a quarter-wave connecting link. High and low band antennas can be oriented independent of each other.

Wattmeter Bridge

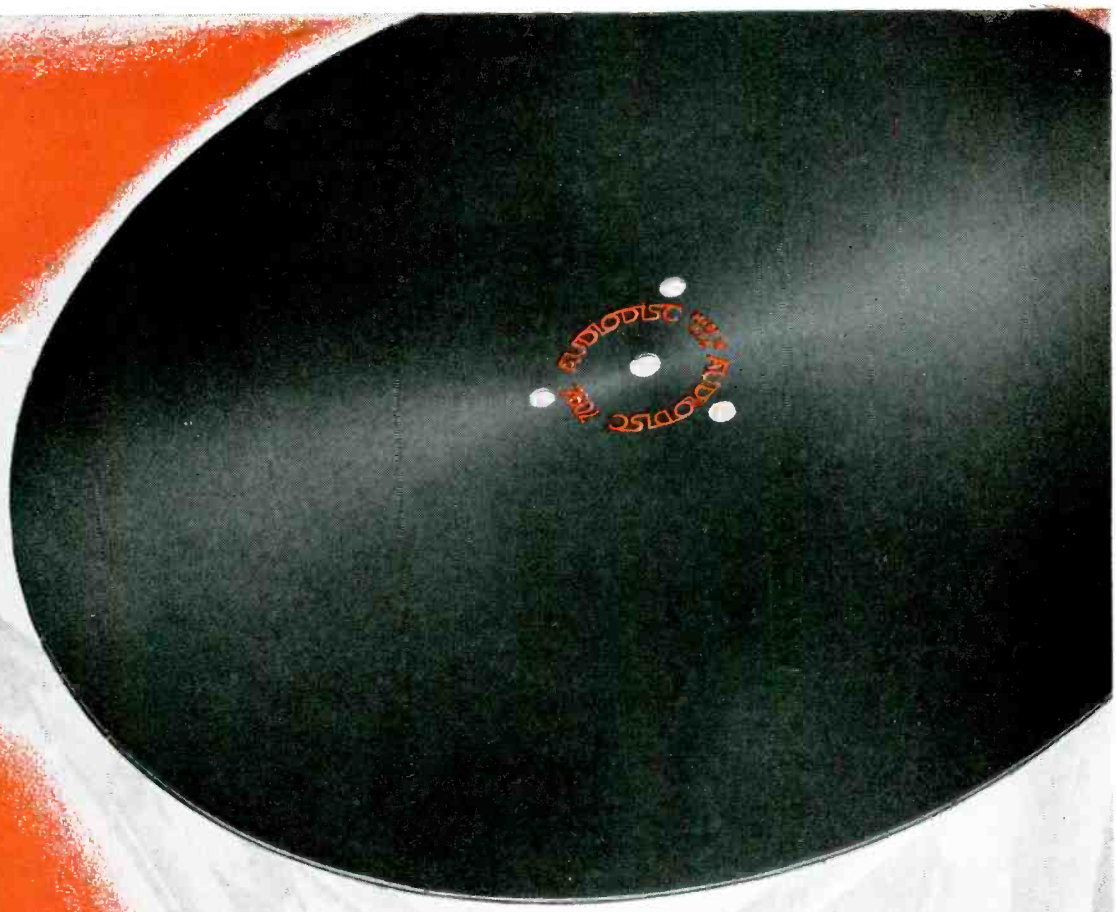
SPERRY GYROSCOPE CO., Great Neck, N. Y. Model 123A is an automatically self-balancing and direct-reading bridge for indicating microwave power measured by a barretter element over a range of 10

milliwatts down to a few microwatts. The unit requires 115 volts, 60 cycles for operation. Weight is 45 pounds. Descriptive literature is available.

Wire Recorder

SEARS, ROEBUCK AND CO., 925 South Homan Ave., Chicago 7, Ill., have introduced the Silvertone general-purpose portable wire recorder. It features an adapter that permits the recordings to be made and played back in conjunction with a console radio. Weight is approxi-

(Continued on p 174)



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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

New plants; new businesses; personnel moves and changes; nine book reviews and seven abstracts of new books

Television Channel No. 1 is Deleted by FCC

PREVIOUS NOTICES by the FCC concerning proposed television channel rules became effective as of June 14, as follows:

(1) Abolition of the sharing of television channels by certain non-broadcast services because of interference problems.

(2) Channel No. 1 (44-50 mc) is deleted and assigned to non-government fixed and mobile services which were sharing channels.

(3) The 72-76 mc band is allocated to the fixed services on condition that no interference is caused to television.

In consequence the Commission proposes to revise the table of allocations of the 12 remaining television channels to service areas throughout the nation. It has also ordered a judicial hearing beginning Sept. 20, 1948 in the matter of utilizing frequencies in the 475-890 mc band for black and white and/or color television broadcasting.

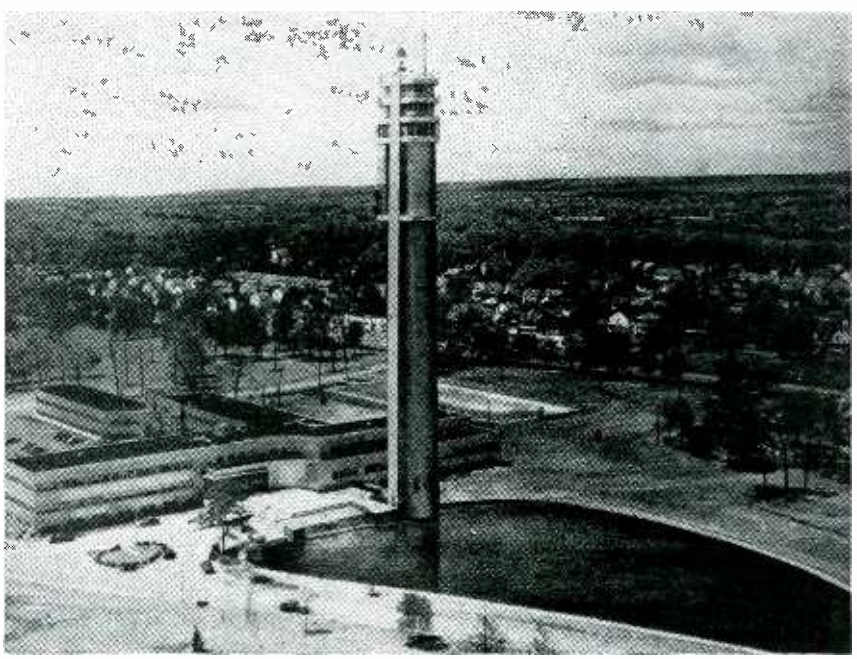
Laboratory Tower Dedication

A 300-foot aluminum-sheathed tower for microwave experimentation was formally opened by Federal Telecommunication Laboratories in Nutley, N. J. on May 19. Rising 358 feet above sea level, the top of the structure overlooks the main laboratory building and has a horizon that varies between 5 and 35 miles.

With 75 percent of the weight concentrated above the 212-foot level it was necessary to anchor the main column in a 10-foot reinforced concrete mat. The uplift loads, estimated to run into several hundred tons during high winds, are carried by reinforced tension cylinders extending 30 feet below the foundation mat into bedrock.

Among the developments demonstrated on the tower were a high-resolution radar with antenna rotational speed of 1 rps, together with a two-color display of reflected echoes and racon signals. A blue-fluorescent tube is used for the beacon return and an optical multiplexer shows this signal against a yellow background that represents the conventional radar return.

E. M. Deloraine, Technical Director of IT&T, summarized the advantages that accrue through the use of microwave links, some using ptm multiplexing, for television, telephone, and telegraph communication. By means of a prepared map he traced a possible microwave network westward through the Orient to Europe from the eastern seaboard of the United States.

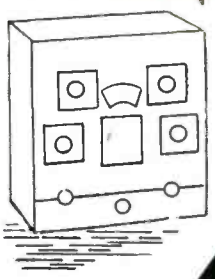


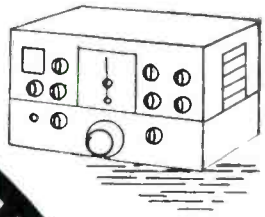
Tower for experiments in television, microwave communication, and electronic aids to navigation by Federal Telecommunication Laboratories

Basic Research Laboratory Dedicated

THE U. S. NAVAL ORDNANCE TEST STATION at Inyokern, California, in the heart of the Mojave desert, recently dedicated the huge new Michelson Laboratory honoring the late American physicist and Nobel prize winner, A. A. Michelson. Said to be the most complete basic scientific research facility of its type

Engaged in research on the physics of the upper atmosphere, C. T. Elvey is shown at work in the Navy's new air-conditioned super laboratory in the heart of the Mojave desert





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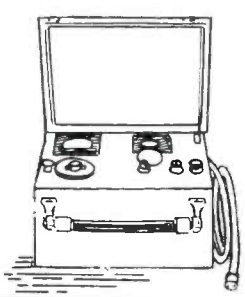
THEN **Lavoie Laboratories can be of invaluable, practical assistance. We have the Engineering Staff—the shop techniques—and the reputation to satisfactorily meet those requirements.**



• We shall be very glad to discuss any phase of UHF work with you. No cost or obligation involved. A resume of LAVOIE facilities may be had if you will address us on your letterhead.

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

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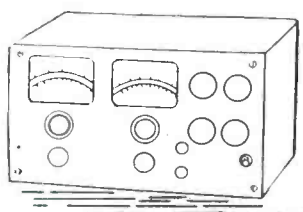


Specialists in the Development and Manufacture of UHF Equipment

MEETINGS

JULY 14-16: International symposium on noise, held by the Acoustics Group of the Physical Society and the Roger Institute of British Architects, at the Royal Institute, Portland Place, London, W. 1.

AUG. 20-29: All-Electrical Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

AUG. 24-27: AIEE Pacific General Meeting, Spokane, Wash.

SEPT. 4-6: ARRL Convention, Milwaukee Auditorium, Milwaukee.

SEPT. 6-11: International television meeting, with exhibition Sept. 2 to 15, Swiss Federal Institute of Technology, Zurich. Address inquiries to Secretariat, International Television Meeting, Gloriastrasse 41, Zurich 6, Switzerland.

SEPT. 13-17: Third Instrument Conference and Exhibit, Convention Hall, Philadelphia, Pa.

SEPT. 20-23: Annual meeting, Associated Police Communication Officers, Inc., Rice Hotel, Houston, Texas.

SEPT. 27-OCT. 1: Third National Plastic Exposition, Grand Central Palace, New York City.

SEPT. 29-OCT. 2: Pacific Electronic Exhibition and IRE west coast Annual Convention, Biltmore Hotel, Los Angeles, Calif.

OCT. 5-7: AIEE Middle-Eastern District Meeting, Washington, D. C.

OCT. 11-12: FM Association Second Annual Convention, Sheraton Hotel, Chicago.

OCT. 25-29: 64th semiannual convention, Society of Motion Picture Engineers. Hotel Statler, Washington, D. C.

NOV. 4-6: National Electronics Conference, Edgewater Beach Hotel, Chicago.

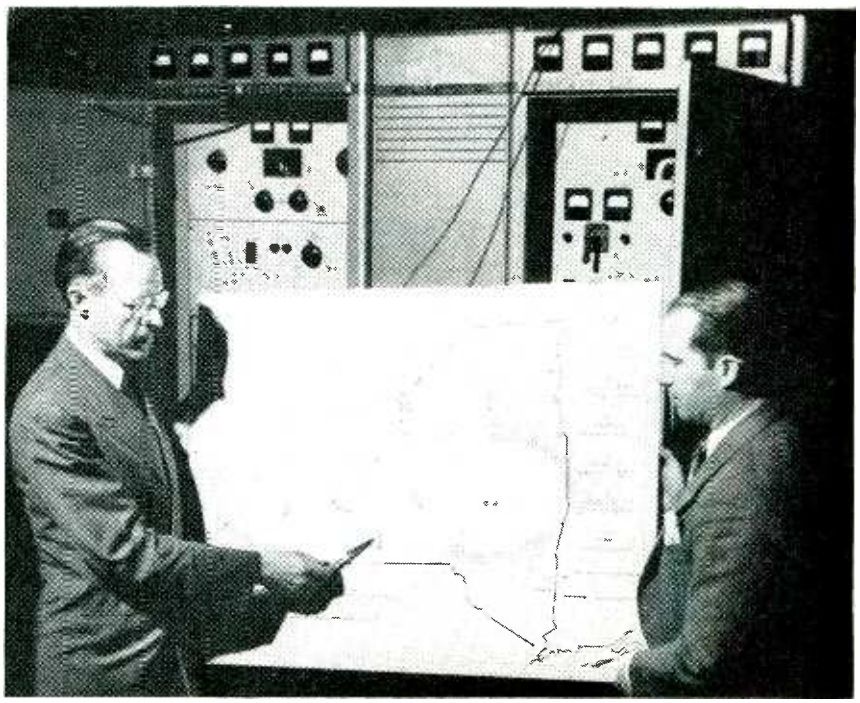
NOV. 29-DEC. 4: 18th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York.

in the world, the new air-conditioned structure covers more than seven acres. Construction costs were over six million dollars.

Scientists working at Inyokern have already developed a new system of photographic analysis capable of accurately magnifying time by some four million times. This "synchronized micro-time photography," used in studies of bullets in flight, is only one of many important projects under way at the desert base.

The Michelson laboratory contains facilities for basic and applied research in the fields of physical and chemical science, aero-physics,

(continued on page 199)



Before a transmitter slated for use by the network, G-E employees W. R. David (left) and W. G. Broughton discuss technical details involved in the Rural Radio Network. About 76 percent of the farms in New York State will be covered by the chain

Farmers' F-M Network

THE RURAL RADIO NETWORK, a chain of six f-m stations to serve 118,000 farms in 40 counties in upper New York State, is expected to be in operation early this summer. Most of the necessary equipment has already been shipped by General Electric Co.

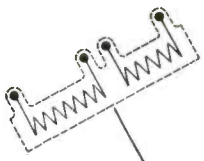
Plans call for operating the six stations as a network with each station simultaneously receiving and transmitting particular programs of interest to farmers. Stations will be at Ithaca, DeRuyter, Cherry Valley, Turin, Bristol Center and Wethersfield, N. Y.

NEW OFFICERS FOR 1948-1949

Newly elected board of directors of the West Coast Electronic Manufacturers Association are, left to right, front row: Ed Grigsby, Altec-Lansing Corp. (treasurer); Wallace Walgren, Electro Engineering Works; James L. Fouch, Universal Microphone Co. (president); Noel Eldred, Packard-Hewlett Co. (secretary), and William Hewlett, Packard-Hewlett Co. (vice-president). Second row, left to right: Robert Newcomb, Newcomb Audio Products Co.; Jack McCullough, Eitel-McCullough, Inc.; John Kaar, Kaar Engineering; Lew Howard, Triad Transformer Mfg. Co.; O. H. Brown, Eitel-McCullough, Inc.; Herb Balderson, Thermador Electrical Mfg. Co.; Fred Falck Jr., Advance Electric and Relay Co.; Jim Hopkins, Girard-Hopkins Co.

IT PAYS to consider

Ward Leonard's "Result Engineering" before you specify or buy Electric Controls

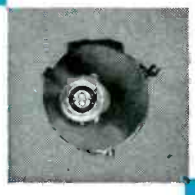


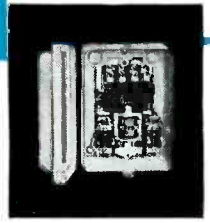
Quality construction, in a range of control devices as wide as Ward Leonard's, still may not be enough to solve *your* particular electric control problem. That's why Ward Leonard adds "Result-Engineering."

Frequently, by slight modification of a basic design or use of available components, Ward Leonard can give you the *exact* result you want —without the extra cost of a *special* design.

Here is "Result-Engineering" . . . one example of what Ward Leonard did to improve a product's performance and speed assembly: two resistors "required" for a television set were *combined* in a single unit, saving space, and cutting assembly time 40%.

Next time *you* specify or buy relays, resistors, rheostats, contactors, starters . . . before you decide to "make the best" of a "standard" component, or pay a premium for a "special", find out what Ward Leonard "Result-Engineering" can do for you.





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RESISTORS
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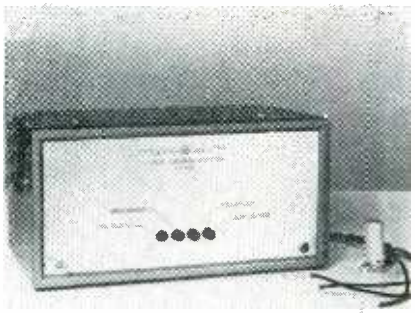
Where Basic Designs in Electric Controls are

"Result Engineered" for You

TUBES AT WORK
(continued from p 126)



Sideband selector unit and probe for connection to the receiver

that the 90-degree phase difference is not preserved outside this range. Frequencies above or below will have a phase difference other than 90 degrees and consequently, when applied to the sum and difference circuits, they will not combine algebraically to add or cancel completely. Incomplete suppression of the unwanted sideband corresponding to these extreme frequencies is the result.

Operating Unit

A single-sideband selector unit embodying the method shown in Fig. 2 and 3 is built for use in conjunction with existing a-m receivers having a nominal i-f frequency of approximately 455 kc.

The unit is attached to the receiver by means of a small probe which is connected to the last i-f stage of the receiver through a short length of low-capacitance shielded cable. The high-impedance i-f signals are transformed to low-impedance level by means of the probe, and are then fed into the selector. The only other connections between the receiver and the unit are two shielded wires for audio.

The selector permits reception of single-sideband signals with carrier, single-sideband signals without carrier, conventional a-m signals (selecting the upper or lower sideband or both), dual single-sideband signals, that is, intelligence A on one sideband or intelligence B on the other sideband with carrier or attenuated carrier and conventional shortwave broadcasts employing exalted carrier.

Selection of any of these is done by four pushbuttons on the front panel. The phase-shift networks

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THE NEW TURBO REL 16-A THERMO PLASTIC TUBING

FEATURING:

- ★ PERMANENT FLEXIBILITY
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- ★ SMOOTH WALL FINISH
- ★ EXPANDED RANGE OF WALL THICKNESSES

REL 16-A is the new heat-resistant TURBO Thermo-plastic Tubing that provides an economical and dependable solution to most electric insulating problems involving high temperature. Approved by the Underwriters' Laboratories for continuous operation at 105° Centigrade, REL 16-A safely withstands even higher temperatures intermittently, without deterioration of mechanical or electrical characteristics. In addition to complete stability under high heat, REL 16-A tubing provides permanent flexibility—maintained under severe temperature conditions, high dielectric strength, negligible moisture absorption (less than 1%). Typical applications in which this tubing offers important advantages over ordinary tubing include the insulation of coils and wiring where baking, potting or soldering is required; equipment with high thermal rise; enclosed units such as motors, generators, transformers, etc. Write today for complete laboratory test results, including UL reports, on TURBO REL 16-A. Samples on request.

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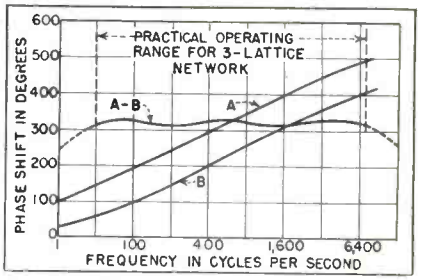


FIG. 4—Characteristics of three-lattice phase-shift network

cover a frequency range of 70 to 7,000 cycles per second. Therefore, the quality of reproduction is usually only dependent upon the i-f pass-band characteristics of the receiver.

Locked Oscillator

Should the carrier frequency delivered by the receiver tend to deviate from that of the selector's oscillator, a d-c control voltage will be delivered by the combination of oscillator frequency, intermediate frequency, and detector.

This d-c control voltage, applied in a feedback loop back to the oscillator through a reactance tube, then serves to restore the i-f carrier and oscillator to frequency synchronism. Moreover, the time constant in the d-c circuit provides the equivalent of memory; should the i-f carrier temporarily disappear because of selective fading or transmitter troubles, the locked oscillator will not get away. This is especially useful in weak-signal, transoceanic communications, and a must when the receiver is unattended over long time intervals.

This feature minimizes the need for retuning against change in transmitter frequency, change in receiver local oscillator frequency, change in selector voltages or temperatures that normally would cause frequency drift.

Satisfactory locking action is produced when the carrier of the received signal, either because of suppression at the transmitter, or because of selective fading, is as much as 20 db below sideband level. When no carrier is transmitted, no locking or control voltage is generated, so that retuning of the receiver will be necessary from time to time. For this reason a small amount of carrier, say 1 or 2 percent of the sideband energy, should

always be transmitted in single-sideband systems for use with this type of receiver.

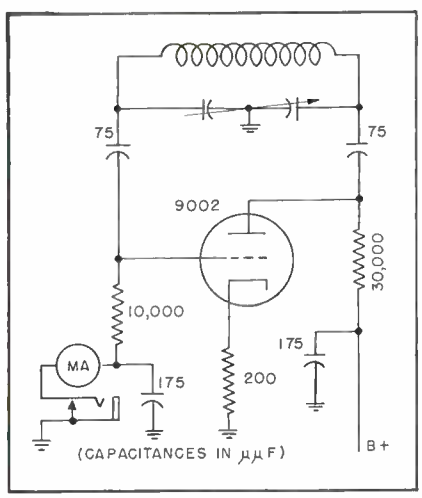
The locking circuit permits listening to a weak signal, even though a strong signal is nearby (in frequency), without the selector oscillator being captured by the stronger signal. The degree of selectivity which this makes possible cannot be fully appreciated by anything short of an actual listening test in a band of crowded signals.

Grid-Dip Oscillator

ONE of the most useful instruments in an electronic laboratory is the grid-dip oscillator with a vhf frequency range. Strangely enough, however, these have not been generally available as a commercial product until recently. Since the early days of radio, however, they have been constructed by the individual engineer to fit particular applications when needed.

The grid-dip oscillator consists of a variable-frequency oscillator with an indicating milliammeter in its grid circuit. When the oscillator tank circuit is coupled to a second resonant circuit, usually by holding the tank inductance near the second tuned circuit, a dip in the grid current indicates the frequency at which power is drawn from the oscillator. A frequency-calibrated dial on the oscillator then indicates the frequency at which resonance occurs.

The resonant frequency of any coil and capacitor combination,



Circuit of the probe portion of the De Vine grid-dip oscillator

The oscillator forms a probe

alone or connected into circuits, resonant lines, wave traps, r-f chokes, and antennas, can thus be determined quickly and changes made to tune them to the desired frequency. Additional capacitance of tubes and wiring needs to be taken into account however if the unit being measured is not connected to its final operating circuit. The frequency change due to tube heating, which is particularly large at the i-f and front-end frequencies used in f-m and television receivers, can be readily determined with the grid-dip oscillator. The frequency at which wiring between components resonates may also be determined.

The circuit of one of the grid-dip oscillators recently announced by De Vine Laboratories is shown in the accompanying diagram. In addition to operation as a grid-dip oscillator it permits the addition of earphones in the grid circuit so that the instrument becomes an oscillating detector for beating against an unknown signal for determining its fundamental and harmonic frequencies.

Use of the headphones also permits operating the tube without plate voltage to form a diode detector for modulated signals from a transmitter or signal generator. Removing the headphones in this

Part illustrated, known as a transfer contact holder was transfer molded of black phenolic for International Business Machines Corporation, New York.

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Many of the functional elements in today's business machines are carefully thought out precision pieces — molded in plastics.

Adoption, generally, has been based upon their superior physical properties, structural strength, lighter weight . . . and also because of the molder's ability for maintaining closest tolerances and model-like quality duplication in quantity.

By proper engineering, a single plastic part often does away with extra separate parts. By integrating contact points, threaded bushings and metal inserts into the one molded piece, costly bench assemblies and hand-set fittings are completely eliminated. Thus . . . plastic parts, in themselves less costly, tend also to further lower the manufacturer's production costs.

The functional plastic part pictured here was Consolidated-molded for International Business Machines Corporation. It serves as the rear frame for a Silent Rotor Secondary Clock. Molded securely in place, as part of the one piece, are four intricately designed, specifically positioned transfer contact points. And, similarly to the many other plastic units we process for this company's highly regarded equipment, this little part plays an important role.

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instance switches the meter back in the grid-cathode diode circuit and permits use as an absorption frequency meter or a field strength meter.

The instrument shown employs seven plug-in coils to cover a frequency range from 1.9 mc to slightly over 200 mc. Each coil is mounted inside a polystyrene cylinder so that it can be inserted in and near tank coils having high voltage without contact to the turns of the coil. The coils are tuned by a split-stator capacitor having specially designed plates to allow a nearly linear dial calibration in terms of frequency.

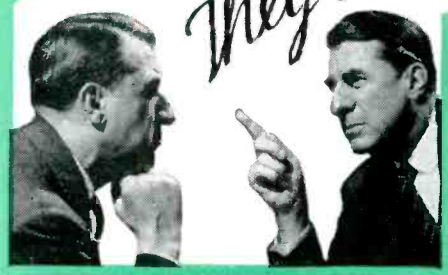
Elements of the circuit shown are mounted in a narrow metal case so that the coil, tuning capacitor, grid meter, and a drum dial are arranged in line. Thus the unit is practically a probe with its coil at one end, and dial at the other end. Having the meter mounted on this unit permits readings to be made while watching the dial when tuning through the range.

Fluoroscope Image Amplifier

A NEW high-vacuum tube electrostatically focuses and accelerates an electron stream to increase the brightness of a fluoroscope screen by 500 times.

With present fluoroscope techniques, the physician must dark-adapt his eyes for twenty minutes to see the image. If he examines a large abdominal thickness the brightness may be as low as 0.00005 millilambert, while a separation of 0.25 inch is necessary before contours between black and white can be distinguished. A brightness of 0.001 millilambert with a contour separation of 0.03 inch is about the center of the fluoroscope range.

The new image amplifier, announced by Westinghouse X-Ray Division at Baltimore, increases the brightness of the fluoroscopic image after the x-rays have passed through the patient. This technique is necessary because the x-ray intensities are already at the patient's tolerance level and is possible because the sensitivity of the physician's eyes are the main limitation to effective fluoroscopy today. Present fluorescent screens have a



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HEINEMANN

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well-known manufacturers of dental X-ray apparatus, say in their descriptive folder, "The line switch is also a safety circuit breaker and is not only a guarantee of electrical and overload safety, but also prevents the line fuse from burning out."

Unfailing, instantaneous, magnetic action is the reason why manufacturers of intricate and delicate instruments depend upon HEINEMANN CIRCUIT BREAKERS for protection against the disastrous effects of short circuit or sudden dangerous overload. However, unnecessary tripping is avoided by means of a time-delay mechanism (a plunger which moves in a liquid-filled, hermetically-sealed tube) which allows passage of inrush current or harmless temporary overload.

Your equipment may require just such flexible yet positive protection. Find out just how the magnetic action of the HEINEMANN CIRCUIT BREAKER can be adapted to your needs.

Close-up of top of cabinet of dental X-ray apparatus showing position of breaker.

Single Pole Auxiliary Breaker

HEINEMANN ELECTRIC COMPANY

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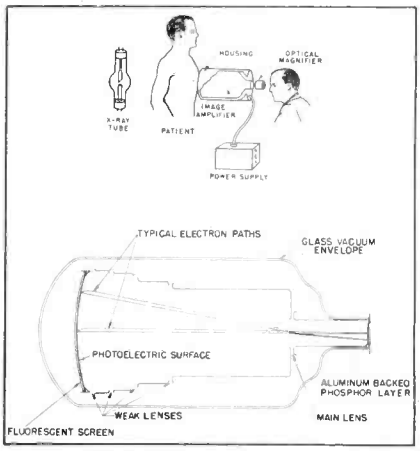
gross efficiency of about three percent so that even a theoretically perfect screen would be only about thirty times as bright.

With the image amplifier tube, the physician will see at once an image almost as bright as a movie screen. He may still dark-adapt his eyes for about three or four minutes to see all the details of the patient's organs at work.

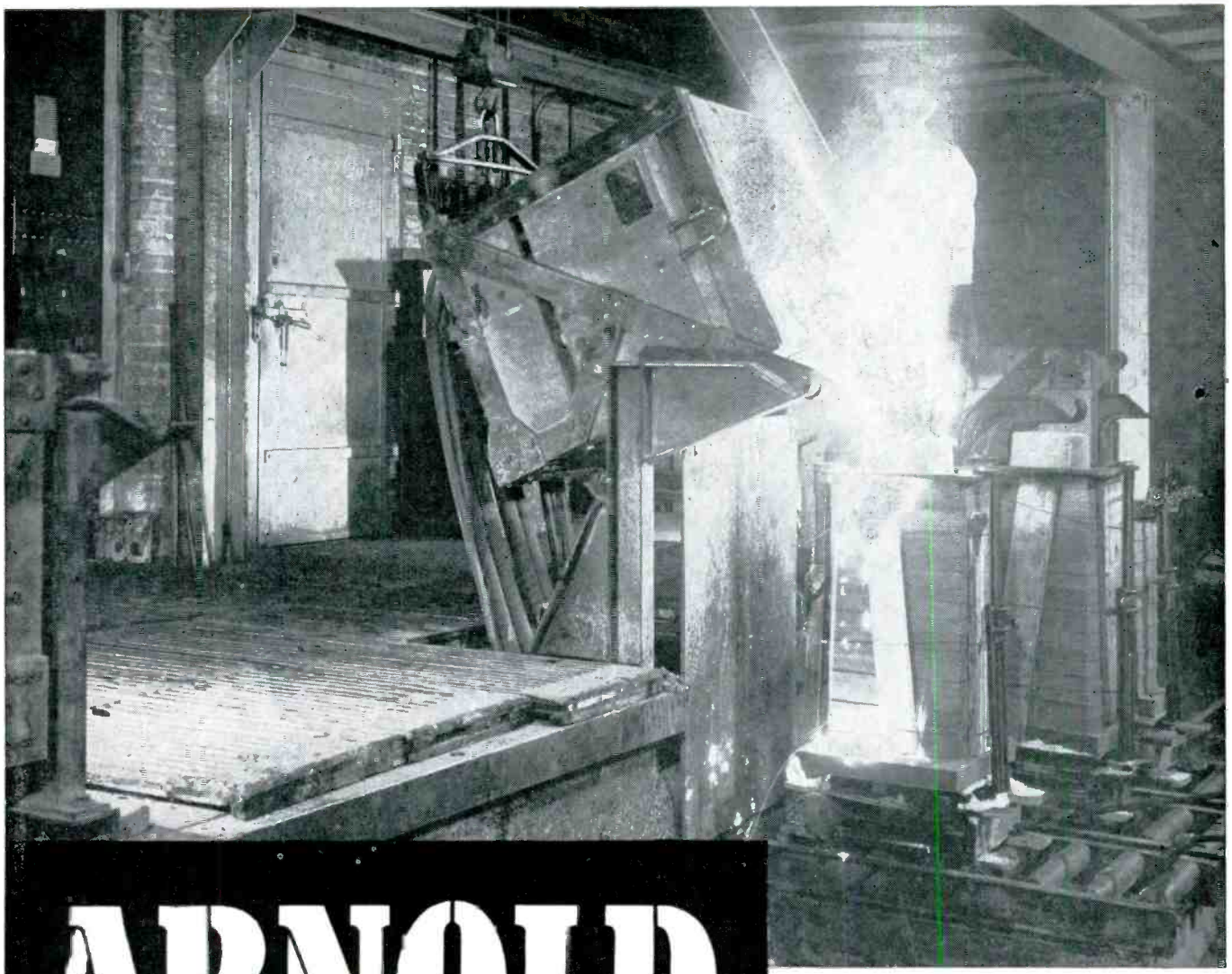
Figure 1 shows the elements of the tube used to increase brightness of the x-ray image. The x-ray quanta is converted into light with a fluorescent screen and thence to electrons by means of an adjacent photo-electric surface. These electrons are accelerated by a high



X-rays that have passed through the patient strike the fluorescent screen at left and produce light photons that eject electrons from the photoelectric surface. The electrons are electrostatically accelerated and focused to form an inverted smaller image on the phosphor at right. Optical magnification brings this image back to the original five-inch size

potential placed across the vacuum tube, giving a brightness gain of 20 times. A further factor of 25 in brightness gain is attained by electrostatic focusing of the electron stream to reduce the image to 1/5 of its size. The reduced image, now brightened 500 times, impinges on a phosphor output layer that converts it back to a visible image which is observed through a conventional optical system that magnifies it by a factor of 5 back to its initial size.

The intensification achieved by reducing the image size in the electron optical system is possible because the brightness is increased in inverse proportion to the area. This is so because all the electrons



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Cutaway view of the image amplifier tube. Its principle of operation is reminiscent of the Snooperscope and Sniperscope used for infrared viewing during the war

are utilized in forming the image. When the area is reduced, the total energy therefore remains constant. Thus the energy per unit area, which is proportional to brightness, must go up. The reduced image seen through an ordinary optical magnifier appears in its original size without losing the brightness gained in the electron-optical reduction.

The image amplifier will permit shorter examinations and allow use of the wafer grid, stereofluoroscopy and even televising of fluoroscopic images.

Elevator Signal Button

THE push-button era is past; now all one has to do is touch the button. Essentially, the new system developed by Otis Elevator Co. consists of a cold cathode, gas triode that replaces the conventional mechanical push-button and its associated relays. Auxiliary electronic equipment controls the elevator stopping system and provides the power supply.

Simple Signal Wiring

Among the advantages obtained by this development are: The push-button, in operating, produces an indicating light to assure the passenger that his signal has operated the equipment, and without requiring auxiliary return wires from the central control station in the motor penthouse. Because there are no

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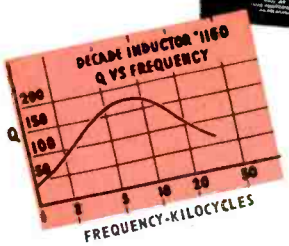
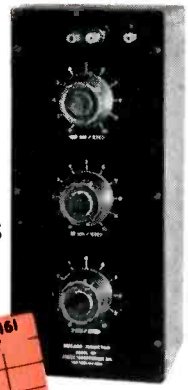
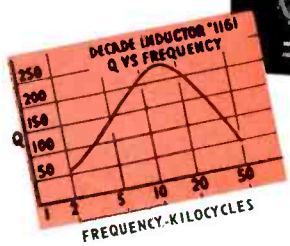
No. 1160
10 x 1 HY steps
10 x .1 HY steps
10 x .01 HY steps
500-15,000 cycles

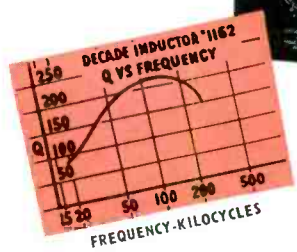




No. 1161
10 x .1 HY steps
10 x .01 HY steps
10 x .001 HY steps
2000-50,000 cycles



No. 1162
10 x .01 HY steps
10 x .001 HY steps
10 x .0001 HY steps
10,000-300,000 cycles



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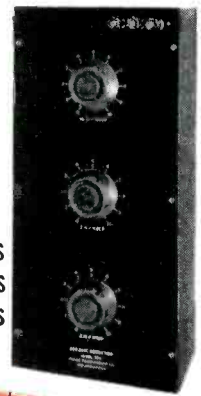
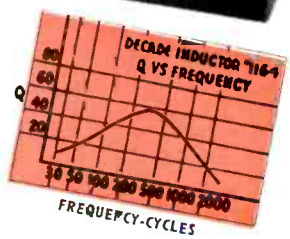
Primarily designed for use in wave filters, tuned circuits and equalizers for audio and supersonic frequencies. The stability, accuracy and high value of Q make these Decade Inductors invaluable laboratory instruments.



No. 1164
10 x 10 HY steps
10 x 1 HY steps
10 x .1 HY steps
50-1000 cycles



Toroidal Inductors

High quality toroidal coils wound on molybdenum permalloy dust cores. All those listed below can be supplied in hermetically sealed cans, commercial type construction or open units. Other types can be supplied out of stock on special orders.

Type T1
1000-15,000 cycles

Inductance Value	Type #
5 MHY	F-800T
10 MHY	F-801T
15 MHY	F-802T
30 MHY	F-803T
50 MHY	F-804T
75 MHY	F-805T
100 MHY	F-806T
200 MHY	F-808T
500 MHY	F-809T
750 MHY	F-810T
1 HY	F-811T
1.5 HY	F-813T
2 HY	F-815T
3 HY	F-819T
4 HY	F-821T
5 HY	F-823T

Type T1-2
2000-30,000 cycles

Inductance Value	Type #
1 MH	F-1800
2 MH	F-1801
3 MH	F-1802
4 MH	F-1803
5 MH	F-1804
10 MH	F-1805
15 MH	F-1806
30 MH	F-1807
50 MH	F-1808
75 MH	F-1809
100 MH	F-1810
150 MH	F-1811
200 MH	F-1812
300 MH	F-1813
400 MH	F-1814
500 MH	F-1815

Type T1-3
10,000-300,000 cycles

Inductance Value	Type #
5 MH	F-1850
1 MH	F-1851
2 MH	F-1852
3 MH	F-1853
4 MH	F-1854
5 MH	F-1855
10 MH	F-1856
15 MH	F-1857
20 MH	F-1858
30 MH	F-1859
40 MH	F-1860
50 MH	F-1861
75 MH	F-1862
100 MH	F-1863

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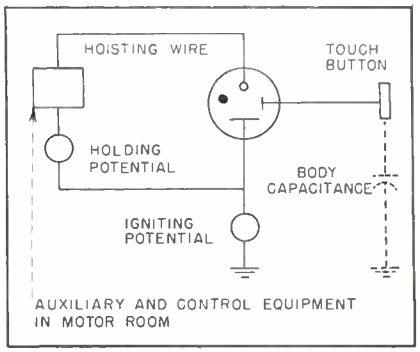

Basic circuit of electronic button; circuit values can be adjusted so that merely pointing at the button fires the tube

moving parts associated with the electronic switch, its life and protection from jamming are improved.

The electronic relays operate on potential difference, rather than on current differences as do electromagnetic relays, so cabling is not required to carry high current (although the gage of the wiring is determined by its mechanical strength which must be sufficient to withstand the strain of pulling it through the conduits during installation, rather than by its current-carrying ability). William Bruns, electrical engineer in charge of electronic development, prefers the electronic signaling system because it permits using high-impedance circuits. However the impedance that can be used across the signal lines with the electronic system is limited by the noise picked up from stray fields in the building; it is necessary to load the lines below the value determined by the electronic equipment itself to prevent false operation.

In addition, operation of electronic equipment is done by potential differences permitting a much wider variation in power supply voltages than is tolerable with relays. The limits of power supply variation with relays are set by the relay pulling in due to over-voltage thus giving false indications, and failing to pull in due to under-voltage. Similar limits exist for gas tubes, but the limits are wider. In the application to elevator signalling, a change in power line voltage from 100 to 150 volts is tolerated by the equipment. An autotransformer supplies the equipment with voltage centered in the tolerance range.

The "touch button" consists of

Which of these practical ideas can YOU use?

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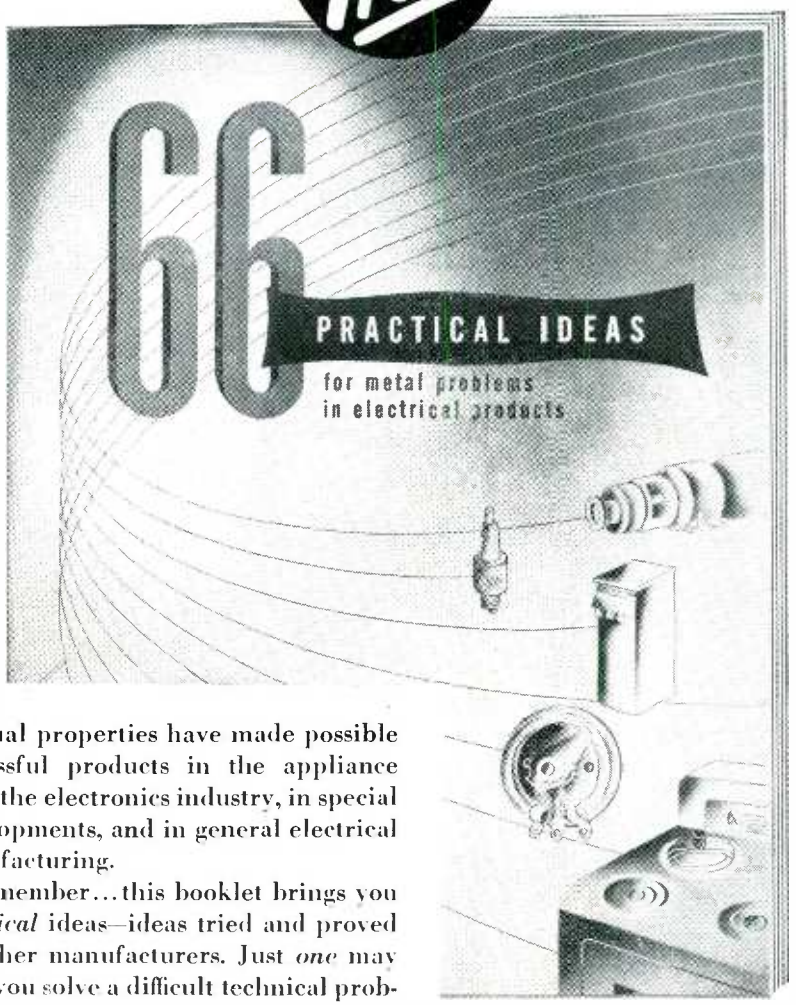

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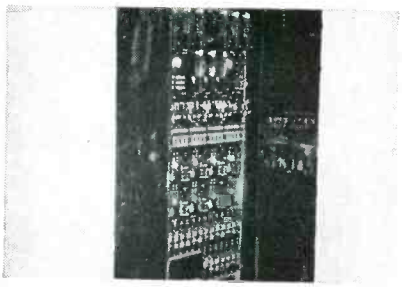


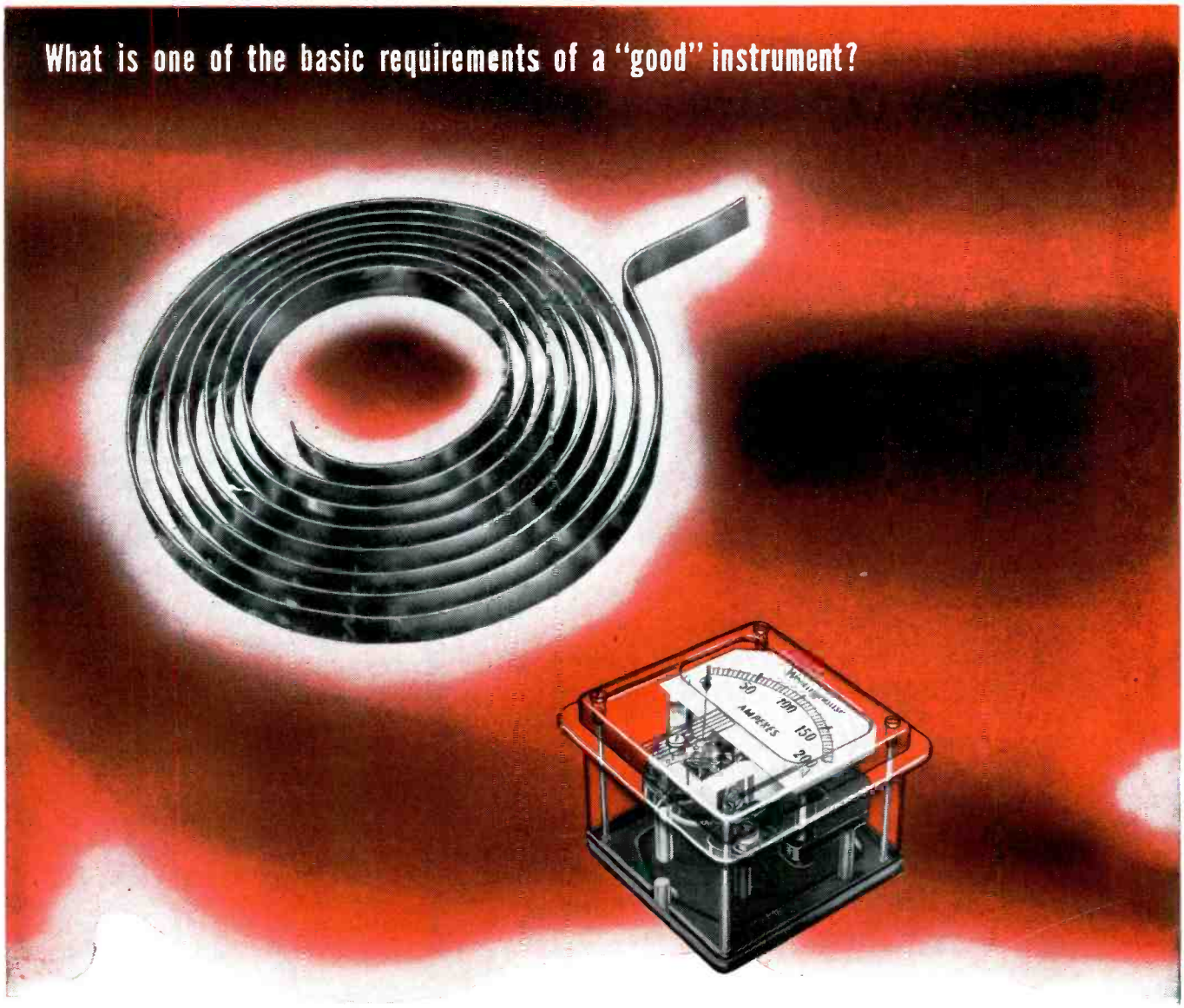
Elevator-control thyratrons and resistance-capacitance circuits are in the lower portion of the rack that houses the rectifiers (top) for the signaling system

a gas triode (similar to an 0A4G) connected as shown in the accompanying diagram. An electrode connected to the control grid is molded into the colored arrowhead of the signal button (red arrow for down, green arrow for up). When one touches the appropriate arrow, body capacitance to ground (metal building frame) closes the circuit thus triggering the tube. The tube is located directly behind the arrow. All tubes on a floor for a given direction are connected together so that touching one lights all.

When the tube fires, it establishes a potential on the floor selector controller on the elevator lift mechanism in the motor penthouse. When the floor selector contacts the potential bearing brush, it cancels the call, extinguishing the tube, and stops the elevator at the floor.

Part of the electronic control installed for the first time in the Universal Pictures Building, New York, is a time delay adjusted to start cycling every time a signal tube fires. The time delay is adjusted to the interval normally required for an elevator to stop at a floor, discharge and take on passengers, and accelerate. If no elevator is in motion after this interval (such as at night when the elevator bank is attended by the watchmen) following the firing of a tube, the time delay sounds a buzzer in the elevators to alert the operators. The time delay continues recycling until interrupted by a signal from a moving elevator.

The equipment that the electronic system replaced consisted of a bank of multicontactor relays and multiconductor cables to all floors. The gas tubes at each floor replace the relays and fewer cable pairs are required to all floors. Although



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electronic signal control is applicable to elevator installations in any building, the present installations are being made in large buildings where elevators travel at 500 feet per minute or faster.

Single-Sideband Converter

IN keeping with the current interest in single sideband reception, the circuit of the Millen adapter unit is shown in the accompanying diagram. It consists of a crystal-controlled low-frequency converter designed to adapt communication receivers for selectable single sideband reception. Eliminating one of the side bands by selection reduces interference, both from the standpoint of noise, and heterodyne signals, owning to the reduction of the normal receiver bandwidth to approximately 25 percent.

The unit consists of a crystal-controlled oscillator and a mixer which converts the normal 455-kc i-f to 50.5-kc; an i-f amplifier with four high-Q tuned circuits; a detector and audio amplifier, and a power supply. A lever-type switch mounted on the front panel switches the oscillator crystal to provide either 49.5 or 50.5 kc to select the sideband which is to be passed.

The 455-kc output from the receiver is coupled to the sideband selector by a small loop on the input cable which is slipped around the diode plate pin on the receiver detector tube. The audio output of the selector can be used directly for headphone reception or the output may be fed into the audio amplifier in the receiver for loudspeaker reception.

The normal receiver audio gain control is turned off so that the output from the receiver detector does not get into the audio amplifier. In some receivers the leakage may be such that it will be necessary to disconnect the first audio amplifier tube.

The i-f transformers T_1 and T_2 are aligned to 50.5-kc and, with the switch in the upper sideband position, the response at 50-kc is about 5-db down.

When the switch is in the double sideband position, T_2 has been retuned by capacitor A to 49.5-kc and this (plus T_1, which is still tuned

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Samples illustrated, from top to bottom:

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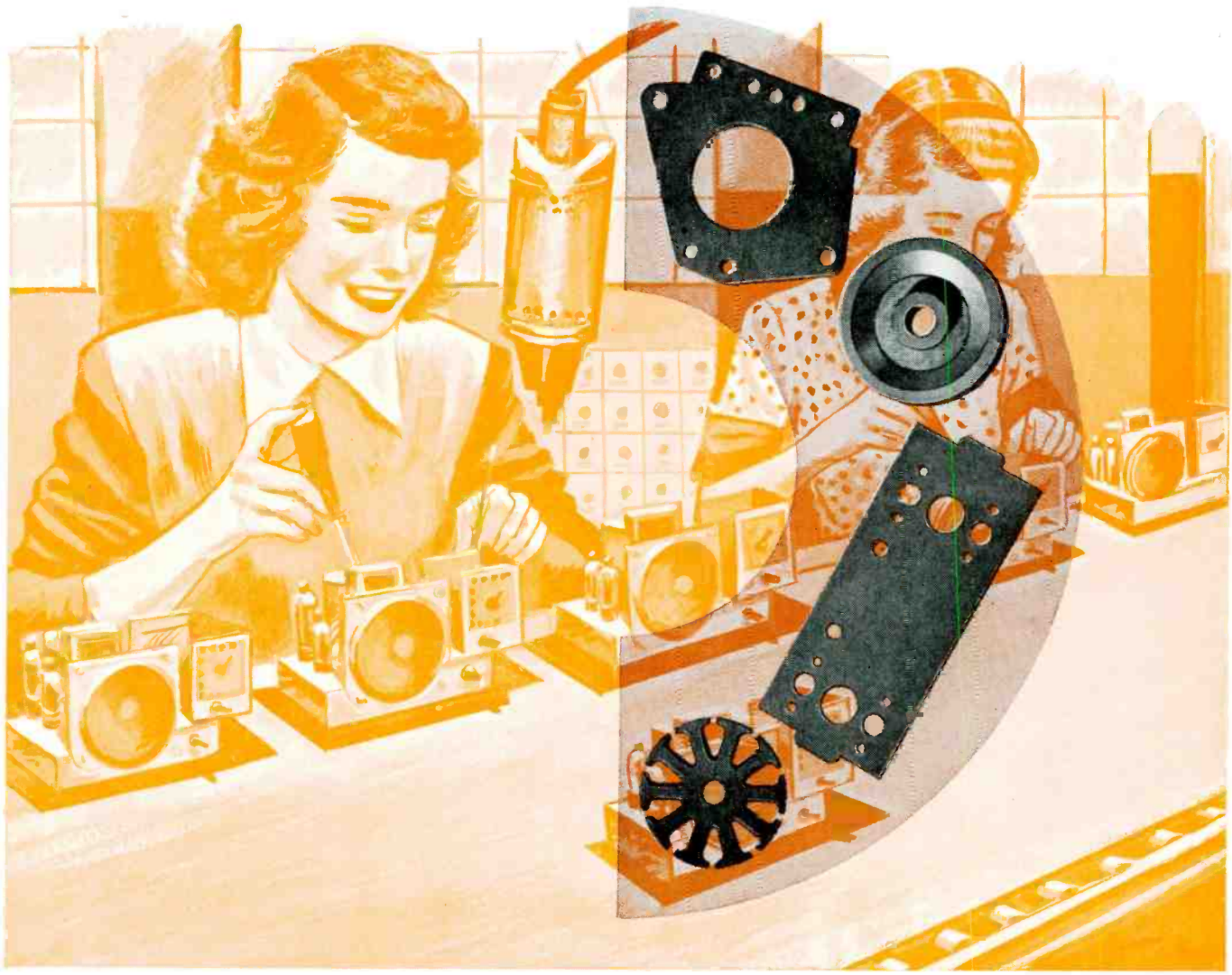
Pulley, machined from Vulcanized Fibre sheet.

Switch back plate. Phenol Fibre.

End lamination for small motors. Vulcanized Fibre.



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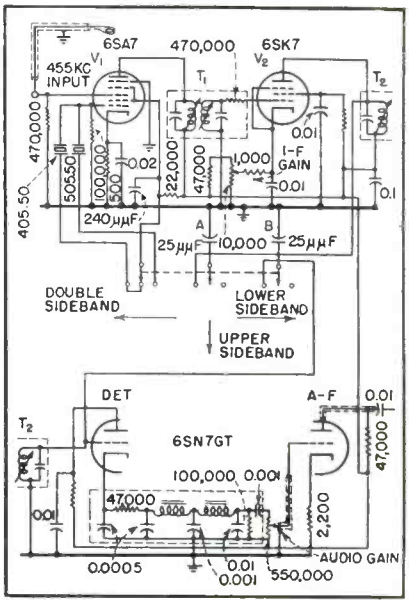


Circuit diagram of the single-sideband converter

to 50.5-kc) results in a sharp-nosed curve ideally shaped for aural carrier tuning peaked at 50-kc. This double-sideband tuning position can be used for normal operation. Its selectivity is high enough to attenuate most high-frequency heterodynes lying above 2,000 cycles.

When the interference gets bad and the off-frequency carrier gets in closer so that the beat note drops to 1,000 or 500 cycles, one of the single sideband positions is switched in, and the tuning control rocked slightly. If the heterodyne persists, the other sideband is switched in and the tuning control rocked again. For maximum rejection it is necessary to climb up slightly on the low-frequency side of the curve to a point about 5-db below the peak.

The first section of the 6SN7GT operates as an infinite-impedance detector, and the second section of the tube is used as an audio amplifier. A high-pass filter having high attenuation to frequencies below 300 cycles is installed in the audio circuit. This filter not only removes undesired low-frequency beat notes, but makes speech sound natural by attenuating the lows in proportion to the highs. It also takes out some of the noise.

X-Raying Flier Reactions

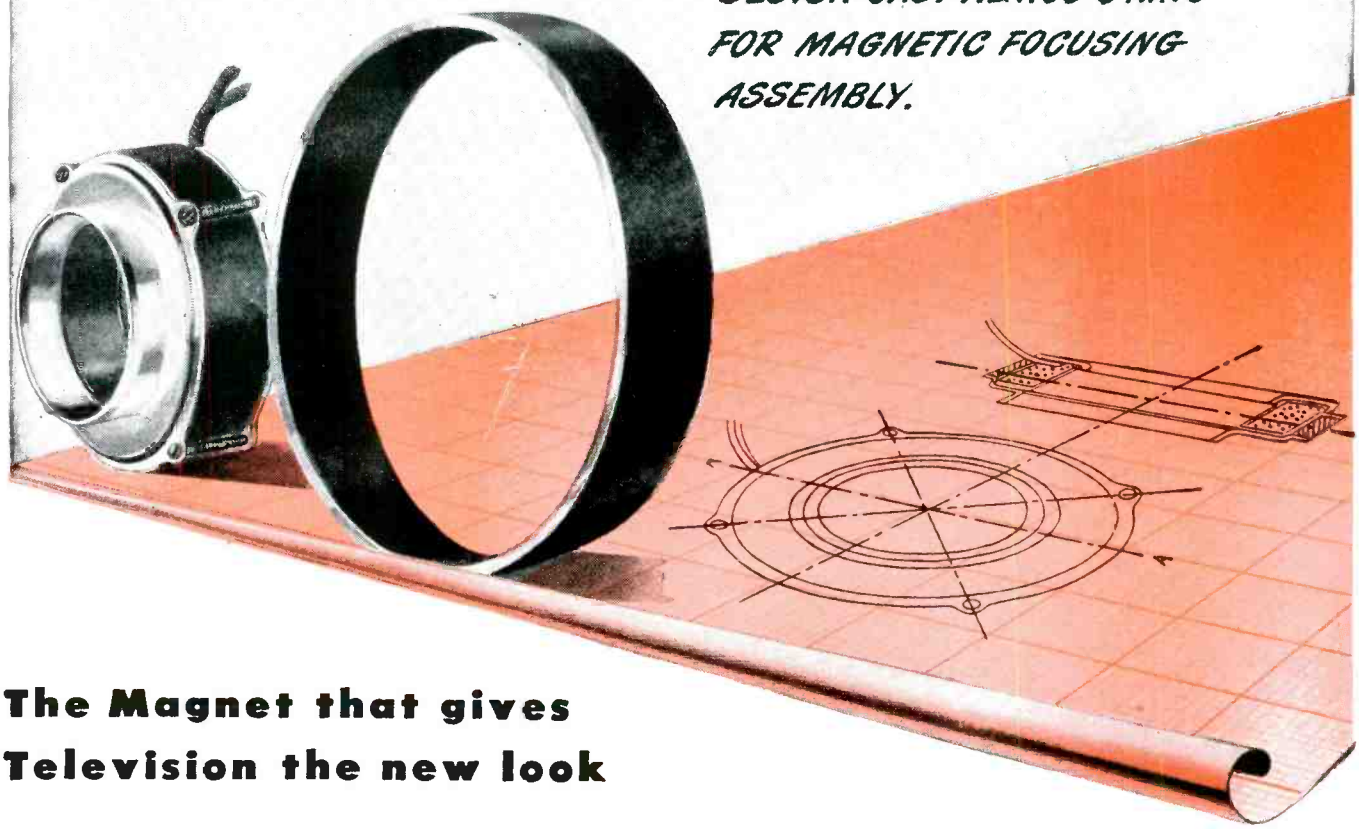
How a flier reacts physically to the strain of a crash landing or the

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS

New Magnetic Focusing Assembly by G.E.'s Electronics Department

PROBLEM—

DESIGN CAST ALNICO 6 RING FOR MAGNETIC FOCUSING ASSEMBLY.



The Magnet that gives Television the new look

Now it's permanent magnets for better television reception. The permanent magnet shown above keeps electrons on the beam . . . eliminates blurring of the television picture. Once the set has been focused further adjustments are unnecessary. And, the use of a G-E permanent magnet results in greater efficiency since no heat is generated by the Cast Alnico ring magnet.

An outstanding feature of this ring magnet is the very thin wall section developed by G-E process engineers. Heretofore this was possible only with sintered magnets. Better permanent magnets as well as new applications are constantly being developed by G-E engineers.

Perhaps you can improve the efficiency of your product with G-E permanent magnets. General Electric will be glad to work with you to improve your product. Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. All are produced under rigid quality control methods. This assures you of receiving magnets of the highest uniform quality for your application.

Clear, sharp television reception with the new G-E Magnetic Focusing Assembly.

The magnetic field set up by the assembly focuses the electron beam on the television screen. The combined effect of the G-E Cast Alnico 6 permanent magnet and a small coil produces this magnetic field axial with the tube neck. The ring magnet supplies the bulk of the magnetic flux while the coil acts as a vernier adjustment. The punched pole pieces collect the magnetic flux and direct it into a uniform radial pattern.

Outstanding advantages of this new assembly are increased efficiency and compactness. Defocusing due to line voltage fluctuation and warm-up drift is eliminated.

METALLURGY DIVISION
CHEMICAL DEPARTMENT, SECTION CM-7
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.

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PERMANENT MAGNETS

GENERAL ELECTRIC

CD48-V8

shock of being catapulted from a crippled plane is being determined in one of the more recent uses of millionth-of-a-second x-ray equipment. Both Army and Navy medical laboratories are making sequence photographs to obtain visual evidence of what happens to a pilot's spine, heart and other organs under such conditions, according to Charles M. Slack, research director of Westinghouse Lamp Division.

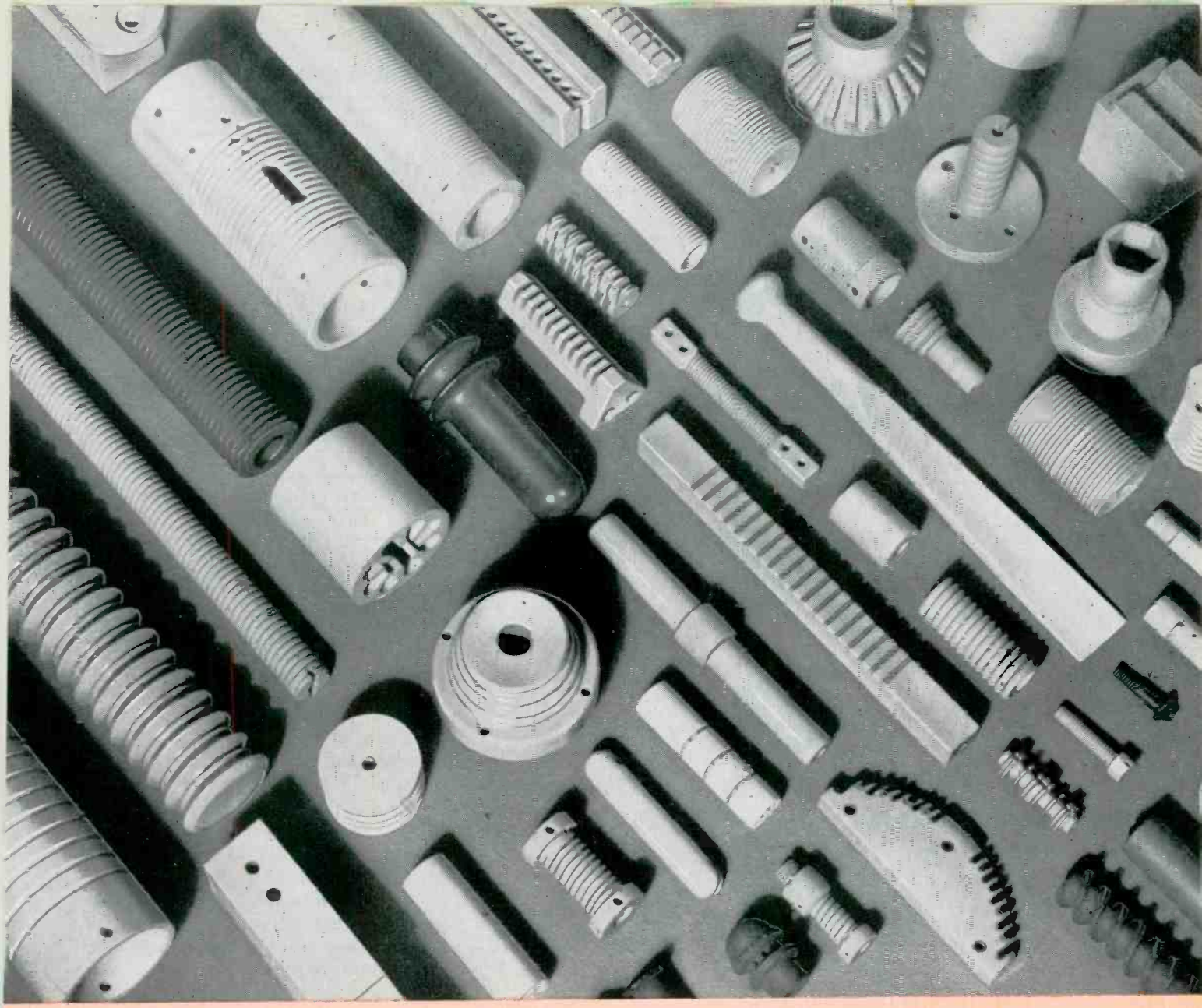
In crash landings, a flier undergoes a shock equivalent to 10 times that suffered by a motorist if he could halt his machine in one second from an 85-mile-an-hour speed. Body harnesses cushion such deceleration blows, but more knowledge of the action of the body organs may be of value in further solving the problem.

At supersonic plane speeds, a pilot would be cut to ribbons by the wind if he tried to climb out, so a catapult throws him out when a button is pushed.

The high acceleration necessary to get the pilot out without his striking the plane causes a violent jolt to his organs, about 20 times as severe as the normal pull of gravity. X-ray studies of ejection-seat body bending, and studies of the proper amount of explosive force required to fire pilots out of the cockpit, are under investigation.

R-F HEATING TRUNK

Diathermy treatments are given sick elephants at the Olympia circus in London when they develop fibrositis of the trunk in wet windy weather



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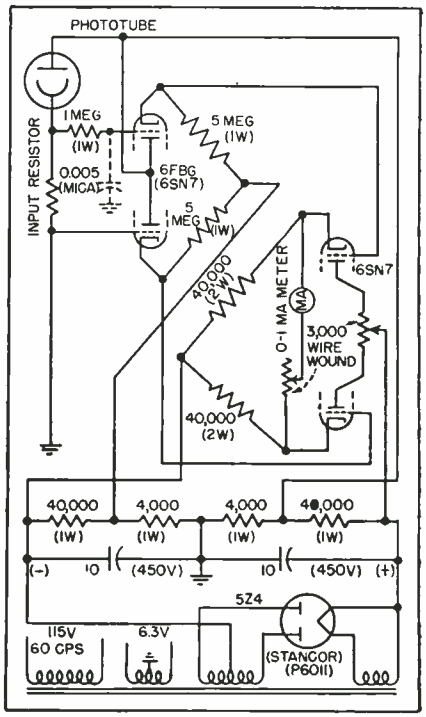
THE ELECTRON ART

(continued from p 130)



Circuit of stable current amplifier

ation is measured with a platinum, zirconium, or tantalum phototube. Current flowing through the phototube in the presence of radiation passes through a large resistance to develop a voltage output. An economic and stable current amplifier was developed for use under these conditions. It is compact and sufficiently rugged to be mounted on manufacturing machinery for quality control. The circuit is shown in the accompanying diagram.

Circuit Considerations

Because the load resistor used with the phototube is of very high resistance, the amplifier must have a high input impedance. The vacuum tube bridge circuit chosen has the necessarily high input impedance and low reverse grid current without requiring regulation of the plate supply. Gas current is minimized by keeping the plate voltage of the first stage low (about 17 volts) and by choosing proper grid bias. The load resistors in the cathode circuit make the amplifier highly degenerative resulting in a very small net change in grid voltage with signal voltage applied and a correspondingly small grid current change. The measured gas current is 75×10^{-6} microamperes, compared with the phototube cur-

rent of 500 × 10^{-6} microamperes. To obtain sufficient current to operate a 0-1 ma meter, a second stage of amplification is used.

The balanced circuit stabilizes the amplifier against changes in power line voltage. Dual triodes are used because changes are likely to affect both sections more equally than they would were each triode, in a separate envelope, and especially because the gas currents will be equal during the life of the tube. A 30 percent change in line voltage (90 to 130 volts) moves the zero setting only 4 percent of full scale.

Because voltage amplification is not needed in this application, the stability is readily obtained by

Spectral response at 1,850 and 2,537 Angstroms are measured in laboratory by placing photometer above lamps

making both stages highly degenerative. Thus a 1.5-volt input produces full scale deflection with maximum sensitivity; 6 volts produce minimum sensitivity.

Although the leakage of the 6SN7 is negligible, a 6F8G double ended tube, dipped in wax, was used to reduce possible leakage during high humidity. However, almost any double triode would be satisfactory in this highly degenerative circuit. The input resistor was sealed in a glass tube and waxed to further prevent leakage at the input. With the phototube and amplifier housed in a 6 × 9 × 5 inch cabinet, and with the input capacitor (which incidentally is another source of leakage) removed, the stability and shielding protected the equipment from disturbance by a spark-gap induction unit 10 ft away.

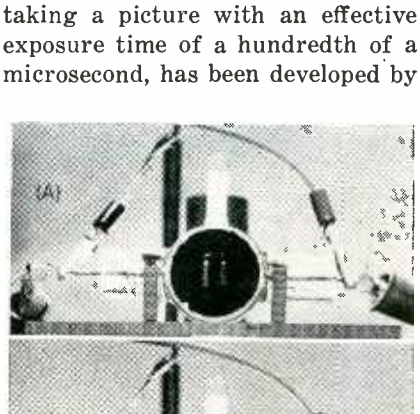
Zero drift after the first 10

minutes warmup is about 2 percent. After an hour's warmup, the drift over 4 hours was unnoticeable. An input resistor is chosen so that, with normal radiation reaching the phototube, from 1.5 to 3 volts are produced across the input. With the phototube covered, the meter is zeroed by adjusting the balancing potentiometer. With a standard source radiating the phototube, the multiplier rheostat is adjusted to give the desired meter deflection.

With a WL-782 Sterilamp about 30 inches from a tantalum phototube, and a 500-megohm resistor, and about an inch of the arc uncovered, full scale meter deflection was obtained. With a Westinghouse RS Sunlamp and a zirconium phototube similarly placed, full scale deflection was obtained at about half sensitivity. A platinum phototube is used to measure radiation near 1,850 Angstroms.

Electronic Camera Shutter

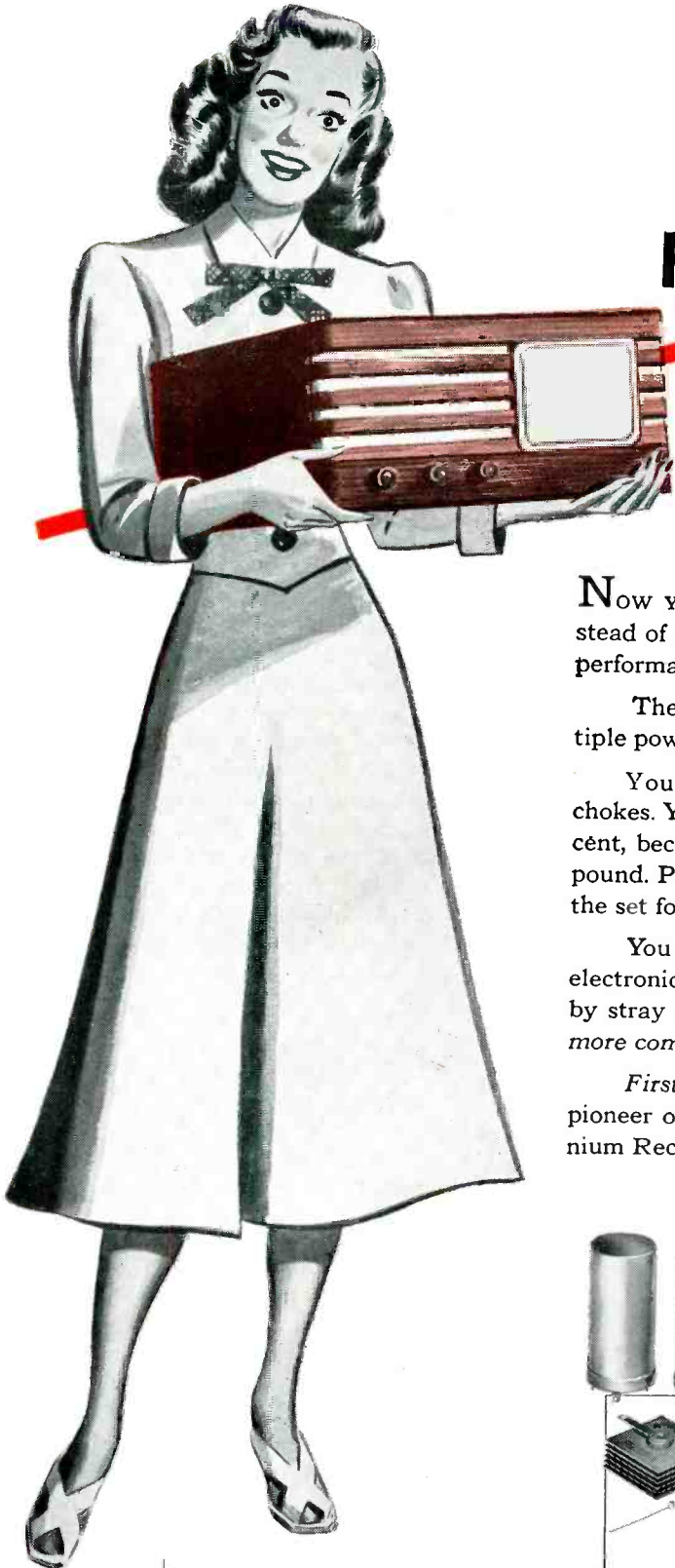
THE FASTEST SHUTTER, capable of taking a picture with an effective exposure time of a hundredth of a microsecond, has been developed by



Normally light is blocked (A), but when voltage is applied to the cell its fluid becomes birefringent enabling the light to pass both polarizing filters (B) of this electro-optical shutter

Dr. A. M. Zarem for use in synchronized microtime photography at the Navy's new Michelson Laboratory at Inyokern, Calif. This shutter is a part of the program for precision measurement of time intervals and study of high speed phenomena.

The Zarem shutter is basically a Kerr cell mounted between crossed polarizing filters. Normally light



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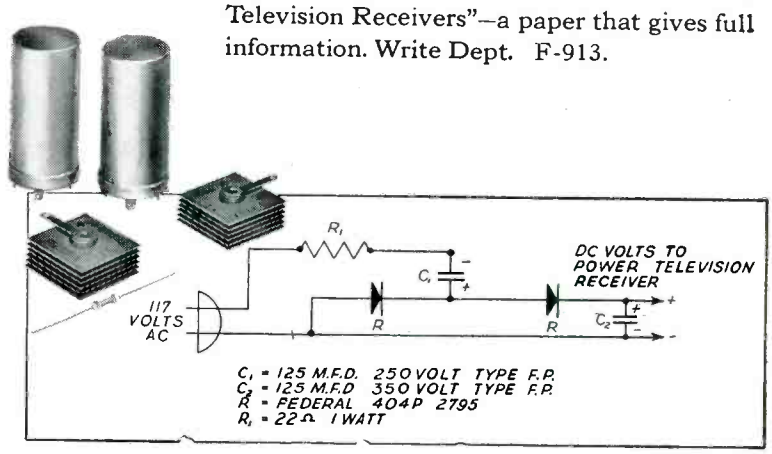

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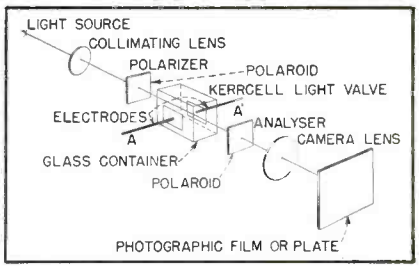


High speed Zarem shutter is Kerr cell between crossed polarizing filters

from the source is polarized in one direction by the first filter and, after passing through the cell, is blocked by the second filter. However when about 5,000 volts are applied across the electrodes of the cell the fluid with which it is filled rotates the light as it passes through so that the beam is unaffected by the second filter. The speed of exposure is controlled by the voltage pulses applied to the cell. A material that rotates the plane of polarization of light is said to be birefringent; application of the voltage makes the fluid become birefringent. The shutter can be operated at a frame rate of some 10,000,000 exposures per second.

Dynamic Sound Reproduction

By T. S. Korn

Chercheur-libre
(Research Associate)
University of Brussels
Brussels, Belgium

AMPLIFIERS for sound reproduction usually have controls for volume and tone, but not for the dynamic range, or simply the dynamics. In fact little attention is given to the ratio of the loudest to the softest levels at which music is reproduced. A qualitative survey of the dynamic requirements of reproduction has been made. A simple circuit for controlling the dynamics has been developed to fill these requirements.

Dynamics of Music

When a volume expander is incorporated in a phonograph playback or radio receiver amplifier to restore the original dynamic range, compressed for recording or transmitting, the opinion of listeners about the enhanced musical contrast is not always favorable. The

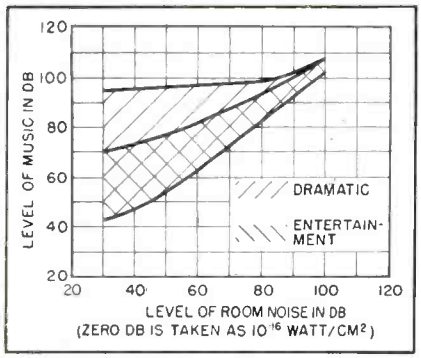


FIG. 1—Preferable dynamic range depends on the ambient noise level in the room

dynamics of music is originally suggested by the composer. The conductor may modify the dynamics in the light of his interpretation, behavior of listeners and local noise. However, the dynamics of music that is broadcast or recorded may not be appropriate for the conditions in the rooms in which it is reproduced. Hence some means of adjusting the dynamics to meet the prevailing auditory conditions is advisable.

The dynamics of music are limited on one hand by room noise and on the other by the highest admissible level for the listeners' ears. Both factors depend principally on the purpose the music is to serve. From the viewpoint of dynamics, musical programs can be classified for their dramatic or their entertainment value. Music reproduced for these two purposes requires different dynamic ranges as well as different average volume levels.

Audience Reaction

High fidelity reproducing systems should be designed to reproduce the full dynamic range of the program. However, listeners demand two types of reproduction, as indicated above: dramatic reproduction in which the listeners' attentions are concentrated on the program, and entertainment reproduction in which the program is an unobstrusive background to other interests. In dramatic reproduction, room noise is usually low (30 to 40 db) and a high level of forte (90 to 95 db) is acceptable, giving a dynamic range of from 40 to 50 db. On the other hand, entertainment reproduction is usually required in noisy rooms (60 to 90

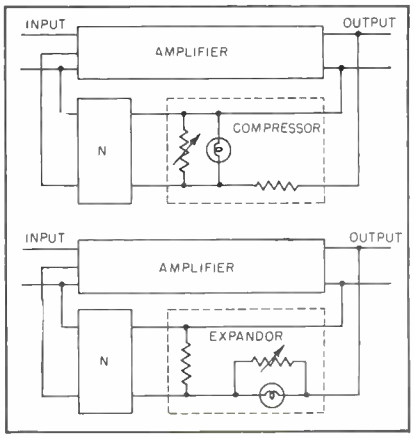


FIG. 2—Variable resistance controls the dynamic change that the lamp can produce

db). The music should not drop below the ambient noise nor rise dominantly above it; the dynamic range for public acceptance has to be below 25 db, possibly as low as 10 db. These ranges should be compared to the dynamic range of 20 to 25 db with which programs are usually transmitted or recorded. Figure 1 shows the dependence on the dynamic range of reproduction on the ambient noise.

Because of these wide dynamic ranges encountered in various conditions, it is advisable to incorporate a dynamic control in quality amplifiers.

Dynamic Control Circuit

Rather than use some form of the conventional dynamic control that requires additional tubes in the amplifier (and must be introduced outside the negative feedback loop usually used in high quality amplifiers) and that has long time constants, one can obtain dynamic control by varying the amount of feedback. Figure 2 shows circuits using this principle for either compression or expansion. The amount of feedback is varied by the nonlinear characteristic of an incandescent lamp, shown in Fig. 3.

In the circuit of Fig. 2 the feedback voltage is obtained from the secondary of the output transformer and is applied to the high-impedance control circuit. This circuit consists of a fixed resist-sistance in parallel. A second linear network may be used to further adjust the amount of feedback. The

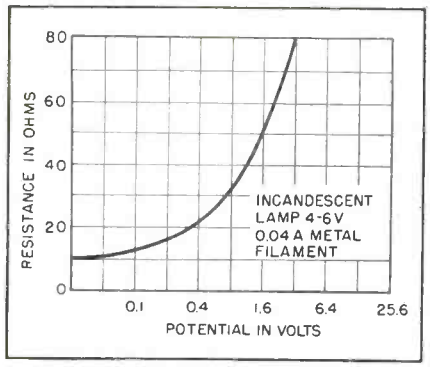


FIG. 3—At higher resistance than shown here resistance exponent is constant

control circuit, by changing the feedback in accordance with the signal level, produces the dynamic compression or expansion.

In this circuit the resistance of the incandescent lamp varies by a ratio of 10:1, thus, with appropriate values for the other circuit parameters, a volume compression or expansion of about 10 db can be obtained. The amount of dynamic change is directly controllable by the variable resistance. A tapped resistance and switch can be used to provide a sequence of dynamic steps from full compression to full expansion. The response of a dynamically controlled amplifier is shown in Fig. 4.

The time delay of the control circuit is determined by the thermal inertia of the filament of the incandescent lamp. By using a lamp rated at 40 ma or so the attack time is about 30 millisec (an attack time less than about 50 millisec is normally unnoticeable) and the release time is about 150 millisec (compared to 100 to 200 millisec of vacuum tube dynamic controls). The control circuit should be adjusted at the highest power output

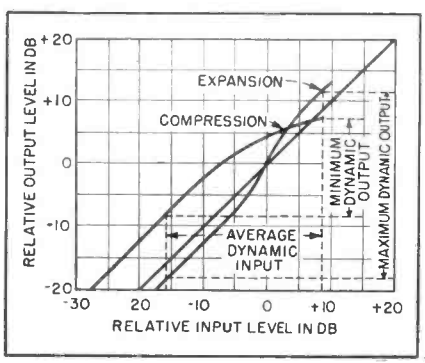


FIG. 4—Dynamic ranges obtainable from amplifier incorporating adjustable adc

of the amplifier. For a 5-watt amplifier with an 8-ohm output, an incandescent lamp of 4 to 6 volts and 40 ma rating should be used. Larger amplifiers require larger lamps or several lamps in series.

Graphical Determination of Percent Harmonic Distortion

By Robert W. Buchheim
Instructor in Electrical Engineering
Yale University
New Haven, Conn.

In designing resistance loaded amplifiers or analyzing vacuum tubes the relation between load resistance and harmonic distortion is frequently needed. Usually numerical calculations based on values read from characteristic curves are made to find this relation; however a graphical method can be used that is simpler. Furthermore, this graphical method has the advantage that it uses the distances from the characteristic curve directly without the necessity of converting them to numbers, and it has an accuracy that is more compatible with the original data than is the arithmetical computation.

Basis for the Method

The commonly used expressions for harmonic distortion are

$$D_2 = \frac{(I_H + I_L) - (I_X + I_Y)}{(I_H - I_L) + (I_X - I_Y)} \quad (1)$$

$$D_3 = \frac{(I_H - I_L - 2(I_X - I_Y)}{2(I_H - I_L) + (I_X - I_Y)} \quad (2)$$

where D_2 is the ratio of the second harmonic to the fundamental and D_3 is the ratio of the third harmonic to the fundamental currents; I_H is the plate current at the positive peak of the grid swing, I_L is the plate current at the negative peak, I_X is the plate current when the grid signal voltage is at half its positive peak, and I_Y is the plate current at half the negative grid swing. Total harmonic distortion D_0 as a fraction of the fundamental is given by

$$D_0 = (D_2^2 + D_3^2)^{1/2} \quad (3)$$

A plot of D_0 vs R_L is required.

For ease of notation let: $A = (I_H + I_L)$, $B = (I_X + I_Y)$, $C = (I_H - I_L)$ and $D = (I_X - I_Y)$, then Eq. 3 can be written

$$D_0 = \frac{\{[2(A - B)]^2 + [C - 2D]^2\}^{1/2}}{2(C + D)} \quad (4)$$

$$= N_0/2(C + D)$$

where $N_0^2 = [2(A - B)]^2 + [C - 2D]^2$

The quantities N_0 and $(C + D)$ can be obtained graphically.

Illustrative Example

Consider a family of plate characteristics for a 6F6G power pentode as shown in Fig. 1. The operating point is chosen at the intersection of the E_B = 250-volt coordinate and the E_c = − 15-volt curve. Load lines corresponding to several likely load resistances are drawn through this operating point.

A sheet of coordinate paper is arranged as in the rest of Fig. 1

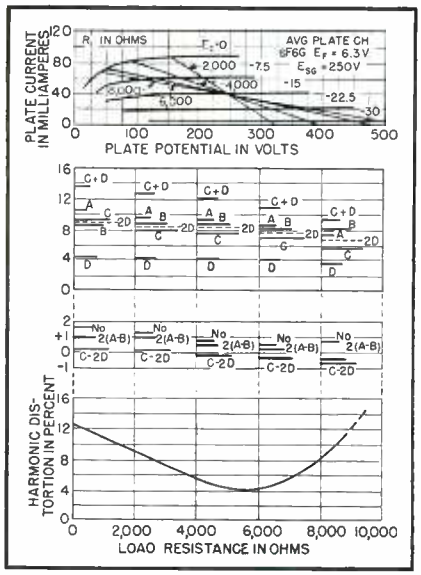


FIG. 1—Using currents from tube characteristic, combinations are plotted and differences and quadratic sumes obtained giving quantities from which percent harmonic distortion is obtained

with vertical lines labeled with the various values of load resistance to be considered. The ordinate of the top coordinate section is in milliamperes; its scale can be arbitrary or it can be transferred directly from above with dividers. Distances representing I_{II}, I_L, I_X, and I_Y are transfered in this way so that a plot of these quantities vs R_L is obtained. There is no need to draw a careful curve through these values, but a free-hand curve helps in identifying them.

From these intermediate curves, curves of A, B, C and D can be obtained by graphical addition and subtraction in accordance with their definitions. Next, in a similar manner, curves of $2D$, $(C - 2D)$, $(C + D)$, $(A - B)$ and $2\ (A - B)$ are constructed.

To obtain N_0 a quadrature addi-

tion of 2 $(A - B)$ and $(C - 2D)$ is made by measuring these quantities at right angles to each other; the diagonal joining their ends is N_0. As shown in the diagram, the graph becomes crowded when the currents have been added to give their sums and differences. Hence the constructions are transferred, as made, to a clear section of the graph below. The distance of N_0 is also plotted in this section.

When N_0 and $2(C + D)$ have been obtained D_0 is determined from slide rule manipulation using Eq. 4. Because D_0 is the ratio of quantities of the same dimensions, the scales of the ordinates can be whatever is convenient. The factor 2 can be eliminated from the final expression for D_0 if the scale of lower work graph is half that of the top section; $(C + D)$ must then be plotted in the lower part.

This construction is carried through for each R_L and a plot of D_0 vs R_L made as in Fig. 1; plots of D_2 and D_3 can also be made conviently. This graphical method is fast and direct. A regular routine should be followed in carrying it out; many of the combinations can be made without changing the setting of the dividers. Errors are easily detected as the construction progresses by any radical singularities in the intermediate curves.

Oil Impregnated Capacitors

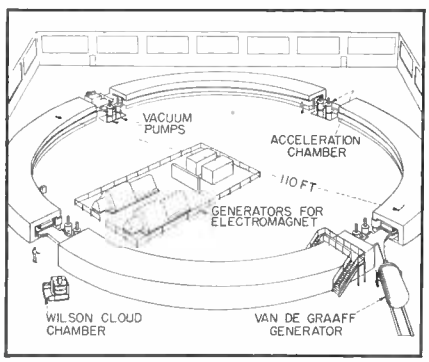
EXPERTS in the field have pointed out to us that characteristics of a few oil capacitors, published in these columns in May 1948, tell only part of the complicated (and apparently controversial) story. The ordinate axis of Fig. 1 should have been "Insulation in Megohm-Microfarads" and that of Fig. 4, "Percent of Capacitance at 25 C"; the author is sales representative for Sprague Electric Co. We hope to present more engineering data on this subject as it is made available.

SURVEY OF NEW TECHNIQUES

MAGNETIC FLUID CLUTCH, invented by Jacob Rabinow of the National

Bureau of Standards, provides smooth control and 100 percent efficiency (no slippage) at loads for which it has been designed. The clutch plates are operated in an oil bath in which finely powdered iron is suspended. Application of a magnetic field via an electromagnet aligns the iron powder from plate to plate producing a strong bond. Unlike conventional dry clutches, this clutch is free from chatter because the static and sliding frictions are practically the same. Its chief application appears to be in servomechanisms where its complete control through the electromagnet and complete locking are of great importance.

CYCLOTRON, to be built at University of California, will have four high-frequency acceleration chambers spaced between segments of the electromagnet. With 5,000 volts applied to each chamber, accelerated particle, injected by Van de Graaf generator, will be ejected toward Wilson cloud chamber after making a million trips around



Layout of projected cyclotron

cyclotron with an energy of 6,000 mev. Accelerator will require five years and $9 million for construction; magnet will weigh 10,000 tons and operate from a 5,000-kw source; machine will be pulsed, operating for about two seconds, then turned off for a few minutes. Experiments under direction of William Brobeck and Dr. E. O. Lawrence, director of the laboratory, have shown the design to be practical.

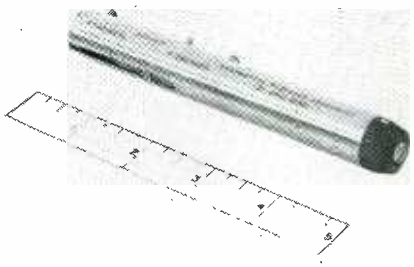
BACK in the 1890's, physicists argued heatedly over whether it should be "corpuscle" or "electron" for the smallest particle of negative electricity.

(continued from p 134)

mately 30 pounds assembled, and price is $119 without wire.

Miniature Capacitor

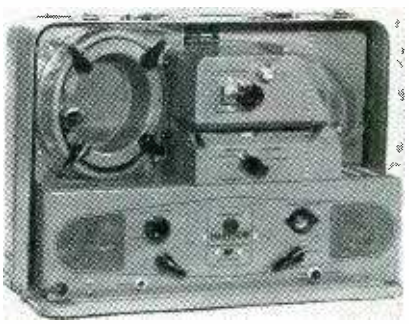
ENGINEERING RESEARCH ASSOCIATES, INC., 1902 W. Minnehaha Ave., St. Paul, Minn., has announced a new miniature variable capacitor having a self-contained



dial with micrometer. Rated capacitance is 9 to 585 μμf per section with less than 0.002 dissipation factor at radio frequencies.

Recorder-Reproducer

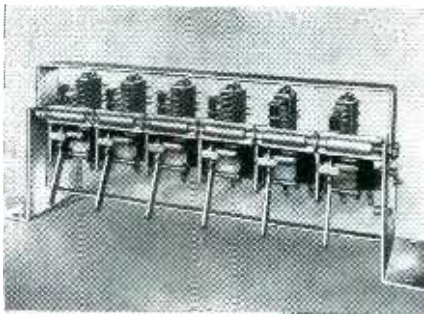
FREDERICK HART & CO., INC., Poughkeepsie, N. Y. Model 60 sound-on-film recorder-reproducer is an all-purpose, lightweight unit which uses 35-mm film to produce a per-



manent sound record. A voice-actuated mechanism automatically starts and stops the machine at any voice level. Foot switch, earphones and other accessories are available for every application.

Indicator Relays

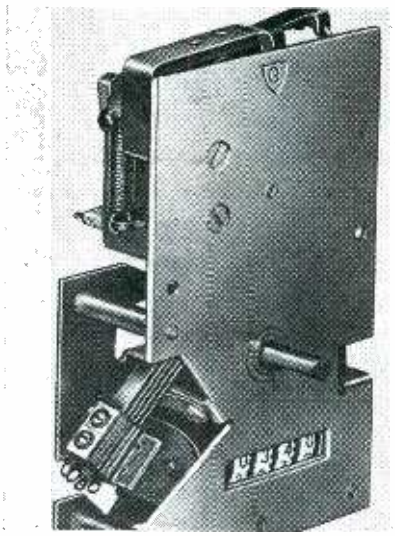
GUARDIAN ELECTRIC MFG. CO., 1625 W. Walnut St., Chicago 12, Ill. This bank of T-11 relays is designed for indicator circuits where numbers and animation such as lights, sound, or both, are in sequence. The



bar which resets the relay arm may be actuated manually, mechanically or electrically with a solenoid. Additional information can be obtained by writing to Dept. T-11.

Counting Device

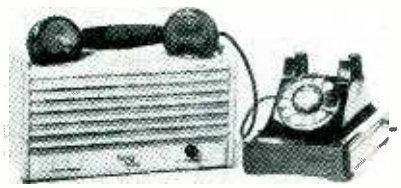
GUARDIAN ELECTRIC MFG. CO., 1625 W. Walnut St., Chicago 12, Ill. This magnet-driven counter was primarily designed for registering the number of musical record selections received from remote points in a



centrally wired music station. The unit features a Series 15 magnet, standard counter, wire-arm counter actuating assembly, with a midget contact assembly having single-pole double-throw and single-pole single-throw switch combinations.

Liquid Level Control

GUARDIAN ELECTRIC MFG. CO., Dept. LL, 1625 W. Walnut St., Chicago 12, Ill. Series G-53143 liquid level control is used principally in carbonated beverage vendors to maintain the level of water in refrigerated storage tanks. The unit operates by means of long and short electrodes inserted through the top of the tank, and relays which start and



versation leaving the caller's hands free to perform other tasks; also to provide group listening facilities. It is useful in busy offices and where telephone waiting time is a factor. Retail net is $39.95.

Soldering Machine

JOYAL PRODUCTS, INC., 12 Grafton Ave., Newark, N. J. A newly developed production soldering machine which operates like a foot

press was designed for the jewelry field and for manufacturers of instruments and small products. The machine is portable and operates on 110-volt a-c.

Wide-Range Tester

PRECISION APPARATUS CO., INC., 92-27 Horace Harding Blvd., Elmhurst, N. Y., has announced the Series 40 circuit tester with dimensions of 3¾ × 6¼ × 2½ inches. The

unit affords 31 a-c and d-c ranges to 6,000 volts, 600 ma, + 70 db and 5 megohms. Two pin jacks serve all standard functions and a special recessed safety jack provides for the 6,000 volt circuit.

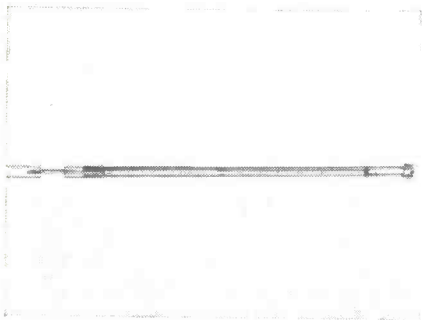
Audio Transformers

ALTEC LANSING CORP., Peerless Electrical Products Division, 6920 McKinley Ave., Los Angeles 1,

Calif., announces a new 20-20 line of audio transformers, flat within 1 db from 20 cycles to 20,000 cycles.

Signal Measurement

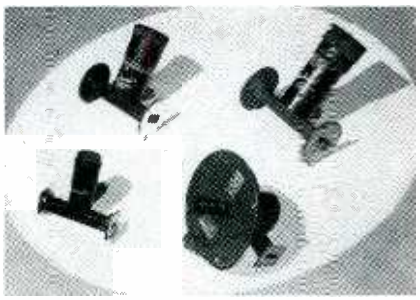
DECIMETER, INC., 1428 Market St., Denver, Colorado. The DM103W slipstick wavemeter was designed for quick and accurate frequency readings on oscillators, receivers or



transmitters in the uhf spectrum. Accuracy is 2 percent or better and range is 90 to 3,000 mc. Further information is given in circular 11F.

Cavity Meters

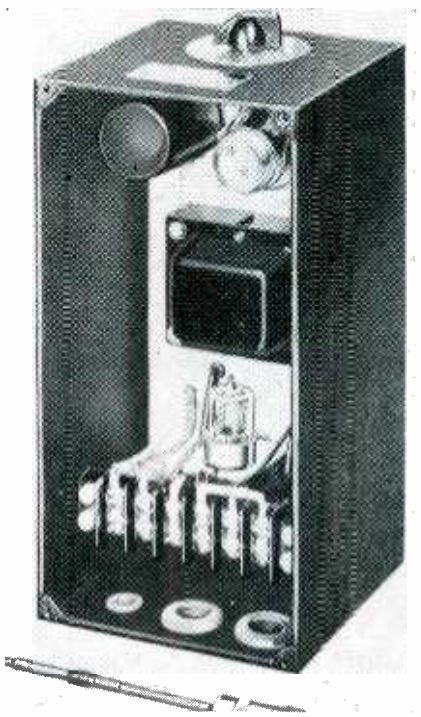
SPERRY GYROSCOPE CO., Great Neck, New York, announces a line of high-Q tunable cavities for measuring microwave frequencies where great accuracy is required. The resonant cavities are electroformed



to obtain minute tolerances, stress-free metal and a true circular shape. The instruments provide continuous frequency coverage from 2,575 to 3,750 and 4,500 to 10,500 mc.

Temperature Control

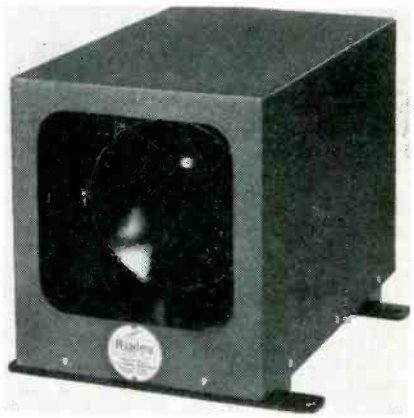
THOMAS A. EDISON, INC., West Orange, N. J., has developed a temperature control which uses a single electronic tube with an electrical resistance-type bulb for thermal



pickup and is of the on-off type. Units are available to cover the temperature range from −100 F to 1,200 F and are adjustable within a range of several hundred degrees.

Burglar Alarm

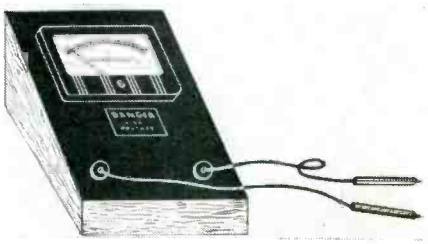
RIPLEY CO., INC., Middletown, Conn. Using a modulated, invisible light beam, the new burglar alarm is proof against attempt at breakthrough by shining a flashlight into the phototube. The receiver portion is tuned to the modulated frequency of the transmitter, so that



any change in frequency or reduction of light intensity sounds the alarm. Lens mountings have micrometer adjustments to facilitate focusing on the phototube. The unit is weather-tight and rust-proof.

High-Voltage Meter

SPELLMAN TELEVISION CO., INC., 130 W. 24th St., New York 11, N. Y., announces a new high-voltage meter for television service men, laboratory technicians and ex-



perimenters. The meter, with range from 0 to 30 kv, draws only 20 microamperes. Technical information is available.

Indexing Turntable

SHERMAN INDUSTRIAL ELECTRONICS CO., 505 Washington Ave., Belleville 9, N. J., has developed an indexing turntable for induction soldering, brazing, or heat treating. Operation requires 60-pound

air supply and 220-volt, 60-cycle single-phase power. As many as 12 work stations can be provided on the standard turntable top.

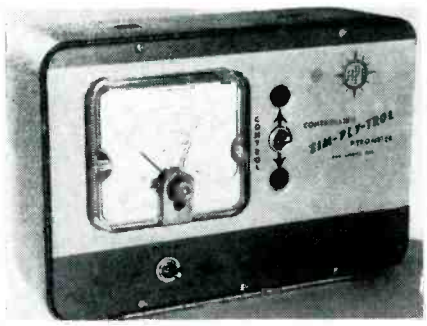
Magnet Coil

G. H. LELAND, INC., 118 Webster St., Dayton 2, Ohio. The Ledex extra-precision magnet coil is layer

wound by a new and exclusive method. Coils are concentric and symmetrical in shape. Further information is available on request.

Controlling Pyrometer

ASSEMBLY PRODUCTS INC., Main & Bell Sts., Chagrin Falls, Ohio. The Simplytrol indicating and controlling pyrometer is a thermocouple-type control for furnaces, ovens, kilns, etc. It operates on the micro-



contact principle, from 110 or 220 volts a-c or 110 volts d-c. The unit can be used for permanent installations or as a portable control for temporary setups.

Electrolytic Capacitors

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. Type AVL hermetically sealed electrolytic capacitors are recommended for use in marine or aircraft applications or wherever high humidity is encountered. Data sheet 110 gives information on various capacitances,

while No. 111 covers a capacitor with a rating of 24,000 μf at 6 working volts.

Phase-Modulated Mike

STEPHENS MFG. CORP., 10416 National Blvd., Los Angeles 34, Calif. Model C-1 microphone uses carrier-frequency phase modulation. The

pickup assembly is ovoid in shape and only 1 x 1¼ inches in size. Low response is linear to one-half cycle in 24 hours. The unit features a high signal-to-noise ratio.

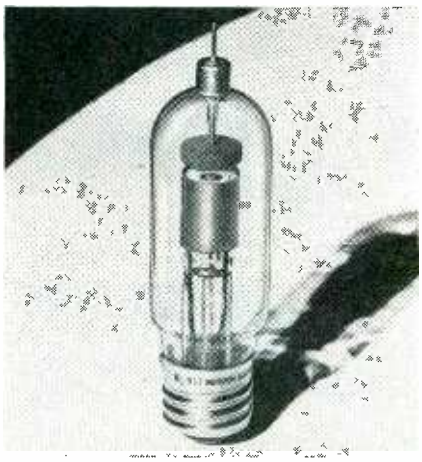
Terminal Strip-Socket

YATES ENGINEERING SERVICES, Box 67M, Cranford, N. J., has developed a new combination tube socket-mounting strip for both point-to-

point and cabled wiring layouts. The unit will soon be available singly or in multiple gangs for such assemblies as audio units or midget radio chassis.

Rectifier Tube

NATIONAL ELECTRONICS, INC., Batavia Ave., Geneva, Ill. The NL-617 is a compact, 5-ampere industrial rectifier tube designed for heavy



duty applications at voltages up to 600 volts d-c. Low condensed mercury temperature makes possible a peak inverse voltage rating of 1,000 volts.

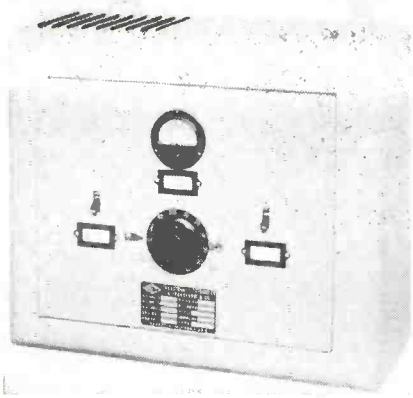
D-C Power Supply

FURST ELECTRONICS, 800 W. North Ave., Chicago 22, Ill. Model 710-SR d-c power supply features a stable basic regulator circuit. Out-

put voltage is continuously adjustable over a range of less than 600 to more than 1,500 volts by the operation of a control knob on the front panel. The unit is built for low-current devices such as Geiger tubes.

Stabilized Rectifier

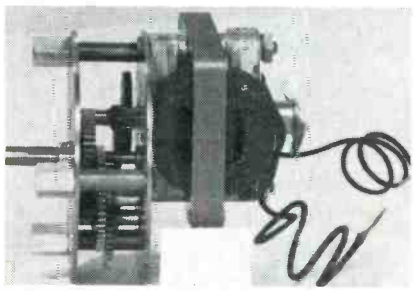
INDUSTRIAL ELECTRONICS AND TRANSFORMER CO., Dept. EE, 1801 East Slauson Ave., Los Angeles 11, Calif. The new stabilized rectifier was developed for installation wherever unattended battery charging is a necessity. Voltage regulating transformers compensate for variations in a-c line voltages to



selenium rectifiers. The output current is 4, 6, or 12 amperes, voltage from 3 to 60 cell ratings; and a-c input can be 110 or 220 volts.

Gear Train

GLEASON-AVERY, INC., Auburn, N. Y. A new gear train for use with the B-30 series of small synchronous and nonsynchronous mo-



tors can be geared to produce clockwise or counterclockwise speeds from 400 to 1 rpm on the final shaft.

Pocket-Size Tester

SUPERIOR INSTRUMENTS CO., 227 Fulton St., New York 7, N. Y. Model

PRECISION POTENTIOMETERS

Toroidal and Sinusoidal

For use in computing and analyzing devices; generation of low frequency saw tooth and sine waves; controls for radio and radar equipment; position indicators; servomechanisms; electro medical instruments, measuring devices—telemetering; gun fire control where 360° rotation, high precision and low noise levels are essential.

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.

Write for Bulletin F-68

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Adjustable V Dipole Antenna for maximum response on FM and TV bands. Dipoles may be adjusted to angle best suited for clear reception and to counteract electrical noise or reflected signal. Ideal for use in congested areas.

Similar to preceding excepting it is equipped with reflector to permit better reception on distant stations. Ideal for all TV and FM installations.

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4810 Highland Ave., Niagara Falls, N. Y.

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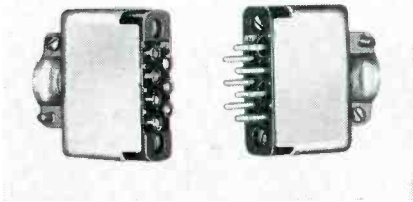
PATTON - MacGUYER COMPANY
17 VIRGINIA AVENUE
PROVIDENCE, R. I.

770 pocket-size volt-ohm-milliammeter was designed for radio and electrical appliance servicemen. Sensitivity is 1,000 ohms per volt. Its two resistance ranges are from 0 to 500 ohms and 0 to 1 megohm.

Seven Contact Connector

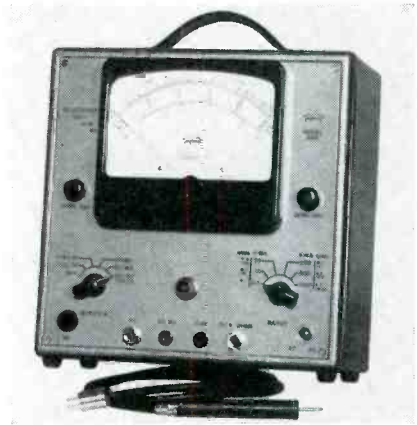
WINCHESTER ELECTRONICS Co., 6 E. 46th St., New York 17, N. Y. The seven-contact lightweight, aircraft-type connector has a breakdown voltage between contacts of 7,500



volts d-c and 5,300 volts a-c. Melamine molded parts with telescoping barriers provide long creepage paths. Weight of the connector is 0.8 ounce.

Volt-Ohm-Milliammeter

THE TRIPLETT ELECTRICAL INSTRUMENT Co., Bluffton, Ohio. Model 2451 electronic volt-ohm-milliammeter was designed for simple oper-



ation, broad test facilities and speed. It eliminates switching back and forth from one range to another to balance the circuit, and requires only zeroing the meter on the range to be used.

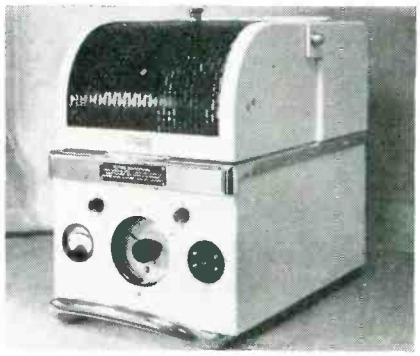
Pulse Generator

KAY ELECTRIC Co., Pine Brook, N. J., announces the Mega-Pulser, an ultra-short pulse generator, providing a pulse with a spectrum

which more than covers the present video frequency range. It operates on 117 volts, 60 cycles, and has a self-contained power supply. Price is $195.

Electronic Preheater

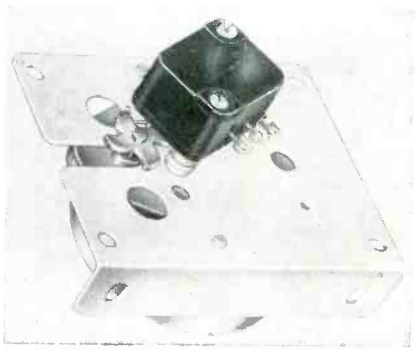
AMERICAN BRITISH TECHNOLOGY INC., 57 Park Ave., New York 16, N. Y. The Radyne medium-sized electronic preheaters are made in various sizes from 20 to 375 btu



output. Heating rate can be adjusted smoothly from zero to full power by arranging the electrode, raising and lowering a knob at the top of the cabinet. Heat output and timing are indicated by dials.

Flasher Timers

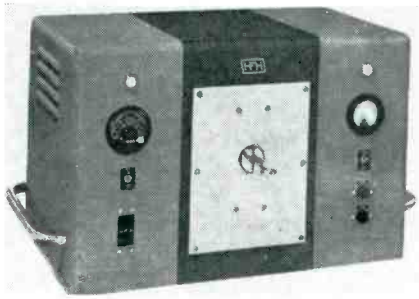
HAYDON MFG. CO., INC., 245 E. Elm St., Torrington, Conn., has designed the No. 5400 series of interrupter or flasher timers for applications requiring that current be fed to a controlled circuit in pulses of constant and predetermined ac-



curacy. The range is from 72 flashes per minute, each 0.4 second in length, to 1 every 2 minutes, each flash 1 minute long.

Power Generator

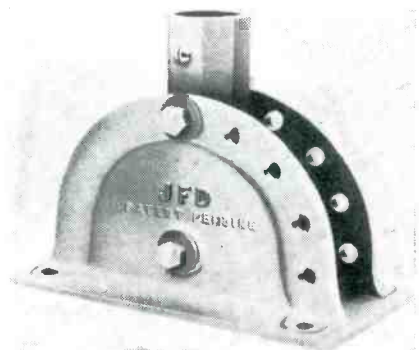
THE HIGH FREQUENCY HEATING CO., 143 Glen Park Ave., Gary, Indiana, announces the HFH-1.2A-L elec-



tronic power generator for production induction heating. Power output is 1,200 watts; frequency, 400 kc.

Antenna Bracket

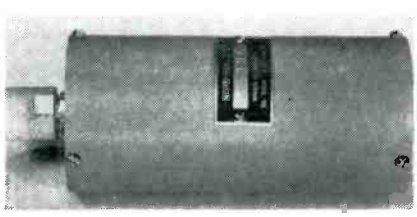
J. F. D. MFG. CO., INC., 4117 Fort Hamilton Parkway, Brooklyn 19, N. Y. The multiposition bracket for f-m and television antenna offers secure setting at whatever



angle the mast is mounted. Request booklet 248S for further information.

Broad Band Transformer

MEASUREMENTS CORP., Boonton, N. J. Model M-236 broad band transformer is designed for matching 72-ohm coaxial to 300-ohm balanced line in the range 40 to 220



megacycles. Type UG-21/U coaxial fittings and soldering lugs are provided.

Field Intensity Meter

RADIO CORP. OF AMERICA, Camden, N. J. A new portable field intensity meter type WX-2A contains a built-in calibrating oscilla-

tor and measures from 10 microvolts to 10 volts per meter in the frequency band from 540 to 1,600 kc. Readings are given directly making it unnecessary to use correction factors or charts.

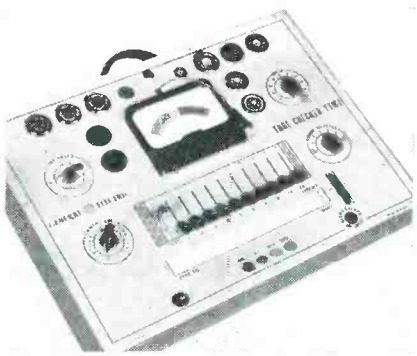
Acoustical Measurements

WESTERN ELECTRO-ACOUSTIC LAB. 621 S. Spring St., Los Angeles 14, Calif. The capacitor microphone unit type 100B illustrated and a

thermal noise source type 300A are available for acoustic measurements. Detailed specifications will be sent upon request.

Tube Checker

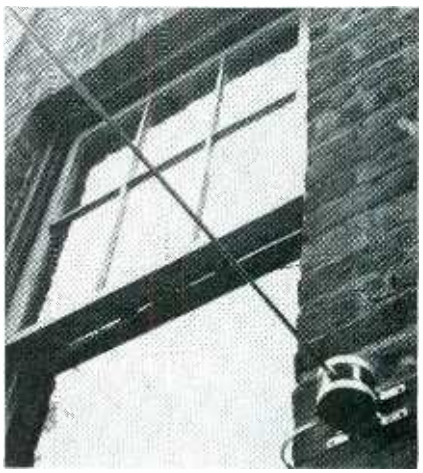
GENERAL ELECTRIC CO., Syracuse, N. Y. In the type YTW-1



tube checker, each tube element has its own circuit switch. All standard receiver tubes as well as pilot bulbs and batteries can be checked.

Window Antenna

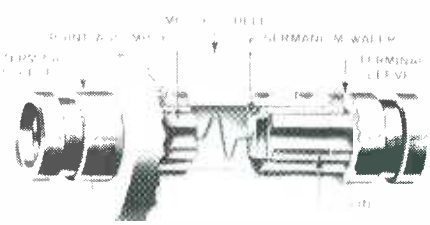
VERTROD CORP., 11 Park Place, New York 7, N. Y. Projecting not more than 45 inches a new television and f-m antenna can be



mounted outside an apartment or dwelling window. A network matches the antenna to 300-ohm line, although a special adapter can be furnished for 70-ohm line.

Germanium Varistors

WESTERN ELECTRIC CO., INC., 195 Broadway, New York 7, N. Y. Distributed by Graybar Electric Co., are several new types of point-



contact germanium crystals, 1N43, 1N44, 1N45, 1N46, 1N47, and D175347. They have low end-to-end capacitance, high current-handling ability, and stable characteristics.

Battery Voltmeter

HEWLETT-PACKARD CO., 395 Page Mill Road, Palo Alto, Calif. Battery-operated vacuum-tube volt-

meter model 404A is designed for a-c measurements from 2 cycles to 20 kilocycles at voltages ranging from 0.001 to 300 volts. Input impedance is 10 megohms shunted by capacitance of approximately 20 picofarads.

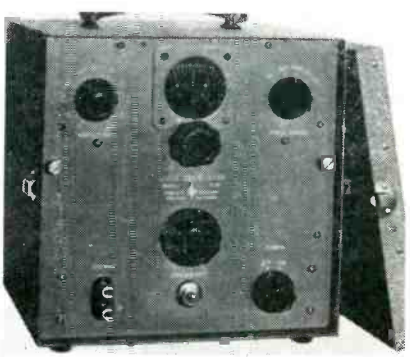
Pickup Preamplifier

GENERAL ELECTRIC CO., Syracuse, N. Y. A new phonograph preamplifier UPX003 designed for use

with a variable reluctance pickup is equipped with power transformer and rectifier, avoiding the necessity for connecting the device into the receiver wiring.

Battery Audio Oscillator

HEWLETT-PACKARD CO., 395 Page Mill Road, Palo Alto, Calif. Model 204A audio oscillator has a frequency range from 2 cycles to 20 kc in 4 decades. Output is 5 volts



into 10,000 ohms. With average use the batteries last three months.

Literature

Color Eye. Instrument Development Labs., Inc., 541 Willis Ave., Williston Park, L. I., N. Y. Type PPG-IDL Color Eye designed for industrial color measurements is pictured in a 4-page brochure. Detailed catalog sheets are also available.

New Motors. Eastern Air Devices, Inc., 130 Flatbush Ave., Brooklyn 17, N. Y., have a 4-page brochure describing Hysteresis synchonous motors for wire and film recorders, sound cameras, and other devices where lack of vibration and hunting is desirable.

Product Index. West Coast Electronic Manufacturers Association, Inc., 1161 North Vine St., Hollywood 28, Calif. A 20-page booklet contains the WCEMA membership list and also an alphabetical product list of radio lines manufactured and distributed on the West Coast. The bulletin is distributed without charge.

Sheet Metal Fabrication. Karp Metal Products Co., Inc., 129 30th St., Brooklyn, N. Y., has just published a 16-page, 2-color catalog outlining facilities for fabricating sheet metal cabinets and enclosures. Up-to-date examples are shown.

Broadcast Equipment Catalog. Radio Corp. of America, Camden, N. J. A-m, f-m, and television broadcast equipment is illustrated in a 247-page catalog that covers the field from microphones to measurement equipment. There is a convenient data section and index. Price is $1.00.

Standards List. American Standards Association, 70 E. 45th St., New York 17, N. Y. An up-to-date list of all approved national standards was recently published and is

now available free of charge. The new price list is useful to manufacturers, consumer groups and government agencies.

Dieless Duplicators. O'Neil-Irwin Mfg. Co., Lake City, Minn. A new 40-page catalog lists benders, parters, shears, brakes, and other metal working equipment.

Connector Catalog. Cannon Electric Development Co., Humbolt St. and Avenue 33, Los Angeles 31, Calif., recently issued the 32-page C-47 edition of its condensed catalog. It covers the thirteen major type series of multicontact electric connectors for radio, aircraft and communications.

Miniature Fluorescents. Stocker and Yale, 48 Birch St., Marblehead, Mass., shows an interesting line of small fluorescent lamps for microscope and similar illumination in a new 4-page illustrated folder. Included are combined lights and magnifiers.

Blowers. Rotron Division, Jenckes Knitting Machine Co., 180 Weeden St., Pawtucket, R. I. Catalog sheets RP-24 and RM-22 give description and technical information on a new line of small, centrifugal blowers with high pressure performance, as required for the cooling of many of the new forced air cooled radio transmitting tubes.

Voltage Regulation. Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. Catalog S-348 describes in detail electronic control of voltages and currents. Photos of applications, circuit diagrams and efficiency and performance curves for a line of a-c and d-c voltage regulators are given.

Components Catalog. P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind. This recently completed catalog Number 1 covers a line of products including capacitors, rectifiers, resistors, switches, vibrators, metals and alloys, contacts and resistance weld-

ing. The 80-page publication is available on request by manufacturers.

Supersonic Reflectoscope. Sperry Products, Inc., 1505 Willow Ave., Hoboken, N. J. Testing of welds in plate, thin sheet and other sections with the superonic reflectoscope, using a new angle transmitter, is fully described in sales data sheet 3021.

Towers. Rostan Corp., 202 East 44th St., New York 17, N. Y. Characteristics of three types of towers are given in a single-page catalog sheet, together with a list of suggested uses.

Broad-Band Antenna. Communications Co., Inc., 300 Greco Ave., Coral Gables, Florida. Information is available on the model 244 high-gain, broad-band antenna designed for communication with mobile units on frequencies above 100 mc.

Position Recorder. Servo-Tek Products Co., Inc., 4 Godwin Ave., Paterson, N. J. The Servograph is a graphic recorder having a circular chart with an inking pen which is remotely controlled by the use of synchros. A four-page folder tells how it works, gives specifications and applications.

Conductive Coatings. E. I. du-Pont de Nemours & Co., Electrochemicals Dept., Wilmington 98, Delaware. Conductive coatings for printed circuits, high-voltage capacitors, static shielding, and other uses are described in bulletin CP-2-1247.

Parts Catalog. Aircraft Radio Corp., Boonton, N. J. A booklet comprising a series of bulletins replete with mechanical drawings, specifications, and illustrations covers test equipment, microwave accessories and electronic component parts.

Lightning Protection. L. S. Brach Mfg. Corp., 200 Central Ave., Newark 4, N. J. Important considerations relative to the role

played by lightning arresters in radio, police and fire alarm, railroad signal, telephone and telegraph circuits are discussed in Catalog 48-A. A complete line of arrester and terminal facilities and accessories is treated.

Storage Battery Research. Gould Storage Battery Corp., Trenton 7, N. J. A new 16-page, fully illustrated brochure introduces a new and complete research laboratory. Among the items featured are raw materials specification and testing, instantaneous voltage measurement and the proving of products of research.

Instrument Recording Materials. Eastman Kodak Co., Rochester 4, N. Y. A 4-page catalog describes eleven films and papers used to record oscillograph traces and similar phenomena. A graph shows variety in speed, contrast, color sensitivity and other specifications as determined by particular instruments.

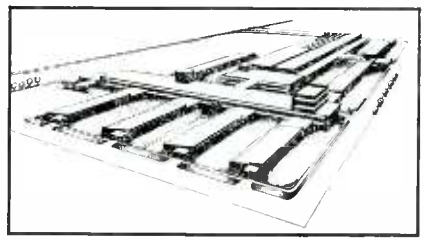
High-Speed Photography. Eastman Kodak Co., Rochester 4, N. Y. Applications of the high-speed camera to industry are described in a 12-page booklet. Information is given concerning operating characteristics and the accessories commonly used.

Predetermined Counters. Production Instrument Co., 710-12 W. Jackson Blvd., Chicago 6, Ill. Bulletin ES-91 is a 16-page illustrated booklet showing the application of electric and electric-eye counting to the requirements of modern industry. Examples given include devices for counting parts, cartons, mechanical operations and folding machine production.

Relay Selection. Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y. The new relay guide illustrates a complete line of twenty-four small, compact, relays of varied types and features. A detailed table enumerates the specifications of each relay. Copies are available upon request.

(continued from p 138)

mathematics, electronics, metallurgy, propulsion systems for rockets and missiles, and fire control and guidance systems. Research is under the direction of L. T. E. Thompson, who is aided by a large staff of scientists and technical personnel.



Artist's sketch gives aerial view of Michelson Laboratory in heart of Mojave Desert

BUSINESS NEWS

WESTERN ELECTRIC CO., manufacturing and supply unit of the Bell System, has arranged to purchase a 130-acre industrial site for the construction of a manufacturing plant at Indianapolis, Ind.

BROWN INSTRUMENT CO., Philadelphia has begun a $2,500,000 expansion program which includes the construction of new five-story building on foundations designed to support four additional floors.

CROWN CAPACITOR CORP., 316 Stuart St., Boston, Mass., was recently formed to produce a line of fixed paper capacitors.

NATIONAL RESEARCH CORP., Cambridge, Mass., has granted an exclusive license to Smith Paper, Inc., Lee, Mass., for the production of metallized paper for use in electrical capacitors.

MACHINE O'MATIC CO., electronic control and attachments manufacturer, recently moved from Flushing, N. Y. to Ashley, Ohio.

ALLEN B. DU MONT LABORATORIES, INC., Passaic, N. J., recently demonstrated a system called tele-transcription for transcribing television shows on film. This opens the way for a new type of television net-

work—a network by tele-transcriptions made by filming video programs off the face of a c-r tube.

RCA INTERNATIONAL DIVISION has concluded an agreement with the Societe des Lamps Fotos, whereby American-type radio tubes will be manufactured in volume in France.

WESTINGHOUSE ELECTRIC CORP. and PHILCO CORP. will establish a joint radio and television center in the Westinghouse-KYM building, Philadelphia, Pa.

PERSONNEL

CHARLES F. STROMEYER, vice-president of the Hytron Radio and Electronics Corp., Salem, Mass., is the new president of Remco Electronics, Inc., New York City.

CARROLL STANSBURY, holder of 54 patents in the fields of motor control, industrial electronics and resistance welding, has been appointed to the electronics division of the National Bureau of Standards, where he will do research work in the Engineering Electronics Laboratory.

C. Stansbury

H. E. Rhodes

HOWARD E. RHODES, formerly vice-president and chief engineer at Aerovox Corp., was appointed chief engineer of the new capacitor plant of Sangamo Electric Co. at Marion, Illinois.

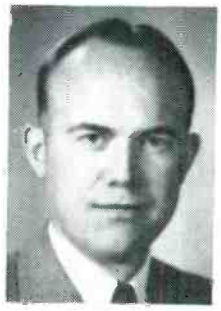
RICHARD HODGSON was recently appointed director of technical operations for the television division of Paramount Pictures Inc.

DONALD G. WILSON has been named chairman of the department of electrical engineering at the University

of Kansas. In 1942 he joined a group at the MIT radiation laboratory doing research on means of propagating microwaves.

CARL MAURER, with the Paramount television division for the past four years, has been advanced to supervisor of development engineering.

MURRAY G. CROSBY, former research engineer for RCA and later a member of the firm of Paul Godley Co., consulting engineers, has opened a radio-electronic consulting and development laboratory under the name of Crosby Laboratories, 126 Old Country Road, Mineola, N. Y.



M. G. Crosby

B. B. Bauer

B. B. BAUER, formerly director of engineering, was recently appointed vice-president of Shure Brothers, Inc.

SIDNEY DAVIDSON, a member of the NBC engineering staff since 1945, has been named studio supervisor of WPIX (Channel 11), The News television station in New York.

WILLIAM J. KELLY, NBC engineer since 1931, has joined WPIX as transmitter supervisor.

ROBERT M. MORRIS, after 12 years as administrative head of television engineering operations for NBC, has been appointed engineer in charge of television for the American Broadcasting network's Central Division.

DOUGLAS H. EWING, previously manager of Teleran Engineering, was appointed manager of all advanced development engineering at RCA Engineering Products Department, Camden, N. J.

CHARLES R. SCHMIDT, formerly electronic engineer with Finch Facsimile, Curtiss Wright and Federal

Telephone and Radio, is now assistant chief engineer at Airlectron Engineering Co., Caldwell, N. J. He will take charge of new product development in electronic instrumentation.

SIMON RAMO, formerly with G-E, has been appointed Research Associate at California Institute of Technology and is now also director of guided missile development at Hughes Aircraft Co., Culver City, Calif.

WILLIAM R. AHERN, associated with General Electric since 1941 as engineer in the television equipment division, was appointed an engineer in the facilities section of the American Broadcasting Company's engineering department in New York.

DONALD L. HERR, formerly officer in charge of the U. S. Naval Shipyard surge project at Terminal Island, Calif., has joined the engineering staff of Allen-Bradley Company of Milwaukee, Wisc., to develop servomechanisms for machine tool and other motor controls.

KARL SPANGENBERG, professor of electrical engineering at Stanford University and formerly technical consultant with the OSRD, has been granted a leave of absence for a year to direct the electronics activities of the Office of Naval Research.

GEORGE R. BASTEDO, previously associated with the development of guided missiles for the U. S. Navy, has been appointed to the staff of the National Bureau of Standards as electronics engineer for the Guided Missile Section.

N. F. SHOFSTALL, with G-E for nearly 20 years, was recently named division engineer in charge of all engineering for the Receiver Division at Electronics Park in Syracuse.

JOSEPH STROCKBINE is the new supervisor in charge of transmitter maintenance at WPIX. He has been in the transmitter department of RCA at Camden, N. J. since 1940, and has tested every RCA television transmitter produced to date, including the RCA TT-5A which is being installed in the Daily News Building.

NEW BOOKS

Radar Beacons

Volume 3 of the MIT Radiation Laboratory Series, EDITED BY ARTHUR ROBERTS. *McGraw-Hill Book Company, New York,* 1947, 489 *pages,* $6.00.

RADAR BEACONS, the third volume of the MIT Radiation Laboratory Series, forms a much desired companion to Radar Aids to Navigation, the second volume in the series. Dr. Roberts and his authors are to be commended for a well directed treatise developed from the viewpoint of system engineering, which too often has been overlooked in beacon design.

Radar Beacons is divided into four parts, namely: Basic Considerations; Beacon Design; Interrogator and System Design; and Beacons in the Field. In the first part, emphasis is placed on system considerations. The design engineer can find no better guidance than the fundamental principle of beacon design which is stated in the text: "A beacon cannot properly be designed by itself, in isolation or in vacuo; the entire interrogating and reply system must be considered as a single unit."

In the second part, a very complete coverage of the components of the beacon is presented. The chapter on beacon synthesis (Part II-Chapter 16) deserves particular mention. It points out design considerations which, if overlooked, can result in malfunctioning or even complete failure of an otherwise well designed beacon.

Part three covers only features of radar design pertaining to interrogation, as radar design itself is the subject of many volumes in the series. Again in this part, overall system design is stressed.

Part four gives some very excellent practical advice on siting, operation and maintenance of beacons—ground, ship and air based. Many photographs are helpful in illustrating this part of the text.

It is regrettable that more data and evaluations were not presented on beacons operating in the 1,000-mc region, because frequencies between 960 and 1,660 mc have been allocated for air navigation and traffic control aids. The airborne

beacon for traffic control and the ground beacon for navigation required in the integrated air traffic control system for military and civil use, as agreed upon by the Radio Technical Commission for Aeronautics, will operate in this part of the spectrum. It is felt that certain of the conclusions drawn favoring microwave (10 cm or shorter in wavelength) beacons might not have been made had 1,000-mc beacon characteristics been more fully considered.

Certain statements made claim accuracies in aircraft navigation by beacons that are understandably, but overly, optimistic. The beacon systems have such inherent accuracy, but unfortunately the presentation does not enable the full accuracy to be used operationally.

To know the editor is to appreciate this quotation found in the text: "As everyone knows, the oboe is an ill wind that no one blows good." The text has a refreshing change of pace which makes for easy reading and clear presentation of the technical material. Radar Beacons should form a valuable ready reference to design and systems engineers.—J. WESLEY LEAS, *Air Navigation Traffic Control Group, Air Transport Association of America, Washington, D. C.*

Loran

EDITED BY J. A. PIERCE, A. A. MCKENZIE, AND R. H. WOODWARD. *Volume 4 of MIT Radiation Laboratory Series, published by McGraw-Hill Book Co., New York, N. Y., 476 pages,* $6.00.

LORAN, the fourth in the Radiation Laboratory Series, was written by eleven contributing authors. Standard loran operates on a frequency of about 2 mc and makes use of both ground and sky wave propagation. Toward the end of the war, development on the loran system operating on frequencies of the order of 180 kc was undertaken.

Chapter I, The Introduction, contains a most excellent classification of navigational systems. This chapter describes most of the outstanding radio navigational systems developed before and during the war.

Chapter II, giving the history of loran, is especially noteworthy. This chapter contains material of a character too often deleted in tech-

nical writings and which will still be of value long after the technical system to which it pertains is obsolete. The reviewer's plaudits therefore go to this chapter in spite of the fact that the Central Pacific section is somewhat redundant and fails to record the struggle for real estate encountered there, and the attempt to build a steel island. But then, interest was so centered in Europe that the Central Pacific Theatre of War did not come fully into focus before the Japanese surrendered. The material of Chapter II is augmented by Appendix A: "The Loran program in the Hydrographic Office."

Chapter III giving the principles of loran is very good, although a few measuring circuit techniques at this point would have been in good order.

Chapter IV on Further Trends was of interest but not as authoritative as other chapters. Perhaps Prof. Pierce, who wrote this chapter, could not say all that he knew of future developments because of the necessity of secrecy. His remarks relating to commercial and military adoptions did not make a forceful impression.

While the discussion on Wave Propagation in Chapter V is directed specifically to the phenomena related to loran, it goes beyond the narrow limits that might be inferred and makes this chapter one of the highlights of the book. There have been many, many condensed descriptions of the mechanism of propagation via the ionosphere, but Pierce's treatment extending over ten pages is considered outstanding. The first section of the book is completed by Chapter VI which describes various methods and equipments used for calculating loran tables and charts.

The second part of the book, consisting of chapters on Timers, Switching Equipment, Transmitters, Antenna Systems, Receivers-Indicators, and Special Techniques and Measurements, are devoted almost exclusively to descriptions of the various pieces of apparatus used during the war. Circuit details are given but very little of the how and why of design appears except in Chapter X. These chapters, with the exception of Chapter X,

on Antenna Systems are almost completely devoid of mathematics, and all serve excellently the purpose for which they were intended.

Appendix B is a list of the loran stations up to October 15, 1945, together with their geographical coordinates.

Appendix C consists of "Demonstrations concerning Geometry of Loran's Lines", and Appendix D is a detailed description of the Determination of Errors in the position of loran transmitting stations. In addition to the appendices, the book contains an excellent bibliography.

The preface states that the purpose of the book is to describe the Loran system, its principles and its equipment as they existed at the end of the war and to offer suggestions for their adaptation and improvement for civilian services in time of peace.

It is this reviewer's opinion that "Loran" has achieved admirably the purpose for which it was written, and constitutes an outstanding book in the Radiation Laboratory Series.—P. C. Sandretto, *Federal Telecommunications Laboratories.*

Microwave Duplexers

EDITED BY L. D. SMULLIN AND C. G. MONTGOMERY. *Volume 14 in MIT Radiation Laboratory Series, McGraw-Hill Book Company, New York, N. Y., 1948, 437 pages, $6.50.*

THIS nine-chapter book, representing the work of six authors, deals primarily with problems where simultaneous transmission and reception is required in a pulsed microwave radar or communication system utilizing a common antenna system and operating frequency.

The text, illustrations and mathematics describe the design and behavior of microwave plumbing as well as the special tubes necessary for electronic switching between the transmitting and receiving functions.

Commencing with an introduction to microwave radar and circuits, it progresses through TR tube theory, gaseous discharges at microwave frequencies, low and high power TR and ATR tubes, branched duplexing circuits, and balanced duplexers, and finally culminates in a 54-page chapter on measurement equipment and tech-

niques for checking the performance of microwave duplexers.

The information is authoritative and is representative of the outstanding work performed by personnel of the MIT Radiation Laboratory during World War II while operating under the National Defense Research Committee. Despite the large amount of formulas or equations as required by design and development personnel, the book is surprisingly understandable when read without taking time out to analyze the mathematics. It discusses the developments which have made American radars outstanding when compared to those of former enemy nations. Any engineer designing or improving a radar system will find his work much easier if he will acquaint himself with the prior art contained in this book. Specifically, he will better resolve the radar equation in the form of shorter receiver recovery time, reduction of blanked-out minimum radar range, protection of the receiver during transmitted pulses, and improvement of reception for the reflected echoes.

The wavelength discussed range from 1.25 centimeters to above 10 centimeters, corresponding to frequencies between 2,700 and 24,000 megacycles. The information is also valuable for any frequency where pulsed radar or radio equipment may be employed. The book is recommended as a permanent reference book for engineering personnel.—SAMUEL FREEDMAN, *De Mornay-Budd, Inc.*

Electronics and their Application in Industry and Research

EDITED BY N. BERNARD LOVELL, PHYSICAL LABORATORIES, UNIVERSITY OF MANCHESTER. *The Pilot Press, London*, 1947, 660 *pages, price* 42 *shillings.*

IN twelve chapters, each by its own author, this book forms a symposium on the subjects of electron physics, photocells for the visible, ultraviolet and infrared, electronic generation of television signals, thermionic tubes for very high frequencies, radar, control applications of cold-cathode tubes, high-frequency heating, moisture content control equipment, electronics applied to servo mechanisms, electronics in medicine and in physiol-

ogy, the betatron and the electron microscope.

The volume deals with basic material and is useful to one wanting a quick survey of a few of the ways in which electronics has come into many phases of human endeavor. Perhaps the best description thus far published on the German work in the detection of infrared radiation will be found in the chapter on this general title. The relations between the American and British versions of the orthicon, the emitron and similar highly complex users of electron beams are well handled. Each of the chapters has a bibliography.

Since much of the material resulted from the war and, therefore, has not appeared in book form before—since the book gives anyone a good survey of the modern applications of electronics—since the chapters are written by experts and, therefore, are authentic, this volume should provide an excellent start into the vast noncommunication accomplishments of electronics.—K.H.

Broadcast Operators Handbook

By Harold S. Ennes. *John F. Rider Publisher, Inc., New York, N. Y.*, 1947, 288 *pages*, $3.30.

The author has assembled available data and techniques connected with radio broadcasting and arranged them in book form. In general, the book is good reading for the technician starting out in the field of radio broadcasting.

The opening chapters describe the reproduction of sound electrically and define the methods of measurement of the sound levels. Control room operations are outlined and the various operating pitfalls are well covered. A number of rules are given as laid down by a representative broadcast station for the guidance of their technical staff. A description of studio setups with microphone placement and accompanying explanation is of value to the newcomer.

A section on preventive maintenance is included which is especially valuable to the operator of any radio station. This section is a reproduction of the system used by the U. S. Army during World War II. These techniques were de-

veloped by the operational research group, composed of broadcasters called by the government for this purpose. Consequently, the information contained herein is the thinking of people with broad experience in the industry.

The book is somewhat difficult to use as a handbook. Articles are prepared more for reading style than reference. It is also noted that representative operations are confined to a narrow range of network operations. The appendix covers apparatus operation but is limited again to a narrow field, being devoted almost entirely to the equipment of one manufacturer.—George Riley, *Radio Station WOR.*

Radio Aids to Navigation

BY R. A. SMITH. *The Macmillan Co., New York,* 1948, 114 *pages,* $2.50.

THERE have been a number of popular articles written purporting to describe the virtues of one or more navigational systems that depend upon radio and other electronic means. There are as well several semitechnical comparisons of systems. For the most part, the former have been a trifle too exuberant and the latter somewhat less than critical.

While Dr. Smith undoubtedly has had no intention of writing a popular treatise, it can be hoped that his concise book will find its way into the hands of those who wish to know some bare essentials about potential or existing electronic aids to air navigation without delving too deeply into a number of competent but exhaustive texts and without seeking out classified or otherwise practically unavailable documents.

The author was engaged in the development of radar methods of navigation at TRE during the war so that he can speak with great authority in this field. His account of other nonradar methods has been written from a full knowledge of other systems since the Telecommunications Research Establishment at Great Malvern was a focal point of all electronics information. Its international character is perhaps pointed up by the fact that it was also host to the British Branch Radiation Laboratory at which were stationed a large number of

semipermanent and transient engineers and scientists from the parent MIT Laboratory in Cambridge, Massachusetts.

Not all scientists seem to be able to forget personal and national pride, but Dr. Smith has succeeded in being dispassionate in three directions at once. Gee, loran, and Sonne are discussed, for instance, on their merits, with no regard for their national origins. The debt that loran owes to Gee is dealt with concisely and briefly with no attempt to assess the national contributions. The Germans are given credit for their ingenious extension of the rotating beam system in Sonne, and it is pointed out that POPI (British) is so far a laboratory system, subject to the same physical laws as any similar type of system operating at a similar frequency.

Besides the systems mentioned, there are others included in chapters on short-range radar interrogators and responder beacons; vhf direction finding; vhf ranges; microwave systems (including H_2S); special systems like GH, Shoran, Oboe; radio altimeters.

Instrument landing systems, both c-w and radar (BABS) types, and airfield control occupy 15 pages. The book starts with a brief summary of prewar systems and their limitations, and ends with a review and glossary.—A. A. McK.

High Frequency Measuring Techniques Using Transmission Lines

By E. N. Phillips, W. G. Sterns, and N. J. Gamara. *John F. Rider, Publisher, Inc.*, 404 *Fourth Avenue, New York* 16, *N. Y.*, 1947, 58 *pages*, $1.50.

This treatise deals with several specific methods of measuring the surge impedance and attenuation of slotted coaxial transmission lines, the magnitude of loads on the line, the magnitude of loads at the far end of an arbitrary cable, and the electrical characteristics of the cable. Eleven specific examples of the procedures and details of the mathematical calculations for measurements made at frequencies above 100 mc and using a slotted coaxial line are given. The 25 pages of procedure and computation provide considerable student practice mate-

rial. Use of a vector slide rule and the Smith Transmission Line Calculator in solving specific problems is illustrated.

The derivation of the formulas used in this test is given in the 23 pages devoted to theory, where a working knowledge of complex algebra and hyperbolic functions is presumed. For convenience in following the theory and in working out the examples, 10 pages are devoted to illustrations, charts, summaries of important formulas, and a table of trignometric and hyperbolic functions of complex quantities.

Although all examples are based on measurements on a specific 52-ohm, 7-ft slotted line, and discussion is practically limited to that necessary for the several measurement procedures used, this text should be of considerable value as a handbook for technicians and students, and as a reference for engineers.—JOSEPH KAUFMAN, *Director of Education, National Radio Institute, Washington, D. C.*

Elementary Industrial Electronics

BY W. R. WELLMAN. *Published by D. Van Nostrand Company, Inc., New York, N. Y.*, 371 *pages*, $3.20.

INDUSTRIAL applications of the science of electronics have now reached such proportions that they can no longer be treated in a superficial manner by our vocational training schools. Recent advances in the art have made full-time courses and adequate textbooks a virtual necessity. This book, written for the beginner rather than the advanced student or practicing engineer, is intended to serve as a basic text for courses in industrial electronics.

The author assumes that the student is thoroughly familiar with d-c circuit theory and therefore plunges right into a discussion of a-c fundamentals and the basic principles of vacuum and gas-filled electron tubes after a brief introductory chapter to give an over-all picture of the field of industrial electronics. Next, high-vacuum, mercury pool, and hot-cathode, gas-filled rectifiers are studied. Following this, vacuum-tube amplifiers for control purposes and oscillators for high-frequency heating are discussed together with electronic con-

trols for motors, generators, and resistance welding. The book closes with a study of photoelectric devices and electronic lamps. This last subject is all too often neglected in this type of textbook. Needless to say, numerous practical applications of each basic function are given as the theory underlying each is treated.

The outstanding feature of this book is the series of experiment sheets that have been included at appropriate points in the text to permit the resourceful student or instructor to demonstrate the principles under discussion. Realizing that equipment for such demonstrations may be rather limited, the author has planned the experiments to use inexpensive and easily available material wherever possible. This is a most helpful consideration.

Also helpful, from the student's viewpoint, is the chapter giving the various symbols used by draftsmen in preparing circuit diagrams, and the series of definitions of common electronic terms. Taken altogether, this book is a welcome addition to the literature.—RAY H. SCHAAF, *National Radio Institute.*

The Radio Amateur's Handbook

BY THE HEADQUARTERS STAFF OF THE AMERICAN RADIO RELAY LEAGUE. (*Twenty-fifth Edition,* 1948), 760 *pages,* $2.

FOR more than twenty years the Handbook has been referred to as the amateur's Bible. Its technique of presenting useful information to a nonengineering audience has matured with the art, however, so that it now attracts readers who require such diverse knowledge as how to build a practical Faraday shield, or who want the pin connections for a given receiving tube. There are 46 completely revised pages listing more than a thousand types, together with base diagrams and complete operating characteristics.

In the 1948 edition, material is presented on theory, principles and design, and construction data. Several new chapters have been added to supplement information previously included with other material. In particular, the ultrahigh frequencies and microwaves take the

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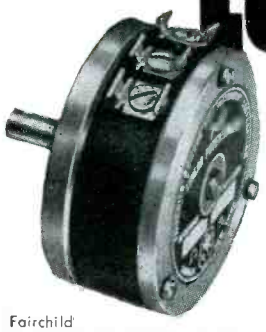

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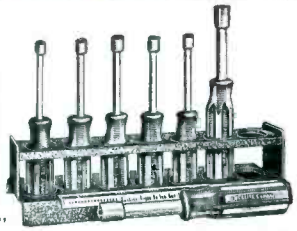

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whole of Chapter 15. For radio amateurs the Handbook is a necessity. Most engineers will find it extremely useful.—A. A. McK.

• • •

Books Received for Review

INTRODUCTION TO THE DIFFERENTIAL EQUATIONS OF PHYSICS. By L. Hopf, Professor, Aachen Institute of Technology, Translated (into English) by Walter Nef, Professor, University of Fribourg, Switzerland, Dover Publications, New York 1948, 154 pages, $1.95. Comprehensive and concentrated survey of use of differential equations, with mathematical concepts developed intuitively from physical phenomena. Such mathematical devices as first order linear homogeneous equations, divergence and curl, and orthogonality are introduced by describing the motion of a particle, electric and magnetic fields, and harmonic analysis. For self study by practicing engineers who have had elementary calculus.

THE RADIO AMATEUR'S BEAM POINTER GUIDE. By John F. Rider (W2RID). John F. Rider, Publisher, Inc., New York 16, N. Y., 1948, 32 pages, $1.00. Twenty-two tables showing the direction (in degress clockwise from north) that an antenna should be oriented in order to beam a signal along a great-circle route. The tables are designed for use in 19 cities of the U. S and three foreign cities, and directions are given for making the slight corrections that may be necessary for locations other than those listed.

SIMA HANDBOOK Scientific Instrument Manufacturers' Association of Great Britain, Ltd, 26 Russell Square, London, W C 1, England, 1947 edition, 219 pages, 10/6d postpaid. Alphabetically arranged list of approximately 2,000 products made by member firms, supplemented by a list of the firms with their products and trade names, an 8-page list of British research organizations, and a 50-page introduction describing the British scientific instrument industry

BESSEL FUNCTIONS. By Enzo Cambi. Dover Publications, Inc., New York, 154 pages, $3.95. Bessel functions of the first kind to all significant orders (those for which $J_n(x)$ exceeds 10^{-15} for the range of x in question) are tabulated. In particular, tables give $J_n(x)$ for values of x from 0 to 0.500 at intervals of 0.001 to 15 places, and from 0 to 10.5 at intervals of 0.01 to 11 places; n extends to 11. Tables also give the Taylor series for J_n of even order integral values of x from 2 to 10.

POWER SYSTEM STABILITY—Vol. I, ELEMENTS OF STABILITY CALCULATIONS. By Edward Wilson Kimbark. John Wiley & Sons, Inc., New York, 355 Pages, $6.00. Methods for solving power networks under transient conditions, including a section on calculating board type analog computers.

PROCEEDINGS OF THE NATIONAL ELECTRONICS CONFERENCE, Volume III, 1947. Published in 1948; 698 pages, paper cover, $4.00, available from Dr. R. R. Buss (Secretary), c/o Electrical Engineering Dept., Northwestern University, Evanston, Ill. Compilation of papers presented at 1947 Conference, 61 in complete form and the remaining 21 as abstracts. (See ELECTRONICS, p 240 Oct. 1947 for list of papers.)

TABLES OF THE BESSEL FUNCTIONS $Y_0(x)$, $Y_1(x)$, $K_0(x)$, $K_1(x)$ 0x1. 71-page booklet, first in new Applied Mathematics Series. Available only from Superintendent of Documents, Government Printing Office, Washington 25, D. C, 35 cents cash. Of chief interest to nuclear technologists, design engineers and physicists; computed at much closer intervals than previous tabulations.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Remote-Control Relay

DEAR SIRS:

I have gone through the article, R-F Operated Remote Control Relay, in the September, 1947 issue of ELECTRONICS and find it of much interest.

In pursuance of the Scheme of Rural Broadcasting of the Government of Bombay, about 500 radio sets have been installed in various villages of this Province and we are considering a proposal for the incorporation of some system whereby the sets could be switched on and off at predetermined times by remote control from the transmitting station. This will, to a large extent, solve the problem of conserving the current drain on the batteries which operate the sets. It will also enable the sets to be remotely operated when special items of broadcast are intended for the villagers.

The approach to the problem is restricted by the limitations which are set out below:

The device should preferably not consume any stand-by current; in case this is unavoidable a stand-by current of not more than 35 to 40 ma from the 6-volt battery is permissible. In any case the vibrator pack which supplies high voltage to the tubes should not be in operation except during program hours.

The device should be very sensitive, sufficiently so to operate from an r-f signal strength as low as 50 microvolts at the aerial terminal.

The resonant input circuit to the device must be sufficiently stable with respect to frequency over a temperature range of from 45 F to 125 F.

The modulating signal for remote control operation should not

take up more than 10 seconds of program time, nor should it (or any of its harmonics) have a frequency exceeding 4.5 kc. The design of the device in the receiver should be such that as much of the duration of the operating signal as possible (within the prescribed limit of 10 seconds) should be necessary to actuate control. This will avoid accidental operation of receiver control through any transient audio frequencies in the actual program that might be similar to the operating signals.

The device should be robust and absolutely reliable. Preferably the relays and any other sensitive parts should be completely sealed to prevent ingress of moisture and dust.

Is any other sensitive device available for the switching operation such as a low-voltage gas triode?

M. M. WAGLE
Office of Engineer-in-Charge
Rural Broadcasting
Government of Bombay
Bombay, India

Electronics—Definition?

DEAR SIRS:

ONE of the most important problems we are going to have to settle on our committee is the definition of "electronics." This is defined in the 1941 Standard as "that branch of science and technology which relates to the conduction of electricity through gases or in vacuo." Usage has extended the scope of this term to include equipment using electron tubes as well as the tubes themselves. This calls for some revision of the old definition.

Should "electronics" and "electron device" be defined broadly enough to include not only the case where conduction takes place through gas or vacuum but also in non-linear resistors now becoming widely known as varistors. Subcommittee No. 13 has defined "varistor" as follows:

"A varistor is a resistor whose current-voltage characteristic is non-linear."

"NOTE: A varistor may be either (a) non-symmetrical, hence producing rectification (this class includes the so-called dry or contact

rectifiers), or (b) symmetrical, showing no appreciable rectification."

In the last analysis, the definitions should follow established usage and my specific question to you is: What do you believe is the established usage of the term "electronics"? For example, is a copper oxide rectifier an electronic device? What has been your usage of this term in the magazine ELECTRONICS; has it been used to cover varistors and varistor applications or only electron tubes and tube applications?

We are also concerned with this same question in the IRE Committee on Electron Tubes.

S. B. INGRAM
Chairman, Subcommittee No. 14
American Institute of Electrical Engineers
New York, N. Y.

DEAR MR. INGRAM:

THE questions in your letter of March 10 are perplexing indeed. They come to us constantly from all manner of sources.

In ELECTRONICS we publish articles on microphones but rarely cover such matters as small motors. Small relays are important in our field. We have done something about copper oxide and similar rectifiers and about photo-conductive light-sensitive cells—not because we necessarily considered them electronic devices—but as tools useful in the field of electronics.

Some attempt has been made to make the electronics field a "small current" field, thus differentiating it from the generation, transmission, or use of power. Small motors, small relays, low-current rectifiers —even fluorescent lamps—have been considered under this sort of definition. But it has not been very successful.

While all the phenomena which we use are basically electronic, I do not think our definition should take in too much territory. I would prefer to limit it to the production and control of free electrons, that is, electrons produced by thermionic, photoelectric or field action. Any device utilizing such phenomena would be an electronic device

and any system using the device would be an electronic system. But whether an electron moving across the interface in a copper-oxide rectifier is "free," or whether an electron traveling up the belt in a Van de Graf generator is "free", are matters which I would hate to have to decide. I think they come closer to my feeling of an electronic device than does a device in which a mere non-linear relation between current and voltage exists (no rectification).

Could we rewrite the definition somewhat as follows: "Electronics is that branch of science and technology which relates to the passage of electrons through gases or in vacua and to systems using devices in which such conduction takes place". This would widen the present definition to include usage but would still limit it to systems using electronic devices. Thus an electroplating system using a high-current non-linear rectifier would not be an electronic system; but a radio system using the same rectifier would be electronic because it employed other devices which *were* electronic. If a battery-charging system used an electronic voltage regulator, it would be an electronic system no matter how it got the direct current which did the charging.

Under some such definition we would continue to define varistors, microphones, and loudspeakers because they are used by the field of electronics and not because we claim they are intrinsically "electronic."

KEITH HENNEY
Consulting Editor
ELECTRONICS

Stagger Tuning

DEAR SIRS:

I wish to disclaim responsibility for the captions accompanying the diagrams in my article "Stagger-Tuned Amplifier Design" in the May 1948 ELECTRONICS. In particular, Fig. 4 and 6 are interchanged, the numerical values in the caption of Fig. 2 are erroneous, and the word "flat" must be omitted in the phrase "flat staggered-pair" of the caption to Fig. 5.

HENRY WALLMAN
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

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1LN5	1.06	6AC5GT	.88	6SS7	.72	12SA7	.59	45	.59	801A	1.10	CK1005	.39
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1P22	11.50	6AD7G	1.06	6T7	1.06	12SF5	.59	46	.88	803	8.95	FF50	.79
1P5GT	.88	6AF6G	.88	6U5	.72	12SF7	.72	47	.88	805	4.95	FL225	1.95
1Q5GT	.88	6AF8	.88	6U6GT	.72	12SG7	.72	49	.88	807	1.25	FM-1000	1.56
1R4	1.06	6AG5	1.06	6U7G	.59	12SH7	.72	50	1.56	808	2.95	GL434	4.95
1T4	.72	6AG7	1.06	6V6	1.06	12SJ7	.72	50A5	.88	809	1.95	GL446A	2.60
1T5GT	.88	6AJ5	.99	6V6GT	.72	12SK7	.59	50B5	.72	810	7.95	HF100	3.95
1U4	.72	6AK5	.99	6V7G	.72	12SL7GT	.88	50L6GT	.59	811	1.95	HY69	2.95
1U5	.88	6AK6	.88	6W7G	.88	12SN7GT	.88	50X6	.88	812	2.95	HY75	1.25
1-V	.72	6AL5	.72	6X4	.54	12SO7	.59	50Y6GT	.59	812H	6.90	HY615	1.25
2A3	1.06	6AL7GT	1.06	6X5	.54	12SR7	.72	53	.88	813	5.95	HYE1148	1.25
2A5	.72	6AO5	.72	6Y6G	.88	12X3	.98	55	.72	814	5.95	RK12	1.95
2A6	.88	6AO6	.72	6Z7G	1.28	12Z3	.88	56	.59	815	2.50	RK22	4.95
2A7	.88	6AT6	.60	6ZY5G	.72	14A4	1.06	57	.72	826	1.25	RK60	.79
2AP1	2.95	6AU6	.72	7A4	.72	14A5	1.56	58	.72	829B	4.95	RKR72	3.50
2B7	.88	6B4G	1.06	7A5	.72	14A7	.88	59	1.06	830B	5.25	RK73	9.95
2C22	.69	6B6G	.72	7A6	.72	14B6	.88	70L7GT	1.56	832A	2.95	T20	1.95
2C26A	.75	6B7	1.06	7A7	.72	14B7	1.10	71-A	.72	833A	39.50	TZ40	2.95
2C34	.98	6B8	1.06	7A8	.72	14B8	.88	75	.59	836	1.15	V70D	6.90
2C40	2.60	6BA6	.72	7AE7	.72	14C5	.88	75TL	2.95	837	2.50	VR75	.98
2C43	2.60	6BE6	.72	7AF7	.72	14C7	.88	76	.59	838	4.95	VR78	.75
2C44	1.75	6BG6	2.40	7B4	.72	14E6	.72	77	.59	841	.69	VR90	.75
2D21	1.69	6C4	.60	7B5	.72	14E7	.88	78	.59	843	.69	VR105	.75
2E5	.88	6C5	.60	7B7	.72	14F7	.88	79	.88	845	4.95	VR150	.75
2E22	1.50	6C6	.72	7B8	.72	14H7	1.06	80	.42	860	3.00	VT127A	3.00
2E24	4.37	6C8G	1.06	7BP7	2.95	14J7	1.06	81	1.28	861	50.00	VU111	1.50
2E25	3.95	6D4	1.95	7C4	1.06	14N7	1.06	82	.88	864	.69	WE532A	4.95
2E30	2.25	6D6	.60	7C5	.72	14O7	.88	83	.88	866A	.89	Z225	1.95
2JB51	4.95	6E5	.72	7C6	.72	14S7	1.06	83V	.88	868	1.95		

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No. S 407 For 304TL or 304 TH. Very few left in surplus. Get yours NOW. **$1.00**

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Made with shock mount to counteract vibration, a heavy duty socket for continuous duty ..... **$1.25 each**

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SOCKET

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FOR 5BP4 OR 7EP4 TUBES. Very high grade ceramic material. Perfect for television or scope use ..... **89¢**

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A steal at **$2.95**

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115 v. primary 60 cy. two secondaries, both 2.5 volts @ 10 amps—each may be used in series to deliver 5 volts @ 10 amps c.t. or as two 866 fil. windings insulated at 10,000 volts. A steal at..... **$4.35**

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Sec. No. 2 5.4 v. @ 3 a.
Sec. No. 3 6.4 v. @ 6 a.
Weight 10 lbs.
Your cost **$2.49**

No. T-6042

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Heavy Duty 750 volts C.T. @ 250 ma. with a 130 volt bias tap—perfect for oscilloscope supply or any application needing these voltages. Size 5¼" high, 5½" wide, 5" deep. Weight 21 lbs.

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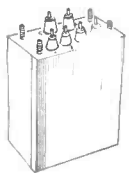

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1/6 horsepower — 5600 RPM series wound motor—27 volts input at 8 amps. 6" overall length, 3¼" diameter, 1" shaft..... **$3.85**

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This may be your last opportunity to stock up on spares at this price—and you fellows who plan to build a kilowatt rig in the near future—here is a golden opportunity to still get in on this "all time new low price."

This is a single tube easy to drive for full kw power with 3000 v. plate, actually 4-75 T's in one envelope.

"Filaments checked before shipment"

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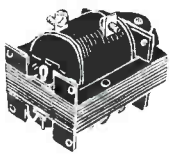


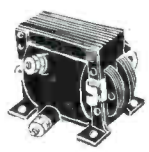
No. R-4242 115 V. 60 Cyc. Type CR 9503-209F Complete with Armature

$1.25

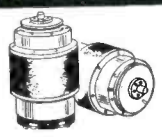
GENERAL ELEC. SOLENOID

No. R-4243 120 V. 60 Cyc. Type CR 9503-208L Complete with Armature

$1.00 each



SELSYN MOTORS

CLOSE  OUT

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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.**

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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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RG 8UF ..... 6¢ ft.
RG 22 UF ..... 15¢ ft.
72 ohm Coax similar to RG 59U....6½¢ ft.

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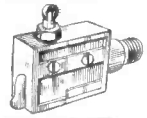

Single pole single throw aircraft type, rugged for outside use—can be used for stopping beam rotation so as not to foul up feed line cable..... **$1.25**

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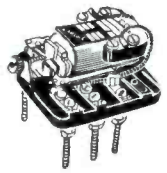
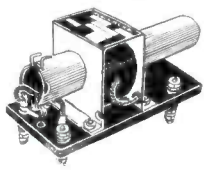


No. R-4013 Double Pole Double Throw 115 Volts 60 cyc. Coil 5 amp. contacts.

$2.65

ADLAKE Type 1040-80



No. R-4012 Mercury Time Delay Relay Normally Opens, Closes in 5 seconds. Open in .3 seconds. ...

$8.75

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No. R - 4010 Adjustable from 1.5 to 3.0 amperes. 110 volt. .60 .cyc. Reset .....

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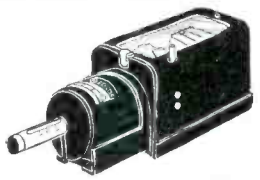
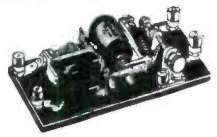


No. R-3001

OVERCURRENT RELAY

Automatic reset—Overload coil is 3000 ohms—Can be shunted for any current simply—Protect those expensive final amplifier tubes, to reset simply press a button. Reset coil is 110 v. 60 cycles **$2.49**



No. R 474

KEYING RELAY

Here is a keying relay made to mount in a tube socket. Double pole Double Throw relay—sealed in vacuum 300 ohm coil. Will follow 100 words a minute. Stock up now..... **$2.00**

No. R-4602

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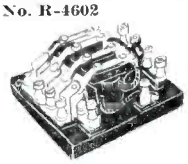
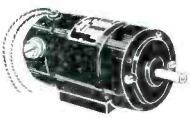


2 110v 60 cy Relay Mounted on one frame. Both relays double pole. One single throw. One double throw. Coils can be paralleled or used independently.

$2.20 each

No. M-574

27 VOLT MOTOR



Series wound 8 Amps. 5600 RPM designed for continuous duty 1/6 horsepower. Body of motor 5" long x 3¼" diam. 5/16" shaft ⅞" long. Your cost **$9.60**

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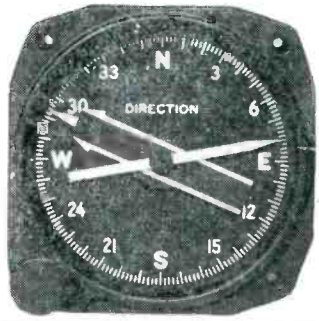

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18V	14	5	4.85
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36V	28	1.1	2.39
36V	28	1.5	2.89
36V	28	3.5	6.75
36V	28	5	7.50
64V	54	.22	3.49
64V	54	5	16.95
90V	80	.15	2.85
135V	116	3	14.95
126V	110	.15	2.95
144V	125	.15	2.95
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460	110	1.6	$6.95
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28	12	150 ma	$.59
72	36	300 ma	.98
130	100	100 ma	.98
216	144	75 ma	1.75

*Use with any VDC Capacitors at 2 X output

Transformers 115V60cyc Sec (Volts/Amps) Fil	
21000CT/.095 Dblr	$19.95
15000CT/.035 Dblr	19.95
3400/1 17KV insul	95.00
3200, 780CT/.2, ... 12/.5	12.95
2000/.01 H sld USN	3.95
1350CT/.15, 6.3/5, 5/2	6.95
1250/.25 $5.25, 2 for	9.95
1250, 640CT/.25	4.95
1200CT/.3 $4.50, ... 2 for	8.98
1100CT/.212	6.95
772/.0025, 2.5/3	3.95
750CT/.375, 500Vwndg	5.25
700CT/.125, 6.3/ 1.25, 5/3	2.95
570CT/.18, 12/4, ... 5/3CSD	3.95
510CT/.125, 6/4, 5/2CSD	3.25
500CT/.06, 6.3/4, Hsld	1.29
500/3 $10.00, 2 for	$19.00
2x330CT/.01	2.49
230or115/10A2KW	19.95
230or115/8A 1.8KW	16.95

HY	MA	Chokes
50	150	$1.95
13.5	1000 1KW V	90.00
12	275	3.29
12	80 CSD	1.98
10	12.5	1.25
8	200, 2 for	2.89
8	150, New Ckd Tbd	1.78
8	110	1.29
5	100, 2 for	.98
3	400 15KV	2.75
3	40, 3 for	1.00
.5	100, 4 for	.98
.01	2.5A 1.5KV	1.49

"TAB" FOR TUBES

OA4G	$1.90	6K7	$.59	845	$3.74
OZ4	1.20	6K8	1.20	860	2.49
1B3/8016	2.00	6L6	1.24	861	14.95
1B24	2.95	6L6G	1.20	864	1.00
1B27	2.95	6L7	.98	865	1.00
1E7G	.98	6N7	.88	866A	1.00
1L4	.88	6S7	1.20	868	1.00
1LC6	1.25	6SA7	.89	872A	2.20
1LH4	1.25	6SC7	.84	884	.75
1LN5	1.25	6SG7	.79	918	1.20
1P5G	.79	6SH7	.38	922	1.40
1P24	2.95	6SJ7	.79	923	.49
1R4/1294	1.25	6SJ7G	.69	931A	3.49
2AP1A	3.95	6SK7	.79	954	.45
2C26	.39	6SL7	.89	955	.45
2C34/RK34	.49	6SN7	.91	956	.49
2C40/446	.73	6SN7GT	.69	957	.49
2D21	.75	6SQ7	.89	958A	.45
2E22	1.50	6SS7	.74	1613	.69
2J21/725	12.49	6V6GT	.98	1614	1.50
2J26	14.95	6U7G	.78	1616	1.39
2J32	16.95	6X4	.98	1619	.39
2J49	35.00	6X5	.88	1622	1.49
2J55	24.95	6Y6G	.88	1624	.70
2J61A	39.95	6Z4/84	.74	1625	.39
2K25/723AB	5.95	7BP7/1813	2.90	1626	.45
2K29	6.95	9JP1	3.95	1629	.58
2V3G	.98	10Y	.59	1635	1.90
2X2	.49	12A6	.89	1641	.75
3A4	.49	12AH7	1.00	2050	.90
3AP1	1.95	12AR7	.95	2051	.49
3B7/1291	.95	12DP7	7.95	7193	.49
3B24	.95	12GP7	7.95	8005	3.25
3BP1	1.90	12SA7	.79	8012	3.95
3BP1A	2.95	12SH7	.88	8013A	4.95
3C23	4.95	12SK7	.69	8020	4.95
3D6/1299	.88	12SQ7	.80	9001	.49
3DP1	2.75	12X3	1.10	9002	.59
3FP7	2.98	15E	1.49	9003	.49
3GP1	3.95	25Z5	.70	9004	.49
3JP12	3.95	35L6	.74	9006	.49
3S4	.55	35Z5	.61	C6J	4.95
4-147	35.00	37	.68	CE206	3.95
5AP1	2.75	41	.68	CE215	5.95
5BP1	3.75	50L6	.72	CK1005	.30
5BP4	3.75	80	.52	F127A	12.00
5CP1	3.75	83V	.89	FG104	14.95
5D21	19.00	205B	3.95	FG105	16.95
5FP7	3.95	211	.79	FG166	49.00
5HP1	3.95	215	2.95	GL434A	7.90
5R4G	1.00	250TH	17.49	HK24/3C24	.81
5T1	1.53	250TL	18.00	RX215	9.95
5U4G	.69	304TH	3.95	T200	12.00
5V4	.98	304TL	2.49	VR90	.74
5W4	.98	307A	3.75	VR92	.45
5Y3G	.53	388	9.95	VR105	.74
5Z3	.88	393	5.95	VR150	.74
5Z4	.88	450TH	25.00	WE388	9.95
6AB7	.98	450TL	29.95	WL468	9.95
6AC7	.72	527/6021	75.00	WL530	49.50
6AG5	.88	631P1/SN4	3.75	WL531	9.95
6AG7	.98	703A	4.95	WL619	20.00
6AJ5	.98	707B/2K28	9.95	TUNGAR*	
6AK5	.69	710A/8011	2.90	20X672*	2.95
6AL5	.98	717A	.69	199698*	2.95
6B4G	1.25	722/287A	9.95	289881*	2.50
6B8G	.98	723AB	4.95	MAZDA PL**	
6C4	.39	726A	6.95	44**Box	.40
6C5	.51	802	1.49	323**Box	10.00
6C6	.73	803	7.95	49**Box	.60
6C8G	.98	804	6.70	50**Box	1.40
6D4	.89	805	3.74	SOCKETS	
6D6	.74	807	1.24	2X2HV	.30
6E5	.98	808	1.95	705/715	.69
6F6/1613	.69	810	5.75	803/304	.90
6F8	1.09	811	1.94	807	.24
6G5/6U5	.95	813	5.94	813	.44
6G6	1.08	814	2.98	829/832	.25
6H6G	.48	815	2.25	866	.24
6H6M	.68	816	1.15	872/211	.49
6J4	2.98	826	.49	Acorn, 6 for	1.00
6J5	.49	828	10.00	Dlhetal	.69
6J6	.49	829B/3E29	4.90	Maginal	.49
6J7	.88	832	2.25	TUBES GTD	
6K5G	1.10	836	1.10	except open Fil	
6K6	.49	837	2.25	& Breakage	
6K6G	.49	WL632A	12.95	Write Qty Prices	

NAVY NOISE LINE FILTERS

10Amps/130VAC/filters from .1to1000mcs min 25DB &from 1to1000mcs/55DB ea $1.29.....2FOR $2.20
30Amp/250VAC&DC filters from .15to1000mcs min 44DB&from .18to30mcs/60DB, Filters line noises for RCVRS, XMTTERS, OIL BURNERS, REFRIG, MCH TOOLS, SIGNS, G'Cost $39@, SPECIAL $4.50@, 2for$8 .....4for $15.00
*LN—Like New Used GOOD GUARANTEED.

"TAB" • Dept. 7E, Six Church Street, New York 6, N. Y., U. S. A. • "TAB"
THAT'S A BUY • • • CORNER CHURCH & LIBERTY STS., ROOM 200 • • • THAT'S A BUY

SEARCHLIGHT SECTION

BC-1160-A TRANSMITTER

157 to 187 Megacycles: Operates off 117 volt 60 cycle power line. This unit can be adapted to a 2 meter band transmitter (especially if to be used in conjunction with the BC-1161-A Receiver) but its chief value is for the valuable parts it contains.

Transmitter BC-1160-A, which is very similar to the BC-1072-A produces a peak output of at least one kilowatt during each of the very short periodically repeated pulses. The high frequency oscillator is under the control of a modulating circuit. The modulator wave has a rectangular form and is of sufficient amplitude so that the transmitter operates at a high level during the pulse period but is inoperative at all other times.

This unit contains the following component items:

BLOWER: 115 volt 60 cycle 28 watts .38 Amps 1525 R.P.M., A.G. Redmond Co.

VARIAC: General Radio, Type 200 B, 115 Volt input, 135 volt 1.5 Amps maximum output.

10 TUBES:

2 #5U4	1 #807
2 #826	1 #6J5
1 #9002	1 #9006
1 #2x2	1 #6SN7

METER: 0-5 Kilovolt & 0-10 Milliampere G.E. or Simpson 3½" Rd flush case (0-1 MA basic movement).

TRANSFORMER:

1 Primary variable from 0-135 volts. Secondary from 0-3500 volts.

1 Primary 117 volt, Secondary 6.3 volt at 1.2 Amp, 275 volt center tap to each side 5.0 volt at 3 Amp.

1 Primary 117 volt, Secondary 4 volt at 16 Amp and 2.5 volt at 1.75 Amp.

Consists also of many other parts, relays, transformers, circuit breakers, interlocks, resistors, chokes, etc., too numerous to itemize.

Complete in metal cabinet 17⅜" X 18½" X 18". Net weight 150 lbs. Illustration does not show exterior cabinet and blower. A Circuit diagram is mounted in cabinet for ready reference.

Net Price $29.50

BC-1161-A RADIO RECEIVER

157 to 187 Megacycles. Operates off 117 volt 60 cycle power line. Ideal for use in conjunction with the BC-1160-A Transmitter. The valuable parts it contains are alone well worth the low price of this unit.

The Receiver BC-1161-A employs a superheterodyne circuit of 14 tubes. The signal is first amplified at the received frequency through two tuned radio-frequency stages and then fed into a converter stage. These stages are inductively tuned. An additional inductively tuned circuit is provided for frequency control of the local oscillator. Separate knobs are provided for each of these four tuning adjustments. The oscillator frequency is adjusted to differ from the frequency of the received signal by the amount of the intermediate frequency. The intermediate frequency amplifier consists of five staggered stages having fixed, inductively tuned, interstage couplings. By staggering the midband frequency of successive stages, a broad band intermediate frequency amplifier is obtained. The signal in the output of the last intermediate frequency stage is detected by a diode. This detected signal is then amplified by a pentode video amplifier. The out put of the video amplifier is fed to a double triode which has no voltage gain but a very low out put impedance.

With a few modifications this unit makes an ideal F.M. receiver. Each set is complete with circuit diagram and the following 14 tubes:

1—6SN7	Cathode Follower
1—6H6	Second Detector
2—6SH7	1st & 2nd R.F. Amp
1—6SH7	Video amplifier
3—6AC7/1852	1st, 2nd, 3rd, I.F. Amp.
2—6AB7/1853	4th, 5th I.F. Amp.
1—9006	Modulator
1—6J5	Oscillator
1—5U4G	Rectifier
1—6E5	Tuning Indicator

Consists also of many other parts, resistors, transformers, condensers, too numerous to itemize.

Complete in metal cabinet 10" high — 16½" wide—15" deep.

Net Price $34.50

PANEL METERS

NEW STOCK—FACTORY GUARANTEED

Simpson 3½" Rd or 3" Sq. fl. bakelite case

1	MADC	@ $7.65
150	MADC	@ $6.75
200	MADC	@ $6.75
250	MADC	@ $6.75
500	MADC	@ $6.75
150	Volt DC	@ $6.75
300	Volt DC	@ $9.45
50	MAAC	@ $6.30
100	MAAC	@ $6.30
3	Amp AC	@ $6.30
5	Amp AC	@ $6.30
10	Amp AC	@ $6.30
15	Amp AC	@ $6.30
25	Amp AC	@ $6.60
150	Volt AC	@ $7.65
300	Volt AC	@ $9.00

SERVICE INSTRUMENTS

NEW STOCK—FACTORY GUARANTEED

Roll Chart Percentage Mutual Conductance Tube Checker, Simpson Model 330 RCP.... @ $132.50
Mutual Conductance Tube Checker. Simpson Model 330 ..... @ $118.50
Roll Chart Plate Conductance Tube Checker. Simpson Model 335 RCP ..... @ $98.50
Set Analyzer VOMA 20,000 ohms per volt. Simpson Model 260 ..... @ $38.95
Set Analyzer VOMA 20,000 ohms per volt with roll top case. Simpson Model 260 RT.. @ $45.95

CODE TRAINING EQUIPMENT

A set of 4 units consisting of: Recorder, Keyer, Practice Tape and Tape Puller for practical training of Morse Code to student operators, etc.

RADIO TELEGRAPH SIGNAL RECORDER

McElroy RRD-900

Designed basically to make inked recordings on ⅜" paper tape of dots and dashes transmitted by students operators for correction of sending errors. Can be connected to output circuit of a radio receiver (impedance of 6-15 ohms) or used for direct recording from a hand or automatic keyer. Operates on 110-120 volt, 25 to 60 cycles. Complete with 1 #117Z6GT, 2 #117 N7GT's (or 117-P7GT's) and 5 reels of blank ⅜" tape in a wood carrying case approximately 10" W x 18" L x 13" H.

CODE KEYING UNIT

McElroy Mfg., Boston

Operation: Designed primarily to read standard code signals from inked tape by means of a photo-electric system and to transmit these signals to an external unit, ie. headsets, blinker, transmitter, oscillator, etc.
Output: Audio signal tone of approximately 800 cycles. Low impedance 15 ohms.
Components: Photo-electric system. Amplifier and oscillator circuits, complete with the following tubes: 4 #117N7GT (or 117P7GT) and 1 photo-tube 923 (or 930) and hand operated tape puller. Operates on 90-130 volts A.C. or D.C.
This unit comes complete in a wood carrying case approximately 10" W x 12" H x 15" L.

TAPE PULLER

McElroy Model TP 890 (or G13-CTP 1300)

Designed to take up the ⅜" tape used on recorders and keyers. Operates on 110-120 volt A.C. or D.C. Speed of motor can be varied by means of a control rheostat mounted on the unit.
Complete with 1 take up reel in wooden carrying case approximately 15" L x 11" H x 11" W.

15 REEL CODE PRACTICE TAPE KIT

Prepared to operate in speed sequence for the beginning students up until they become high speed operators. Provides the most simple code characters at beginners speeds, to the most complex message characters for the high speed operator.

Each reel lasts approximately one hour which provides a total operating time of 15 hours of code message.

These four units make an ideal set for students, schools, etc., in learning to transmit and receive the telegraph code. It may also be used for many applications where relaying facilities are required or where certain experiments and research projects require the recording and transmission of interrupted signals at specified intervals, etc.

SURPLUS - NEW - GUARANTEED

All four units complete, Net, F. O. B. N. Y..... $75.00

HIGH ALTITUDE ALTIMETER

Radio Set SCR-518

This item consist of a complete set of apparatus for installation on aircraft for use in determining the height above the terrain. The nominal range of the equipment is from 0 to 20,000 feet, but is operative to an altitude of approximately 30,000 feet. The complete set of main components when equipped with tubes and fuses, with cable interconnections, with antenna arrays, and primary power source connections, properly made, constitutes a complete and operative equipment. All necessary voltages, other than the primary source, are generated within the equipment. The source of power is an aircraft d-c supply of 24 to 28.6 volts. The total power consumed is approximately 300 watts. Operates at approximately 515 Megacycles.

The set consists of 6 major separate component items. **Receiver, Transmitter, Power unit, Indicator, Control Box & Junction box.**

This equipment comes complete with antennae, connecting cords, brackets, connectors and 29 tubes as supplied by the manufacturer. Brand New—in original cartons. Made by RCA-govt. cost approximately $900.00. Complete with OPERATING INSTRUCTIONS & CIRCUIT DIAGRAMS

Can be used, as is, for use as an altimeter, or for adaptation to radar for marine use, protective or police systems, television etc.

The many valuable parts in this set alone are well worth many times this low price of Only $24.50

Shipping weight approximately 150 lbs. f.o.b. N. Y.

(For detailed particulars of individual components see our advertisement in the May 1948 issue of "Electronics")

PORTABLE CHRONOMETRIC TACHOMETER

To measure speeds from 0 to 20,000 R.P.M. with scale callibrations in 10 R.P.M. divisions. Divide scale reading by 2 when using the peripheral wheel and you can read surface speeds up to 10,000 F.P.M.

A 2" open face dial provides unequaled readability. Each division on large dial indicates 10 R.P.M. & each division on small dial indicates 1000 R.P.M. Readings are similar to those made on kilowatt hour meters. Results of tests remain on dial until next test taken.

Complete with 2 tips, peripheral wheel, & operating instructions—No stop watch or other timing mechanisms required. Made by Jaeger Watch Co. model 43 A-6. Complete in velvet lined case 5" x 3½" x 1½". List Price $75.00.

Surplus—New—Guaranteed $24.50 f.o.b. N. Y.

MULTIPLE RANGE, CONTINUOUS INDICATING PORTABLE TACHOMETER

Three ranges in R.P.M. & three ranges in F.P.M. 300-1200, 1000-4000, 3000-12,000 R.P.M.

Large 4" dial shows INSTANTANEOUSLY & CONTINUOUSLY the speed or change in speed of any revolving shaft or surface.

Complete with 4 tips, peripheral wheel, extension rod and operating instructions. No stop watch or other timing mechanisms required.

Made by Jones Motorola, Stamford, Conn. Comes complete in velvet lined case 7 1/8" x 4" x 5". List price $75.00.

Surplus—New—Guaranteed $24.50 f.o.b. N. Y.

All items are Surplus-New-Guaranteed. C.O.D.'s not sent unless accompanied by 25% Deposit. Orders accepted from rated concerns, public institutions, etc., on open account. We carry a complete line of surplus new meters suitable for every requirement, such as portable, panel, switchboard, recording instruments, laboratory standards, etc. Over 50,000 Meters in Stock. We also stock various surplus components, tubes, parts, and accessories and can supply large quantities for manufacturers, exporters, etc. Send for free circular Manufacturers, Exporters, Dealers—We invite your inquiries.

MARITIME SWITCHBOARD

338 Canal Street **Worth 4-8216-7-8-9** **New York 13, New York**

TELL US—TELL OTHERS—SAY YOU SAW IT IN ELECTRONICS!

SPECIALIZED ELECTRONIC MATERIAL

ALL MERCHANDISE GUARANTEED TO BE AS SPECIFIED

HIGH QUALITY • LOW PRICE • IMMEDIATE SHIPMENT

STANDARD BRAND PRECISION RESISTORS

Types WW3, WW4, and WW5

Following sizes are in 1% and 2% tolerance Price $.35

1 meg	66,000	1500
.8 "	54,500	1400
.75 "	46,000	1200
.7 "	40,000	1000
.6 "	33,000	750
.4 "	20,000	280
.268 "	13,300	235
.22 "	12,000	130
125,000	11,000	125
120,000	7,500	110
109,000	4,500	55
100,000	4,300	22
95,000	4,000	20
92,000	2,500	14
84,000	2,230	12
82,000	2,200	10
80,000	1,700	6

Following sizes are 5% or better tolerance, Price $.15

110,000	70	40
22,000	50	35
		30

The following sizes 1% or better. Price $.10

41,808	105.8	4.4
14,460	63.96	4.35
4,285	53.32	4.3
1,123	33.22	3.94
988	23.29	3.5
414.3	13.52	1.563
366.6	13.333	.29
220.4	10.2	.268
147.5	5.1	.25

Last Minute Specials

These are in limited quantity and subject to prior sale.

MOTOR GENERATOR

MOTOR

Janette type PE 3—220 volts, 60 cycles, 3Φ—2 H.P., Speed 1725.

GENERATOR

Janette type CF34—110 volts, 100 cycles, 1Φ—7.8 amps, 0.8 KVA, RPM 3000, Shunt winding. Plus attached DC Generator—output 100 volts, 40 watt—RPM 3000, Comp-Wound. The entire unit mounted on steel base 15" x 33" x 3" and furnished with a control panel having the following equipment: GE Motor Starting Switch, GE Magnetic Switch, GE Start-Stop Control, GE Heavy-duty rheostat, 1 Fuse box, 3 GE CR 9158 Resistors. **Price $150.00**

GENERAL RADIO PRECISION WAVEMETER Type 224

Range 75-24000 meters in 5 steps. Complete with coils charts and miscellaneous fittings and housed in a box 19" x 11" x 11½". .....**Price $150.00**

3 PHASE TRANSFORMERS

Primary 208 volts, 60 cycles—3 Phase Delta Conn. Secondary 3700 volts, 410 ma. Y conn. Overall dimensions 7" x 15" x 9". .....**Price $19.50**

HIGH VOLTAGE-HEAVY DUTY TRANSFORMERS

Primary 115 volts, 60 cycles. Secondary 7000 volts, 500 ma. Overall dimensions 10" x 11" x 8". **Price $25.00**

VIBRATION TABLE

This unit consists of a heavy duty motor with weighted flywheels mounted on a spring-supported table top 2' x 3' size. Overall height of the steel table is 32 inches and has the following equipment, 2 speed-control rheostats, on-off switch, and fuse-box. .....**Price $75.00**

RELAYS

Telephone Type Relay #D161984 Dual Contacts Six Pole Double Throw Coil 700 ohms 24 Volts D.C. **Price $1.25**

Telephone Type Relay #DB28091 Dual Contacts 4 P.S.T. Normally open Dual Winding Coil 175 ohm and 180 ohm 12 V. D.C.....**Price $ .95**

Leach #1054, coil 260 ohms, 24 volts DC Heavy contacts, two pole single throw.....**Price $ .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 .....**Price $ .95**

Allen Bradley Bulletin-810 Magnetic Overload Relay Dashpot type .15 amps. continuous adjustable range .095-29 amps. D.C. Resistance 300 ohms S.P.S.T. N.C. 600 Volts Max. .....**Price $1.25**

Struthers Dunn S.P.D.T. Relay 36 Volt coil—20 ma. Contacts 2 amps at 115 V.A.C...**Price $ .95**

Relay—D.P.D.T. Heavy contacts Coil 6 volts D.C. 18 ohms .....**Price $ .95**

Leach type 1154 D.P.S.T. Heavy contacts Coil 50 Volts 50/60 cycles .....**Price $1.25**

Struthers Dunn #61BXX104 D.P.S.T. Coil 12 Volts D.C. Contacts 25 amperes at 12 Volts D.C. **Price $ .95**

Allied Control #D0X8 4 Make 4 Break. Heavy Contacts Coil 18 turns #10 enamelled wire. **Price $ .75**

Relay S.P.S.T. WE Co. #D163781 unit encased in vacuum tube shell with octal base. 2 pins term for coil, two for switch, 2500 ohms 10 V.D.C. Operating current 4.3 ma. release current 2.5 ma. cont. rating 1 amp. Switching speed up to 200 cycles .....**Price $1.95**

Switchboard Relay, WE Co. #D164816 3 windings **Price $2.95**

Allied Control #BOY-X5 Coil 6 Volts D.C. Contacts D.P.D.T. plus SPST N.C. Heavy contacts **Price $ .95**

Aircraft-type Starter Relay Leach type #7220-3-24 Coil 24 Volts D.C. Res. 132 Ohms. Very Heavy Contacts .....**Price $ .75**

Isolantite Relay D.P.D.T. Heavy Contacts Coil 100 ohms, 12 Volts D.C.....**Price $ .75**

Weston Mod. 705 Relay — meter type. Requires only 7½ microamperes (plus or minus) to close contacts. Coil resistance approximately 50 ohms. Solenoid reset coil—400 ohms at 18 volts D.C. Limited quantity. .....**Price $3.95**

TIME DELAY RELAYS

Thermal vacuum type
S. P. S. T. 100 ohm coil
24 Volts AC/DC
90 second delay .....**Price $ .95**

Cramer Time Delay Relay—#44SP3 N.L. Motor 115 Volts—60 cycles—Two Pole Switch 115 Volts at 10 amps—One circuit closes at 4 seconds, other circuit closes at 40 seconds. **Price only $4.95**

HIGH FIDELITY INPUT TRANSFORMERS

Ferranti #4794 Balanced winding, shielded type. Description—Turns ratio step-up 2/1 primary inductance 133 Henrys ± 1 DB 60-9000 cycles. Can be used to match any single or push-pull plates to any single or push-pull grids—overall dimensions 2¼" x 3" x 2½".....**Price $1.75**

GENERAL RADIO CAPACITY BRIDGE

Type 216—Complete and in perfect condition. **Price $65.00**

TRANSTAT VOLTAGE REGULATORS

Manufactured by Amertran, three Models are available

Model #TH 2½B
Fixed Winding 230/130
Commutator range 0-260 Volts, 65 KVA.
Max. amp. 2½
Price $19.95

Model #29144
Fixed Winding 115 Volts—60 cycles
Commutators range 103-126 Volts
Maximum output .25 KVA
Housed in shielded case 5" x 6" x 6"
Price $6.95

Type RH
Fixed Winding 115 Volts—400 cycles
Commutator range 75-120 Volts
Load—.72 KVA
Housed in Shielded case 5½" x 6" x 6½"
Price $1.95

RADIO NOISE FILTERS

These line noise filters are available in large quantities and priced for quick sale.

Mallory NF 12-6EG—Housed in a bathtub type container and rated at 7 amps, 50 volts D.C. Solder lug terminals .....**Price $ .35**

Mallory NF7-3A—Housed in silver-plated rectangular case 3¾" x 1⅞" x 2½" with male and female amphenol AN3108 plugs .....**Price $ .95**

Mallory NF7-4—Housed in rectangular case 3" x 1½" x 7½". Internal screw terminals. Rated at 12 amperes—35 V.D.C. .....**Price $ .95**

Mallory NF2-2—Housed in square case 3¾" x 2½" high—Rated at 50 amperes 35 volts...**Price $ .95**

General Electric Noise Filter—Housed in square case 4¼" by 3" high. Rated at 200 amperes at 50 volts .....**Price $ .95**

Mallory NF2-1—100 amps, 35 volts—Housed in shielded container 3¾" square x 2½" high screw terminals .....**Price $ .95**

Solar Elim-O-Stat—Type EA105—50 amps at 50 Volts—$ .95. Type EA109—50 amps at 35 volts. Both units are housed in container similar to Mallory NF2 .....**Price $ .95**

Bendix—model 3937—Generator Filter—50 amps, 120 Volts D.C.—Housed in shielded containers 4" x 3¾" x 8" .....**Price $1.25**

Line Noise Filter—Unshielded and mounted on a bracket Suitable for use on regular power lines—Consists of two .01 molded condensers and 140 turn solenoid choke coil.....**Price only $ .10**

4000-6000 VOLT LOW CURRENT DC SUPPLY

These units have been designed for use with television, cathode ray, electron multiplier and other types of equipment requiring high voltage with currents up to 1 milliampere. Brand new completely wired and tested. Ready to operate from 115 volt power line. D.C. output is filtered.
Price Complete $12.50

2000-3000 Volt D.C. Supply, similar to above, but with lower output voltage. Ready to operate from 115 Volt power line. **Price Complete $7.95**

Write for Descriptive Catalog Listing a Large Variety of Electronic Components

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131 LIBERTY STREET *Telephone: WOrth 4-1169* **NEW YORK 6, N. Y.**

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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**

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**

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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**

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D.P.S.T., Normally open, 115V, 60 Cycle, A.C. coil, 30 Amp contacts, fibre base with 4 holes for mounting. Dimensions, 4½" L x 3" W x 2¾" H.

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Non-Shorting, Model 312, Cat. #312-10, 25 Amps A.C., 10 taps, without knob. Dimensions: 3¼" Diam. x 3¼" Deep.

Your Price **$1.50**

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For use with low voltage, D.C., 100 Amps. Dimensions: 3¼"H x 4"D x 1" W.....**$1.75**

TRANSTATS—3 K. V. A.

Type RH Input: 115 V. 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-30 Volts at 30 Amps. No Knob.

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(same type, but .25 KVA. Input: 103-126 V. Output: 115 V.-2.17 A.)

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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.

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0-1 Ma 2" G.E. DW41 (special scale)	$2.95
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0-2 Ma 2" Sun 1AP525-5	2.25
0-3 Ma 2" Weston 506 with metal case	1.85
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0-35 V. 2" Simpson (metal case)	2.95
0-100 Ma 2" sq. Simpson 127	2.95
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0-1 Ma 3" G.E. DO-41	4.95
0-15 Ma 3" Westhse NX-35 (scale: 15/150/300)	2.95
0-10 A. 3" Simpson #25	4.50
0-30 Ma DC G.E. DO-58, 4½"x4" (Black or White Scale)	4.95
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0-300 A. 3" Roller-Smith (Bake Type TD-50 MV) (with ext. shunt)	4.95
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0-15 V. 2" Westhse BX-33 (Black scale)	2.75
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0-150 V. 3" G.E. DO-41	4.75
0-150 V. 4" Weston 643 (Black scale—flush—metal)	6.75

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0-75 A, 4" Weston 642 (Surface Metal Case)	6.75

All meters are white scale flush bakelite case unless otherwise specified.

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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

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New — Manuractured only 3 Months Ago

Full Wave Bridge, Input Max. 24V AC, Output 18V @ 10A, continuous duty.

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6 Amp. (Tungar type) for battery chargers, rectifiers, etc.

Your Cost **$1.50**
(minimum order of 10 tubes)

RHEOSTAT, OHMITE MOD. N,

300 Watts, 150 Ohms, 1.41 Max. Amps, 6" Diam., Weight 2¾ lbs., without knob.

Price **$5.25**

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500 Watts, 250 Ohms, Tapered, 2.5-.51 Amps, 8" Diam., Weight 4 lbs., without knob.

Price **$7.50**

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Full Wave Bridge

Approximate Rating

Federal Type #	Input Max.	Output Max.	Amps.	Price
10B1CV1	18 V.	14 V.	.5	$.98
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

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

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.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**

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Range 350-450 Cycles, Weston 637, aircraft type, 3½".
Complete **$4.95**

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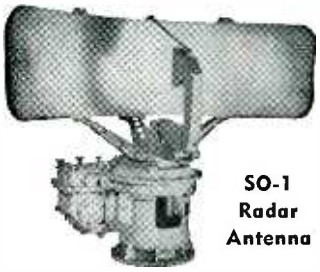

SO-1 Radar Antenna

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Brand new packed in original cases.
Type SO-1 $125.00—Type SO-8 $120.00
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W. E. TYPE D-168479 MERCURY CONTACT RELAY

For application in all types of high speed switching devices. Long service life, high operating speeds. Large current and voltage handling capacity, uniform and constant operating characteristics under adverse atmospheric conditions. Hermetically-sealed mercury-wetted contacts in gas-filled glass envelope. Free from moisture, dirt, corrosion and atmospheric pressure.

1000 hours life at 60 operations per second. Two coils of 700 ohms, and 3300 ohms. Operating current, coils series aiding—6.6 mils. Release current, coils series aiding—5.2 mils. Four page Technical Data on request.

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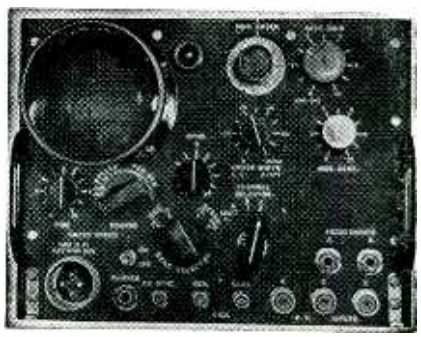

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10 CM WAVEGUIDE

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KOLLSMAN MAGNETIC COMPASSES (Brand New)

Type B-16

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1D-24/ARN-9. Brand new.

Price $3.95

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Used in Art. 13 Transmitter

Brand New

Price $1.50

20,000 ohm., De Jure Potentiometer and Dial Assembly. Brand New.

Price $2.75

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Phone jack, one end, Coax Receptacle other end.

Price $1.35

BRITISH COAX CONNECTOR

Right angle Type 10H-701.

Price $.25

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Any unfiltered source of 350-400 volts DC may be connected to this unit to provide filtered and regulated output at 150 and 300 volts. Contains 12 Hy choke; 3-4 mfd. capacitors; bleeder, divider and current limiting resistors, etc. Ideal in the Lab for experimental set-ups. Complete, brand new with 2-VR 150 tubes.

$7.95

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Bridge Type

Input: 36 V. AC
Output: 28 V. DC., 1.1 Amps

Brand New $2.75

400-2600 CY. POWER SUPPLY

Input:
80 or 115 volts, 400 to 2600 cycles

Output:
1200 volts D.C. at 1.5 MA.
400 volts D.C. at 130 MA.
6.4 A.C. volts at 0.8A (ins. for 1500 v. D.C.)
Includes tubes: 1—5R4GY, 1—2x2, 1—6AK5, cathode ray tube socket, resistance capacitance filter, two focus controls, an intensity control and 6AK5 reinserter circuit.
Brand new. Complete $13.75

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Input: 115V.-60 cycles.
Output: 20 V., at 10 amps. Also tapped at 6V., for pilot light. Ideal for Selenium Rectifier Applications, etc.

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Type 2JIF3—115 volts—400 cycles. Brand New.

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400-2600 CY. POWER TRANSFORMER

As used in Power Pack Described Above ...$4.75

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Type SS501
Brand New

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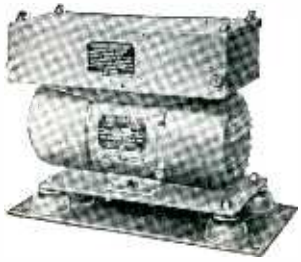
Large stock of various types of Synchros as follows: 5B, 5G, 5SF, 5SDG, 5DG, 6DG, 7G, C78414, C78863, 2J5FBI, CAL 18300, C78411, AY101D, etc.



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Input: 105/130 V.DC. at 6 amps.
Output: 13 V.DC. at 40 amps or 26 volts at 20 amps.
Designed for radio use. Fully R.F. filtered. Complete with Square "D" switch box, spare fuses, brushes, etc. Brand New, packed in original wooden cases.

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MOTOR GENERATORS

Brand New War Surplus Machines built by Allis Chalmers Co. to U. S. Navy Specifications.
Input: 115V. D.C. at 14 amps., 3600 rpm. Output: 120 V. A.C., 60 CY. 1 ph. at 10.4 amps., 1000 Watts continuous duty. Ball bearings. Splashproof. Fully enclosed. Centrifugal starter. Frequency adjustable to load. **Price $125.00**
Same machine but for 230 V. D.C. input.. Price $125.00. Spare parts kit with extra brushes, brush-holders, field coils, bearings, etc., for either machine, **$29.50.**

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Pioneer type 12123-1-A. Input: 24 V.DC. 12 amps. Output: 115 V., 400 cy., 3 ph. Capacity 100 va. New .....**Price $79.50**
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"X" BAND AN/APS-15A: Compl RF head and modulator, incl. 725-A magnetron & magnet, two 723A/B klystrons (local osc & beacon), 1B24 tr, rcvr-ampl, duplexer, HV supply, blower, pulse xfmr, Pk Pwr out: 45 KW apx. Input: 115V, 400 cy. Modulator pulse duration .5 to 2 microsec. apx 13 KV. PK. pulse. Compl with all tubes, incl 715 B, 829 B, RKR 73, two 72. Compl. pkg. new.....$210.00
COMPLETE PKG. as above, less Modulator..$150.00
10 CM. RF PACKAGE. Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer $150.00

DYNAMOTORS

Type	Input Volts	Input Amps	Output Volts	Output Amps	Radio Set	Price*
BD 77KM	14	40	1000	.350	BC 191	$9.95 N $5.95 LN
PE 73	28	19	1000	.350	BC 375	$4.95 N
DM 21	14	3.3	235	.090	BC 312	$2.79 LN
DM 21CX	28	1.6	235	.090	BC 312	$2.49 N
DM 25	12	2.3	250	.050	BC 367	$2.49 LN
DM 28R	28	1.25	275	.070	BC 348	$3.75 N
DM 33	28	7	540	.250	BC 456	$3.95 N
DM 42	14	46	515 1030 2/8	.110 .050	SCR 506	$3.95LN
PE 55	12	25	500	.400	SCR 245	$4.95 LN
PE 86 N	28	1.25	250	.060	RC 36	$1.95 N
PE 101 C	13, 26	12.6/6.3	400 800 9 AC	.135 .020 1.12	SCR 515	$3.49 N
BD AR 93	28	3.25	375	.150		$4.95 N
23350	27	1.75	285	.075	APN-1	$3.50 N
35X045B	28	1.2	256	.060		$2.25 N
ZA .0515	12 24	4/2	500	.050		$3.95 N
ZA .0516	12/24	8/4	275	.110		$4.25 N
B-19 pack	12	9.4	275 500	.110 .050	Mark II	$6.95 N

*N—New. LN—Like New.

30 FT. MAST SETS

Heavy duty rugged plywood. Crated in 3 sections with coupling material. Two masts for ideal flat-top antenna. Unused .....$40.00 per set

MICROWAVE ANTENNAS

SO-13 ANTENNA. 24" dish with feedback dipole 360 deg. rotation, complete with drive motor and selsyn.
New .....$75.00 Used.....$45.00
DBM ANTENNA. Dual, back-to-back parabolas with dipoles. Freq. coverage 1,000-4500 mc. No drive mechanism $65.00
AN/128A ANTENNA. Two Vertical dipoles working against a square reflector apx. 3' x 4'. Range: 140-200 mc. .....NEW $40.00
AS-125/APR Cone type receiving antenna, 1000 to 3200 megacycles. New.....$4.50
APS-4 3 cm. antenna. Complete. 14½" dish. Cutler feed dipole directional coupler, all standard 1" x ½" waveguide. Drive motor and gear mechanisms for horizontal and vertical scan. New, complete..$65.00
AN/TPS-3. Parabolic dish type reflector approx. 10' diam. Extremely lightweight construction. New, in 3 carrying cases $89.50
RELAY SYSTEM PARABOLIC REFLECTORS: approx. range: 2000 to 6000 mc. Dimensions: 4½' x 3' rectangle, new $85.00
TDY "JAM" RADAR ROTATING ANTENNA. 10 cm. 30 deg. beam. 115 v.a.c. drive. New.....$100.00

POWER EQUIPMENT

STEP DOWN TRANSFORMER: Pri: 440/220/110 volts a.c. 60 cycles, 3 KVA. Sec. 115 v. 2500 volt insulation. Size 12"x12"x7" $40.00
PLATE TRANSFORMER. Pri: 117 v. 60 cy. Sec. 17,000 v. @ 114 ma, with choke. Oil immersed. Size: 24"x29"x12". Amertran $65.00
PLATE TRANSFORMER. Pri: 220 v. 60 cy, 3 phase, 30 KVA. Sec. 6150, 5620, 5050, 4500 volts. Oil filled, 89 gal. Size: 54"x32"x23". Amertran. Approx. wt. 1500 lbs.....$250.00
Fil. Transformer: Pri: 220 v.a.c., 60 cy; .05KVA. Sec. 5 v.c.t., 34,000 v. test $24.50
Fil Trans. UX6899. Pri: 115 V, 60 cyc. Sec: Two 5V, 5.5 Amp Wdgs. 29KV Test.....$24.50
Plate Transformer: Pri: 115/230 v.a.c., 50-60 cy. Sec: 21,000 v, 100 ma.....$145.00

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PE 206-A. Input: 28 VDC @ 38 amp. Output: 80 volts @ 500 volt-amps, 800 cycles. Leland. New, complete with enclosed relay, filter, instruction book ..$12.50
PE 218: Input: 25-28 VDC @ 92 amps. Output: 115 volts @ 1500 volt-amps, 380-500 cycles. Poor physical but good running condition. $12.50

.25 mfd @ 20 KVDC $17.50
.1 mfd @ 10,000 KVDC, 14F191 .....$15.00
.0016 mfd @ 15 KVDC, # 26F700.....$8.45
.015 mfd @ 16 KVDC, # 25F835.....$7.50
.005—.005—.01 mfd @ 10 KVDC.....$6.95
.06 mfd @ 15 VDC, 25F585-G2.....$8.70
2x.1 mfd, 7 KVDC, 25F774 .....$3.95

Precision condenser: #D-166602, 16 mfd @ 400 vdc, temp comp-50 to 85 deg C. $7.50
Precision condenser: D-161270, 1 mfd @ 200 vdc, temp comp-40 to plus 65 deg. C.....$5.00

.00015 mf @ 20 KV, 1970-404.....$25.00
.0001 mf @ 20 KV, G3.....25.00
.0051 mf @ 15 KV, G4.....25.00
.006 mf @ 10 KV, G3.....17.50

MICROWAVE TEST EQUIPMENT

W. E. 1 138 A. Signal generator, 2700 to 2900 Mc range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram $50.00
TS-238 GP. 10 cm. Echo box with resonance indicator and micrometer adjust cavity. 2700 to 2900 Mcs calibrated $85.00
3 cm. wavemeter: 9200 to 11,00 mc transmission type with square flanges $15.00
3 cm. stabilizer cavity, transmission type. $20.00
Direct reading VSWR meter. Complete with amplifier, bolometer input—AC crystal—DC crystal connections $45.00
3 cm Wavemeter. Micrometer head mounted on X-Band guide. Freq. range approx. 7900 to 10,000 Mc. $75.00

5J30 THE NEWEST THING IN UHF. 10-350 MC. MAGNETRON IN GLASS ENVELOPE. NEW, COMPLETE WITH DATA SHEET $39.50

TUBE	FRQ. RANGE	PK. PWR. OUT.	PRICE
2J31	2820–2860 mc.	265 KW.	$15.00
2J21A	9345–9405 mc.	50 KW.	$25.00
2J22	3267–3333 mc.	265 KW.	$15.00
2J26	2992–3019 mc.	275 KW.	$15.00
2J27	2965–2992 mc.	275 KW.	$15.00
2J32	2780–2820 mc.	285 KW.	$15.00
2J38 Pkg.	3249–3263 mc.	5 KW.	$25.00
2J39 Pkg.	3267–3333 mc.	8.7 KW.	$25.00
2J55 Pkg.	9345–9405 mc.	50 KW.	$25.00
3J31	24,000 mc.	35 KW.	$17.50
700A	680–710 mc.	100 KW.	$35.00
720BY	2800 mc.	1000 KW.	$25.00
KLYSTRONS: 723A/B $7.75		707B	$20.00

MAGNETS

For 2J21 725-A, 2J22, 2J26, 2J27, 2J31, 2J32, and 3J31 .....Each $8.00
4850 Gauss, ⅝" bet. pole faces, ¾" pole diam....$8.00
1500 Gauss, 1½" bet. pole faces, 1⅝" pole diam...$8.00
1000 Gauss, electromagnet, adjustable 2⅜" to 3" bet. pole faces. 2½" pole diam. $12.00

TUNABLE PKG'D "CW" MAGNETRONS

QK59 2675-2900 Mcs. QK61 2975-3200 Mcs.
QK60 2800-3025 Mcs. QK62 3150-3375 Mcs.
New—$45 each New—$55 each

LABORATORY ACCESSORIES

REACTOR: .01HY, 2.5 amp. 1500 v ins "Kenyon" $3.50
BROAD BAND S THRU X themistor mount with type "N" input $8.00
SPERRY KLYSTRON TUNER Mod. 12.....$2.00
SINE POTENTIOMETERS, GE#251 x 96 or W.E. #KS 15138 LO1 .....$3.50
CG 27, TYPE "N" CABLE ASS'Y, 3' long, male to female $2.50
PH-SHIFTING CAP., 180 deg. W.E. #D-150734 $2.50
KLYSTRON SOCKETS for 723 A.B. and similar types. 2 for $1.00
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LINE INSERTION ATTENUATOR, type OAX-1. 20 Db. attenuation, with 3-contact plug and socket (amphenol 16S-5) $2.25
TS 115/APS-2F 10 CM ANTENNA in lucite ball, with type "N" fitting $4.50
OAJ NAVY TYPE CYT66ADL, ANTENNA in lucite ball, with Sperry fitting $4.50
10 CM. FEEDBACK DIPOLE antenna, in lucite ball, for use with parabola $8.00

3BPI	...$1.25	3FP7	...$1.20	5FP7	.....$1.75
3DP1	...$2.25	3GP1	...$3.35	5JP2	.....$4.00
3EP1	...$2.95	5BP1	...$1.20	12GP7	...$10.95

"PPI", ROTATING YOKE TYPE, complete with all necessary oscillator circuits, CR tube 5FP7, complete with tubes. Used with SO radar.....$100.00
RT39/APG-15. Transmitter-receiver. 2200-2700 mc APX. Complete with 2C43 lighthouse plumbing. Tlt. 30 mc. I.F., all enclosed in compact pressurized housing. New, less tubes $100.00
CP 14 APS-15A COMPUTER. Compiles slant range-ground range against altitude.....$15.50
CURSOR DIAL ASSEMBLY for 7" CR tube. Azimuth calibrated to 360 deg. Roller bearing mech. .$12.50
BC 701-A RADAR RECEIVER, Part of SCR 521 and ASE eqpt. 176 mc operation, receives bilobed search and homing patterns. Complete with tubes and antenna switching motor $37.00
BC 704-A SCOPE, part of SCR 521 and ASE equipment. "L" scope with linear range sweep. With all tubes, including 5BP1 .....$17.50
YAGI ANTENNA SWITCHING MOTOR for ASE and SCR 521 sets. Operates on 24 v.d.c., at 1800 RPM. DPDT $2.00

COAXL CONNECTORS

831R	.....$.35	UG 21/U	.....$.85
831SP	.....$.35	UG 86 U	.....$.95
831AP	.....$.35	UG 254/U	.....$.75
831HP	.....$.15	UG 255/U	.....$.85

Homedell male to type "N" male adapter.....$1.25

PULSE EQUIPMENT

APQ-13 PULSE MODULATOR. Pulse Width .5 to 1.1 Micro Sec. Rep. rate 624 to 1348 Pps. Pk. pwr. out 35 KW. Energy 0.018 Joules $49.00
TPS-3 PULSE MODULATOR. Pk. power 50 amp, 24 KV (1200 KW pk.); pulse rate 200 PPS, 1.5 microsec; pulse line impedance 50 ohms. Circuit—series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New, with all tubes $49.50

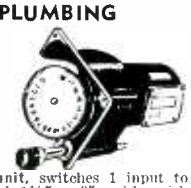
PULSE TRANSFORMERS

G.E. #K2731	....$19.50	W.E. #D166173	..$12.50
K2450A	...$15.00	KS9948	... $6.50
K2748A	...$12.00	KS9800	... $2.00
W.E. #D169271	.. $9.95	Utah 9318 or 9280	$1.25

715 B, with socket $8.50
705 A, with socket $1.50

MICROWAVE PLUMBING

10 CENTIMETER



Waveguide to flexible coax coupler (RG 18/U), with flange Gold plated. App. 10" high $17.50
Magnetron to waveguide coupler with 721-A duplexer cavity, gold plated $45.00
10 cm. waveguide switching unit, switches 1 input to any of 3 outputs. Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. New and complete $135.00
721-A TR cavity with tube. Complete with tuning plungers $5.50
Line Stretcher complete with remote control cable in standard guide with square flanges.....$50.00
Waveguide section, MC 445A, rt. angle bend, 5½ ft. OA, 8" slotted section $21.00

⅞" RIGID COAX—⅜" I.C.

Right angle bend, with flexible coax output pickup loop $8.00
Short right angle bend, with pressurizing nipple $2.00
30 ft. flexible section, ⅞ rigid to ⅞ rigid.....$7.50
Rigid coax to flex coax connector.....$3.50
Stub-supported rigid coax, gold plated. 5' lengths. Per length $5.00
Rt. Angles for above.....$2.50
⅞" coax. rotary joint.....$8.00
Rt angle bend 15" L. OA.....$2.00
Flexible section, 15" L. Male to female. Pressurized $4.25

3 CM. PLUMBING
(STD. 1" x ½" GUIDE UNLESS OTHERWISE SPECIFIED)

TR cavity for 724-A TR tube, transmission or absorption types $3.50
724-A TR tube $2.50
Waveguide section, CG 251/APS-15A, 26" long choke to cover, with 180 deg. bend of 2½" rad. at one end $4.00
Rotary joint with slotted section and type "N" output pickup $8.50
Waveguide section, 12" long choke to cover, 45 deg. twist & 2½" radius, 90 deg. bend.....$4.50
Stabilizer cavity feeding waveguide section, with filtered output and attenuating slugs.....$20.00
Slug Tuner/attenuator, W.E. guide, gold plated..$3.75
TR/ATR Duplexer section with wavemeter iris flange $4.00
Right angle elbow, 5½" choke to cover, 2½" radius E or H plane $5.00
Twist, 90 deg., 6" choke to cover.....$5.00
Waveguide sections 2½" long, silver plated, with choke flange .....4.....$4.50
Waveguide, 90 deg. bend E plane, 18" long.....$4.00
Rotary Joint, choke to choke.....$6.00
Rotary joint, choke to choke, with deck mounting $6.00
S-curve waveguide, 8" long cover to choke.....$2.50
Duplexer section for 1B24.....$10.00
3 cm. waveguide, 1" x ½", per ft.....$1.50
Circular Choke flanges, solid brass.....$.55
"T" section (TR-ATR) choke to choke, supplied with circ. or sq. flanges.....$3.50
Directional coupler CG 124 APS-15A on 16" section cover to cover 15 deg., bend.....$5.00
Feedback dipole with 90 deg. twist, 7½".....$3.50
Waveguide to Type "N" Coax Adapter.....$6.50

2K25/723AB, X band local oscillator mount with (1) choke coupling to beacon reference cavity; (2) choke coupling to TR and receiver; (3) Iris coupling with AFC attenuator to antenna waveguide; (4) Radar AFC crystal mount; (5) Receiver crystal mount; (6) Attenuating slugs. Mfg. DeMornay Budd $22.50
TR/ATR Duplexer section for above.....$4.00

2½" Flexible section, cover to cover.....$4.00
Short Arm "T" section, with additional choke output on vertical section $4.00

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
K-Band Rotary Joint $45.00

400 CYCLE TRANSFORMERS

PLATE XFMR: Pri: 115 v, 400 cy. Sec: 9800 v or 8600 v @ 32 ma dc.....$12.50
#12033, Plate Xfmr: Pri: 115 v, 800 cy. Sec: 4550 vct, 250 ma. $4.50
KS 9445, Pwr Xfmr. Pri: 115 v, 400-2400 cy. Sec: 592 vct, 120 ma, 6.3v, 8 amp; 5v, 2 amp.....$3.50
PLATE XFMR. Pri: 115 v, 400-2400 cy. Sec: 4500 v, 6 ma $6.50
#7143. Pri: 115 v. 400 cy. Sec: 6.3 v. 7 amp, 8.3 v. 8.8 amp; 6.3 v, 1.3 amp $2.50
FIL XFMR: Pri: 115 v, 400 cy. Sec: 6.3 v, 9 amp; 6.3 vct, .65 amp; 2.5 v, 3.5 amp; 2.5 v, 3.5 amp...$3.25

FEDERAL F.T.&R 101-A TWO WIRE APPLIQUE . . . Provides necessary balancing facilities for four wire repeater when used on two-wire lines which may be voice-frequency telephone lines of open wire, or non-loaded or loaded cable. Std. 19" channel iron rack mtg. Price, new, compl. with tech manual ...$54.00

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D-167332 (Bead)
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VARISTORS $.95 ea.
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D-171631

Delivery from Stock!!

INVERTERS

(400 Cycle)

Pioneer —
12116-5-A, 12117-2-A, 12123-1-A.

Holtzer Cabot—MG-149F, MG-149H, MG-153F, (3 phase)

General Electric—5D21NJ3A.

Leland—10563, PE-218.

Inverter—Wincharger PU-7/AP. Input 28V DC at 160 amps. Output 115V 400 cycles at 21.6 amps. Voltage and frequency regulated. Continuous duty. Net weight 75 lbs. Dimensions 18" x 8" x 10".
Stock #SA-164. **Price $99.50 ea.**

WESTINGHOUSE FL BLOWER

115 V. 400 cy. 17 C.F.M. Includes capacitor.

Stock #SA-144 **Price $6.75 ea.**

60 CYCLE AC MOTORS

G.E. Reversible. 1/150 H.P. Shunt wound. 40 volts 5000 rpm. Split field. Stock #SA-18. **Price $4.75 ea.**

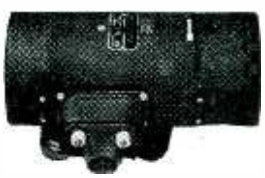
Stock #SA-19. Similar to above but not split field. **Price $2.75 ea.**

Barber-Colman. 0.001 H.P. wound shaded pole type. Reversible by relay or s.p.d.t. switch. Stock #SA-27. **Price $3.75 ea.**

Timing Motor—Haydon 1 rpm. 115 V. A.C. Stock SA-133. **Price $2.85 ea.**

Pioneer Magnetic Amplifier Assembly. Saturable core type output transformer. 400 cycle. Operates from plates of 6SN7 to supply 1 phase of servo motor. Stock #SA-44. **Price $8.75 ea.**

AMPLIDYNES



G.E. Aircraft

5AM31-NJ18A.

Input 27 V. D.C. @ 44 amps. Output 60 V. D.C. @ 8.8 amps. max. 530 watts. Stock #SA-111. **Price $14.50 ea.**

60 cy. G.E. Amplidyne—5AM45DB15. Input 115 v. 60 cy. Output 250 v. DC at 0.6 amps. Cont. Duty. Stock #SA-147. **Price on request.**

SERVO MOTORS

Pioneer—CK-2 and 10047-2-A for 400 cycles.

Diehl—FP-25-3, **FPE-25-11** (CDA-211052) **and ZP-105-8** (CDA-211377) for 60 cycles.

110 RPM MOTOR

G.E. 5BA10AJ18D. 27 V. @ 0.7 amps. 1 oz/ft torque. 1⅜" diam. x 3½" lg. Operates on **AC** or **DC.** Stock #SA-98.

Include 15¢ for P.P. and handling **Price $2.95 ea. net**

DC MOTORS

John Oster. Series wound. 27V 7000 rpm. 1/100 H.P. Stock #SA-30. **Price $3.75 ea.**

Westinghouse—1171391. 27 V 6.5 amps. series. Fan cooled. 3" diam. 4½" lg., ⅛ H.P. Cont. duty. Stock #SA-156. **Price $6.75 ea.**

Delco 5069370. 27.5V Alnico field. 10,000 rpm., has straight shaft extension. Stock #SA-16. **Price $4.75 ea. net.**

DC Timing Motor—Haydon ½ rpm. 29 volts, 100 mils. Stock #SA-157. **Price $3.95 ea.**

Constant Speed DC Motor—G.E. 5BA25MJ-24. 24V DC 7100 rpm. RC noise filter. Stock #SA-100. **Price $8.50 ea.**

G.E. Reversible—5BC26AC134. 1/20 H.P. 24V @ 3.4 Amps. Shunt wound. Cont. duty. 4½" diam. x 6½" lg. 1¾" shaft extension, ⅜" diam. 2¼" sq. 1" conduit box mounted on motor. Explosion proof.
Stock #SA-143. **Price $12.50 ea.**

G.E. 10 RPM—5BA10FJ12—40 lb/in. 24 V. 1.1. amps. **Reversible.** Stock #SA-17 **Price $8.75 each.**

Synchron 10 RPM Timing Motor—24 V. Hansen Mfg. Co. Stock #SA-110. **Price $3.75 each.**

250 RPM. Delco 5067127—27 V. PM field. 1¼" diam. x 3¼" lg. 42 tooth ⅝" pitch diameter pinion on 0.250" shaft. Stock #SA-108. **Price $2.95 each.**

Delco Constant Speed Motor A-7155

1/30 hp. 3600 rpm. Cont. duty. 2½" diam. x 5½" lg. ⅞" shaft extension, 5/32" diam. 4 hole base mounting. Stock #SA-94 **Price $6.50 each.**

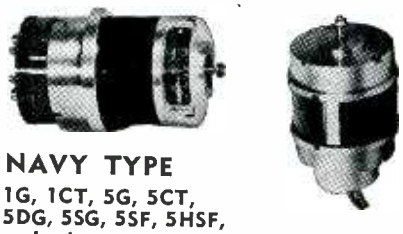
ACTUATOR

Foote Bros. 10801. 1/6th H.P. 24 V. @ 11.5 amps. 5 inch linear travel. Limit Switches.

Stock #SA-161. **Price $12.50 ea.**

All Prices F.O.B. Paterson, N. J.

SYNCHROS



NAVY TYPE
1G, 1CT, 5G, 5CT, 5DG, 5SG, 5SF, 5HSF, and others

Pioneer Autosyns—AY-1, AY-14, AY-20, AY-30, AY-54, **AY-101D,** 851.

Kollsman—775-01.

G. E.—2J1F1, 2J1G1, 2J1H1, 2J5HA1, 2J5-FB1, 2J6F3, etc.

Size 5 Synchro Generator

Similar to Navy Ordnance type 5G with shaft detail per Army Ordnance Dwg. C-78414. 115 v. 60 cy. Stock #SA-43. **Price $9.50 ea.**

NULL TYPE SYNCHRO INDICATOR

Precision position indicator. Uses Bendix size 5 Selsyn, rectifier tube, transformer, magic eye tube and illuminated 360° dial. Ideal for Hams, labs and experimenters. May be used with SD-43 Synchro transmitter. Stock #SA-119. **Price $7.95 ea.**

400 CYCLE MOTORS

E.A.D. J-33. 115 V. 3 phase, Synchronous. 8000 rpm. 2" x 3". Stock #SA-59. **Price $6.75 ea.**

E.A.D. J-72B. 115 V. 2 phase induction motor. 4700 rpm. Stock #SA140. **Price $9.75 ea.**

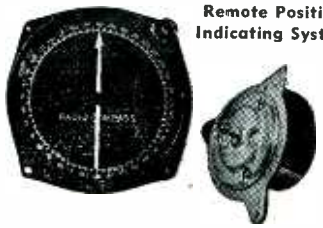
DC Selsyn System—24 V DC transmitter and indicator. Indicator calibrated for flap position. 360° dial easily added.
Stock #SA-129. **Price $9.50 per system.**

Radio Compass Loop LP-21-LM. Stock #SA-99. **Price $9.50 ea. net.**

Phase Shift Capacitor—4 stator single rotor. 0-360° phase shift.
Stock #SA-114. **Price $4.75 ea.**

Magnesyn—Pioneer CL-3, 6 power. Transmitter or receiver. Stock #SA-6.
Price $3.75 ea.

Remote Position Indicating System



Ideal for Ham Beam Position Indicator or industrial uses. 6-12 volts 60 cycles. 5-inch indicator with 0-360° dial. Heavy duty transmitter. Stock #SA-115. **Price $9.95 per system.**

Write or call for complete listing.

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Surplus Division

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VACUUM CAPACITOR
50 MMF—5 KV
Brand New
$2.98

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TUNE YOUR BEAM with an R. F. AMMETER
Basic 0-3ma. movement, 2½" meter.
Special—$2.25

1 K.W. POWER SUPPLY KIT

2500-0-2500 V @ 500 MA
or
2000-0-2000 V @ 500 MA
(oil-filled Xformer from BC610)

1—Swinging choke
1—Smoothing choke
1—Fillament Xformer
2—2 Mfd.—3000 v. Condenser
2—872 A Tubes
2—Plate Caps for 872A
2—Sockets for 872A

Special! All parts New! **$99.50**

STEP DOWN TRANSFORMER

PRIMARY 440/220 VOLTS
SECONDARY 230/115 VOLTS
.600 KVA
$14.95

SELENIUM RECTIFIERS
Full Wave Bridge Type

INPUT	OUTPUT		
up to 18v AC	up to 12v DC	½ Amp.	$0.98
up to 18v AC	up to 12v DC	1 Amp.	1.95
up to 18v AC	up to 12v DC	5 Amp.	4.45
up to 18v AC	up to 12v DC	10 Amp.	7.45
up to 18v AC	up to 12v DC	15 Amp.	9.95
up to 18v AC	up to 12v DC	30 Amp.	14.95
up to 36v AC	up to 28v DC	1 Amp.	3.45
up to 36v AC	up to 28v DC	5 Amp.	7.45
up to 36v AC	up to 28v DC	10 Amp.	12.45
up to 36v AC	up to 28v DC	15 Amp.	18.95
up to 115v AC	up to 100v DC	.25 Amp.	2.95
up to 115v AC	up to 100v DC	6 Amp.	6.95
up to 115v AC	up to 100v DC	5 Amp.	19.95
up to 115v AC	up to 100v DC	3 Amp.	12.95

OIL CONDENSERS
NATIONALLY ADVERTISED BRANDS
All Ratings, D. C.

2x.1mfd.	600v	$0.35	1mfd.	2000v	$0.95
.25mfd.	600v	.35	3mfd.	2000v	2.75
.5mfd.	600v	.35	4mfd.	2000v	3.75
1mfd.	600v	.35	15mfd.	2000v	4.95
2mfd.	600v	.35	2mfd.	2500v	2.49
4mfd.	600v	.60	1mfd.	2500v	1.25
8mfd.	600v	1.10	.25mfd.	2500v	1.45
10mfd.	600v	1.15	5mfd.	2500v	1.75
3x.1mfd.	1000v	.45	.05mfd.	3000v	1.95
.25mfd.	1000v	.45	1mfd.	3000v	2.25
1mfd.	1000v	.60	25mfd.	3000v	2.65
2mfd.	1000v	.70	.5mfd.	3000v	2.85
4mfd.	1000v	.90	1mfd.	3000v	3.50
8mfd.	1000v	1.95	12mfd.	3000v	6.95
10mfd.	1000v	2.10	2mfd.	4000v	5.95
15mfd.	1000v	2.25	1mfd.	5000v	4.95
20mfd.	1000v	2.95	1mfd.	7000v	2.95
24mfd.	1500v	6.95	3mfd.	4000v	6.95
.25mfd.	2000v	1.05	2mfd.	3000v	3.45
.5mfd.	2000v	1.15	2x.1mfd.	7000v	3.25

HIGH CAPACITY CONDENSERS

2x3500 mfd.—25 WVDC	$3.45
2500 mfd.—3 VDC	.39
2x1250 mfd.—10 VDC	1.25
1000 mfd.—15 WVDC	.99
200 mfd.—35 VDC	.59
100 mfd.—50 WVDC	.49
4x10 mfd.—400 VDC	.89

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Standard Brands

1N21	$0.39	F-127A	$22.50
2AP1	2.25	371B	2.95
2C40	1.19	450TH	24.95
2D21	.89	703A	7.95
2V3G	1.25	715B/C	12.95
2X2	.69	721A	4.35
3AP1	3.00	723A/B	3.95
3BP1	2.95	726A/B	23.50
3E29	2.95	801	.49
3GP1	3.95	802	1.98
5BP4	4.94	803	6.95
5CP1	3.95	804	9.95
5JP1	11.95	805	4.95
5LP1	11.95	806	14.95
5R4GY	.98	807	1.15
5Y3	.39	808	2.95
6AB7	1.20	809	1.50
6AC7	1.20	810	6.95
6AC5	1.20	811	1.95
6AG7	.99	812	3.15
6AJ5	.99	813	6.95
6AK5	.90	814	3.95
6AL5	.81	815	3.95
6AQ6	.81	829-A-B	3.95
6AR6	1.29	832	3.95
6B4G	1.20	833A	39.50
6C4	.49	836	1.75
6C5	.67	837	2.50
6D4	.99	838	3.75
6F6	.81	861	69.50
6J4	3.95	866	.90
6J5	.62	872A	2.50
6J6	.89	884	.98
6L6G	1.20	885	.98
6L7	.98	902P1	8.45
6N7	.99	954	.75
6SH7	.81	955	.75
6SL7	.91	956	.75
6SN7	.91	957	.75
6SR7	.67	958	.75
7A4/XXL	.81	959	.75
7F7	.99	1005	.35
7L7	.99	1616	2.94
10Y	.98	1619	.75
15R	1.50	1622	1.98
HK24G	1.75	1624	.90
28D7	.98	1625	.75
30	.81	1626	.75
VR75	.99	8001	6.49
VR90	.75	8005	4.95
VR105	.75	8011	3.75
VR150	.75	8016	1.89
100TH	12.95	8025A	4.95
100TS	3.00	1654	1.98
211	.98	9001	1.15
75T	2.95	9002	.98
250TH	17.50	9003	.98
257B	7.95	9004	.98
304TH	9.95	9005	.98
HY615	.89	9006	.98
706CY	22.50	F-128A	75.00
717A	.65		

PERMALLOY SHIELDS
for CATHODE RAY TUBES

3" Shield $1.49
5" Shield 1.98

SCR-518 ALTIMETER

Famous SCR 518A Altimeter. Brand new factory cartoned. Worth over $900.00. Made by RCA. Has 29 tubes. Works in the 500 MC region. This is the complete unit. Transmitter, receiver, power supply and 3" scope indicator. Reads altitude up to 30,000 ft. Operates on 28 volts. D. C. Complete with tubes. 6SK7, 2 8012, 2 6SJ7, 6C8, 6SN7, 6F8, 23D4, 6Y6, 6V6, 10 6AC7, 3 2x2, 954, 955, 956, 6J5, and 3 in. CR tube 1808P. A RED hot scoop at only $69.50

TRANSFORMER—115 V, 60 Cy.
HI-VOLTAGE INSULATION

3710v @ ma.; 2x2½v @ 3A	$9.95
2500v @ 15 ma.	6.50
2500v @ 4 ma.; 2½v @ 2A. 6.3v @ 1 amp.	7.95
2150v @ 15 ma.	5.50
1750v @ 4 ma.; 6.3v @ 3A	6.50
1600v @ 4 ma.; 700v CT @ 150 ma.; 6.3v @ 9A	7.95
525-0-525v @ 60 ma.; 925v @ 10 ma.; 2x5v @ 3A; 6.3v @ 3.6A; 6.3v @ 2A; 6.3v @ 1A	7.95
500-0-500v @ 25 ma.; 262-0-262v @ 55 ma.; ma.; 6.3v @ 1A; 2x5v @ 2A	4.49
500-0-500v @ 100 ma.; 5v CT @ 3A	4.95
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400-0-400v @ 200 ma.; 5v @ 3A	4.95
350-0-350v @ 150 ma.; 5v @ 3A; 6.3v @ 6A; 78v @ 1A	4.95
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
385-0-385-550v @ 200 ma.; 2½v @ 2A; 5v @ 3A; 3x6.3v @ 6A—PRI. 110/220	7.95
350-0-350v @ 150 ma.; 5v @ 3A; 6.3v @ 7.5A; 6.3v @ 3A	4.95
350-0-350v @ 35 ma.	1.49
340-0-340v @ 300 ma.; 1540v @ 5 ma	5.95
335-0-335v @ 60 ma.; 5v @ 3A; 6.3v @ 2A; 0-13-17-21-23v @ 70 ma.—PRI. 110/220	4.95
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
120-0-120v @ 50 ma.	.98
80-0-80v @ 225 ma.; 5v @ 2A; 5v @ 4A	3.95
24v @ 6A	3.50
13.5v CT @ 3.25A	2.95
3x10.3v @ 7A; CT	9.95
12.6v CT @ 10A; 11v CT @ 6.5A	7.95
6.3v @ 10A; 6.3v @ 1A	3.50
6.3v @ 1A; 2½v @ 2A	3.45
6.3v @ 21½A; 6.3v @ 2A; 2½v @ 2A	5.95
6.3v @ 25A; 6.3v @ 3A; 5v @ 12A; 6.3v CT. 9A	4.95
5v—190A $17.50	6.3v @ 1A ..... .98
5v—115A 14.95	8v CT 1A ..... .98
6.3v CT @ 3A; 5v CT @ 4A	4.25

TELEGRAPH KEY J 37

Fully adjustable, ⅛" silver contacts and 5 ft. rubber cable, with PL-55 plug. Brand New..**69¢ each**

2 SPEED PLANETARY DRIVE

Fits condensor shaft back of panel, or dial knob shaft 5 to 1 and 1 to 1 ratios. For any ¼" shaft.....**Special 79¢ each—2 for $1.50**

FILTER CHOKES
HI-VOLTAGE INSULATION

8 hy @ 550 ma	$7.95	325 hy @ 3 ma	$3.49
8 hy @ 300 ma	3.95	1 hy @ 800 ma	14.95
25 hy @ 160 ma	3.49	10 hy @ 250 ma	2.49
12 hy @ 150 ma	2.25	10 hy @ 200 ma	1.98
12 hy @ 100 ma	1.39	10/20 @ 85 ma	1.59
30 hy @ 70 ma	1.39	15 hy @ 125 ma	1.49
.05 hy @ 15 amps	7.95	15 hy @ 100 ma	1.39
.1 hy @ 5 amps	6.95	3 hy @ 50 ma	.29
4 hy @ 600 ma	5.95	30 hy Dual @ 20 ma	1.49
200 hy @ 10 ma	3.49	8/30 hy @ 250 ma	3.50
600 hy @ 3 ma	3.49	10 hy @ 100 ma	1.29

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BIG VALUES IN SURPLUS

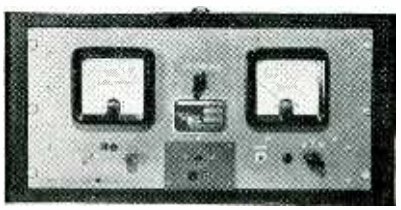
General Electric AMPLIDYNES

MODEL 5AM45DB20

INPUT: 115 volts, 1 Φ, 60 cycles, 5 amps.
OUTPUT: 250 volts, .6 amp. 150 watts, cont. duty. 40 C.—Temp. Rise 3450 RPM.

BRAND NEW! Special Price **$53.50**

Fitch Radio Crystal Duplicator Model QZ-1000



Calibrates crystal plate of unknown frequency against standard plate of desired frequency. Consists of standard and test oscillators whose outputs are mixed to produce an amplified beat note the frequency of which is shown on meter with ranges of 500, 5000, 50,000 cycles. In sturdy metal cabinet with hinged cover, 9"H x 13"W x 19"L. 4" square activity and frequency meters on front panel. Complete with tubes. New **$39.95**
Used but excellent condition $22.50

Electric Specialty Co. CONVERTERS

SPECIFICATIONS
PRIMARY: 86 volts, direct currrent 2.85 amperes. 3600 RPM.
SECONDARY: 115 volts, 2.18 amps. 250 va; 50% P.F. 60 cy. ball bearings. Base of white metal for table or side mounting. Used with resistors in field circuit or in series with converter for 110 volt DC operation.

Used but in perfect operating condition GUARANTEED **$9.80**

Transtat Voltage Regulators

MFG. BY AMERICAN TRANSFORMER CO.
TYPE RH LOAD KVA 0.5

INPUT: 115 volts, 400 cycle 1 phase
OUTPUT: 92-115 volts 5.5 Amperes Max. Ideal for temperature — filament — motor speed—illumination and rectifier controls, compensating voltages, general and dielectric testing, calibrating instruments, and many other laboratory uses.
BRAND NEW **$3**

RCA Audio Frequency Meter Type 306-A

Can be used to great advantage in industrial applications when the frequency in cycles per second is converted to r.p.m. also used to check frequency of unknown sources of voltage; as a check on calibration of beat frequency oscillators or other generators.

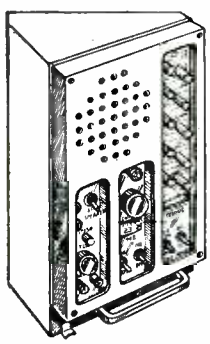
Features
- Direct reading—0 to 50,000 cycles.
- Regulated Power Supply.
- Ten ranges, 6" meter scale.
- Output drives recording meter direct
- Accuracy unaffected by input wave shape.
- Limiting circuit makes reading independent of input voltage over wide range.

Specifications:
Frequency Range ....0-50,000 cycles in ten ranges
Input Voltage .....1 to 200 volts rms
Input Impedance .....25,000 ohms
Recorder Output .....5.0 ma. 1000 ohms max.
Accuracy .....±2%
Power Supply .....105-125 volts, 50-60 cycles
Power Consumption ..70 watts
Height 8¾"; width 19"; depth 13⅝"; weight 41 lbs.

Used but in excellent condition

AN ELECTRO VALUE....$75

BC-603 RECEIVER



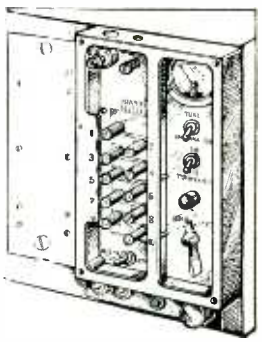
Beautiful mechanical, electrical construction. Ten channel push button or manual tuning. Range 20.0—27.9 MC. Perfect for ten meter converter as HF coil sections readily tuned to lower frequency. No conversion wiring required.

The four section gang condenser and pushbutton assembly ideal for FM broadcast tuner. With tubes but less dynamotor. With few changes can be used on fire or police bands. Used but in excellent condition. **$13.95**

Companion Unit to the BC-603 Receiver. Wide or narrow-band FM. 30 watt power output. Excellent possibility for ten or eleven meter exciter. Range 20.0—27.9 MC. Working space permits modification. Complete with tubes but less power supply and xtls.

Dont overlook the crystal oven with thermostat and heaters . . . or the five section variable . . . or thermo ammeter. Used but in excellent condition. **$11.50**

BC-604 TRANSMITTER



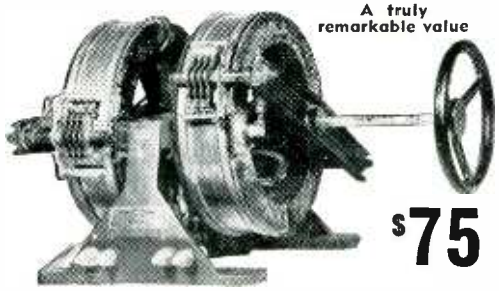
Both BC-603 Receiver and BC-604 Transmitter $22.50

"TRANSTATS" Amertran Voltage Regulator (Variable Transformer)

BRAND NEW!
In Original Factory Cases

11.5 KVA; Fixed Winding; 115 Volts; Commutator Range 0-115 Volts, Maximum Amperage 100. Can be reconnected for 230 volts with maximum amperage of 50. Blueprint of connections supplied.

A truly remarkable value



$75

Brand New TUBES!

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28D7	60¢	89Y	30¢
39/44	35¢	801	60¢
1629	15¢	VT-127A	$2.25
OB3/VR90	70¢	5FP7	$1.89
10Y	30¢	721A	$1.00
		WE708A	$2.25

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Industrials Schools - Labs

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

METER SPECIALS

1½" GE 0-1 MA Basic	$3.95
2" GE 0-30 amps. D.C.	2.95
2" GE 0-1 amp RF (internal thermo)	2.95
2" GE 0-5 ma (amp scale)	1.95
2" GE 0-1.2 ma (0-100 scale)	2.49
2" Western type 507 0-120 ma RF	4.95
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2" Gruen 0-3V DC (1000 ohms per volt)	2.45
2" Weston 150-0-150 Microamps	3.49
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3" GE 200-0-200 volts DC	2.95
3" McClintock 0-1 ma	3.95
3" Westinghouse 0-2 ma DC	3.95
3" Westinghouse 0-20 ma DC	3.95
3" GE 0-15 ma DC (square)	3.95
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WIRE WOUND RESISTORS

Standard Make

5 Watt type AA, 20-25-50-200-470-2500-4000 ohms	.09 ea.
10 watt type AB, 25-40-84-400-470-1325-1900-2000-4000 ohms	.15 ea.
20 watt type DG, 50-70-100-150-300-750-1000-1500-2500-2700-5000-7500 10000-16000-20000-30000 ohms	.20 ea.
30 watt type DI, 100-150-2500-3000-4500-5300-7500-18000-40000 ohms	.24 ea.

1% PRECISION RESISTORS

Standard Make

200-2500-5000-8500-10000 ohms	$.39 ea.
50000-95000 ohms	.49 ea.
100000-750000-1 meg	.89 ea.

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

U. H. F. COAX. CONNECTORS

UG12U—831R—831J—UG21U—831AP—831SP .39 ea.

Large stocks of Coax. and A/N connectors.

VARIABLE CERAMICON TRIMMERS

1.5 to 7 MMF—.24
5 to 20 MMF—.24
4 to 30 MMF—.24
7 to 45 MMF—.24
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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

STEPDOWN TRANSFORMER

220/110 volts. 100 watts. Fully encased. 5⅛ x 4¼ x 5⅛ .....$2.49 each

HIGH VOLTAGE MICAS

CD .001 600 W.V. Type 9	$ .19
CD .01 600 W.V. Type 9	.29
CD .027 600 W.V. Type 9	.49
CD .0005 5000 W.V.	.79
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
R.C.A. .02 2000 V. 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.	.30

CHOKE BARGAINS

WE 4.3 hy 620 42 ohms	$ 4.95
N.Y.T. 8 henry 160 ma. 140 ohms D.C.	1.39
C.T.C. 1.5 henry 250 ma. 72 ohms	.60
R.C.A. 50 henry, 680 ma. high voltage	19.50

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 cables, etc.
Weight 1200 lbs. Export Packed. Excellent for emergency power. Brand new $575.00

Scope Transformer hermetically sealed 1,800 volts, 4 ma, 6.3 volts, .9 amp. 2½ volts, 2.5 amps., 5 x 3¼ x 3¾....$5.95

FEDERAL SELENIUM RECTIFIER

Full wave. 36 volts input. 28 volts output at 6.1 amps. Brand new $7.95

SPERTI RF VACUUM SWITCH

9200 volts peak. 8 amps. Used as antenna switch in Collins ART 13. BRAND new $1.75

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
25 ohms 25 watt Rheostat	.39
Microswitch 10 amps. (Interlock)	.59
C.H. Bat Handle Switch—D.P.S.T. ½ H.P.	.95
Veeder Root Counter	.95
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Tremendous stocks on hand. Please send requests for quotes. Special quantity discounts. Prices f.o.b. N Y. 20% with order less rated, balance C.O.D. Minimum order $3.00.

"A POWERFUL BABY"

This plate transformer built to rigid Signal Corps spec. input 118 volts, 25 to 60 cycles. Has 2 separate 118 volt primaries and can be used on 110 or 220 volts. Secondary 800 volts center tapped at 775 mills. Exceptional regulation even when loaded to 900 mills! Fully cased—4 mtg holes. 37 lbs. net wt. 6½ x 6½ x 7⅛. Peak value at 7.95 10 for $70.00

"BRUTE FORCE"

This fully encased choke 6 Henry at 550 mills. 28 ohms dc resistance. Built to rigid Signal Corps specs. Net weight 16 lbs. 5⅛ x 4¼ x 5⅝. A great buy at $4.95 each. 10 for $40.00.

FILAMENT TRANSFORMER

Two separate 118 volt, 25 to 60 cycle primaries. Can be used on 110 or 220 volts. Secondary 5 volts at 15 amps. Built to Signal Corps specs. Fully encased. 5 x 4¼ x 5⅝. Net wt. 10 lb. $3.75 each. 10 for $30.00.

VERSATILE POWER

These transformers have many uses—filament, isolation, stepdown, bias, etc.
All have 2 separate primaries for 110/220 volt 25-60 cycle operation. Primaries. Can be used in series or parallel.
3 Choices of Secondaries:
Type 504—115 volts 500 mills and 6.3 volts 5 amps.
Type 505—115 volts 900 mills and 6.3 volts 2 amps.
Type 502—0-70-75 volts at 2.5 amps. (35-37 v. in series)
Fully encased—4 mtg. holes. 5⅛ x 4¼ x 5⅛.
Your cost any type .....$1.95 each
10 for $17.00.

MIDGET VARIABLE BARGAINS

Hammarlund MC 250S 250 mmf	$ .60
Hammarlund MC 320S 320 mmf	.79
Hammarlund APC 100 100 mmf	.39
Bud MC 913 Dual 35 mmf. D.S.	1.25
Hammarlund HF 15 15 mmf	.39
National TMS 150 mmf	.79

"A CLOSEOUT" AMERTRAN TRANSTAT or Stepdown Transformer

110/220 volts 60 cycle input. Output variable plus or minus 10% of 115 volts at 8.5 amps. Also can be connected to give different voltage combinations. Brand new .....only $12.95 Limited Quan.

AMERTRAN VOLTAGE REGULATOR

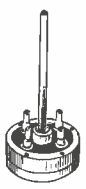
130/230 volts 50/60 cycles input. Output variable from 0—260 volts. 1.3 KVA, single phase. Used but good $19.50

OIL CONDENSER

11 mfd	250 vac—.85	.15/.15 mfd 6000 vdc—1.95	
5 mfd	150 vac—.49		
1 mfd	600 vdc—.29	.1 mfd 7500 vdc—1.95	
2 mfd	600 vdc—.39	.15/.15 mfd 8000 vdc —2.75	
4 mfd	600 vdc—.59		
3/3 mfd	600 vdc—.79	4 mfd 8 kv dc—19.95	
10 mfd	600 vdc—.95	.01/.01 mfd 12 kv dc—5.75	
14 mfd	600 vdc—1.35		
2 mfd	1000 vdc—.79	.005/.01 mfd 12 kv dc—5.50	
4 mfd	1000 vdc—.95		
15 mfd	1000 vdc—2.95	.03 mfd 16 kv dc—5.75	
2 mfd	1500 vdc—1.25	.65 mfd 12,500 vdc—12.95	
1 mfd	2000 vdc—1.45		
2 mfd	4000 vdc—5.50	.75/.35 mfd 8/16 kv—12.95	
3 mfd	3000 vdc—3.95		
1 mfd	5000 vdc—4.50	.1 mfd 25 kv dc—17.50	
		.02 mfd 20 kv dc—7.95	

T. P. D. T. ANTENNA RELAY

110 V. 60 cycle coil Steatite insulation. Only 1.95 each.



4 QUADRANT PHASING CONDENSER

4 Stator Single Rotor. 0-360 Degrees Rotation. .....Only 2.95 each

Phone Cortlandt 7-6443

PEAK ELECTRONICS CO.
188 Washington St., New York 7, N. Y.

DEPARTMENT EA
SEND FOR BULLETIN

RELIANCE SPECIALS

RG 8/U

NEW-UNUSED

52 OHM

COAXIAL CABLE

500-2500 feet	$30.00 per M
3000-5000 feet	27.50 per M
5500-10,000 feet	25.00 per M
10,500-20,000 feet	22.50 per M
over 20,000 feet	20.00 per M

No charge for reels.

COAXIAL FITTINGS

Hood 10¢ Socket 40¢ SO 239 83-1R Plug 40¢ PL 259 83-1SP Angle Adaptor 40¢ M-359 83-1AP

PL259A, 83ISPN, 83-IAP, UG21U, UG22U, CUF 49190 (83-1SP with small hole for RG59U Coaxial Fittings UG255U (Adaptor, takes 83-ISP one side & UG88U other), UG85U Baby "N" plug, UG27U ..... 40¢ each

UG87U Baby "N" Socket, Gold Plated with Hood Attached ..... 50¢ each

UNIVERSAL JOINT

ALUMINUM

1 1/8" lg. x ½" OD

¼" ID **35¢**

POSTAGE STAMP MICAS

8.2 mmf				
10*	90*	300 mmf	.001 mfd	.0068*
22	130*	360	.0012	.0082
24	180*	390*	.0015	.01
27	185*	400*	.002	
30*		430*	.0022*	
39		488*	.0027	
47		500*	.003	
62		630*	.0033	
68		650	.0039	
82*		820	.0047	

* Silver Mica

5 mmf to .001 mfd — 5¢, silver — 10¢
.0012 mfd to .0027 mfd — 7¢, silver — 20¢
.0029 mfd to .0068 mfd — 12¢, silver — 50¢
.0082 mfd — 16¢
.01 mfd — 18¢

ASSORTED HARDWARE (Brass)—Screws, Nuts, Washers, Rivets, Solder lugs, etc. 3 lbs. $1.00

NUTS—3/8-32 (volume control) plated, 1/2-32 (toggle switch) silver plated ..... $1 per C

TELEPHONE FIELD WIRE (W-110-B). One Mile spools. 2 twisted wires, each 4 strands steel and 3 strands copper. Only ..... $14 per mile

THERMOSTATS—Norm. closed 70°C., 50°C or 36°C, fixed temp.—shaped like cartridge fuse, 115V. contacts ..... 75¢ each

POWER TRANSFORMER, 3" x 2½" x 4" overall, 650 Volts C. T., 6.3V., 5V $2.35

BC 1072 A IFF X'MITTER

in MAPLE CHEST 150 to 200 Mcs 115 V., 60 Cyc.

POWER SUPPLY gives: 0-5000 v.d.c. (Variac control) 312 v.d.c., 300 v.d.c., 6.3 vats. Also contains: 11 tubes (6J5, 82c, 6SN7, 5U4G, etc.), 5 KV meter, Blower, Condensers and many other useful parts too numerous to list. Used. Shipping Wt. 245 lbs.

Only $22.50

400 MA CHOKE

12 H., 90 ohm DC 12 lb. net, 4½"x5⅜"x4¼" high, four ¼" mtg. holes, hermetically sealed.

Only $3.85

ALLEN Socket Head Screws, stainless steel, 10-32 size ⅜", ½", 1½" ..... $3 per c

ALLEN SET SCREWS

2–56x1/16	6–32x3/16	8–32x3/8
4–40x1/8	8–x1/8	1/4–20x1/2
4–40x3/16	8–32–x1/8	

All sizes ..... $1.50 per C
Wrenches (2-56 out of stock) ..... 2¢ each

Wrapped — BALL BEARINGS — New

Mfg.	ID	OD	Width	Price
Fafnir 33K5	3/16"	1/2"	5/32"	25¢
ND 34	5/32"	5/8"	3/16"	30¢
Norma XA 134RPP	1/4"	5/8"	3/16"	35¢
ND 38	5/16"	1 3/64"	9/32"	45¢
Timken	1/2"	1 3/8"	7/16"	85¢
ND 5202C13M	1/2"	1 3/8"	1 3/8"(dual)	1.25
ND 88503	43/64"	1 37/64"	21/32"	1.00
MRC 206SFF	1 3/8"	2 7/16"	5/8"	1.25
Fafnir 545	2 1/6"	2 5/8"	15/32"	1.00

NEEDLE BEARINGS

	ID	OD	
B88 1/2" wide	1/2"	11/32"	25c
B108 1/2" wide	5/8"	13/16"	30¢
GB34X 1/4" wide	3/16"	11/16"	25¢

SHAFT—Stainless 3/16" dia. 12" ..... 15¢
BOSTON Miter Gears, G 461, 18 tooth ..... 20¢ pair
SMALL RELAY for Model Work, etc., ⅞" x 1⅜" x ⅞" high, 1200 Ohm Coil, 12 V., Use on 6 V. by weakening spring, SPDT Contracts ..... 55¢ each
SELENIUM RECTIFIER, Bridge, Type for Meter Operation, used with above Relay—REGULAR $2.50—ONLY ..... 70¢ each

JONES BARRIER STRIPS

10—142W.—45¢ each, 5—140—12¢ each, 18—240—35¢ ea.
Jones 10 Pin Plugs—S 410 CCT & P410 AB 75¢ pair

HEINEMANN CIRCUIT BREAKER — Catalog #AM1510R—120 V.A.C., 20A $1.50
THERMAL CIRCUIT BREAKER—2A., 3A., 5A., 6A., 8A., & 15A. ..... 50¢ each
TIMER—115 V., 60 Cyc., 2 Watt Operation. 10A.—115 Volt Contact Rating. Turns on 15 Minutes, Then off 15 Minutes Continuously $2.95
FEDERAL TEL. STEPPING RELAY—UA 12486—6 Pole 11 Position, 24V Coil $3.95

ELECTROLYTIC CAPACITORS

(20-20 mfd x 450V. & 20 mfd x 25V.)—One plug-in unit ..... 95¢
8-16 mfd x 150V. ..... 40¢ 50 mfd x 25V. ..... 15¢
1000 mfd x 25V. ..... 85¢ 200 mfd x 25V. ..... 20¢

NEW—CERAMIC TRIMMERS—UNUSED

Only 30c each—$25 per C.

4 to 30 mmf 4 to 47 mmf 20 to 120 mmf

TUBE SOCKETS

Octal Steatite	8¢ each	$6.00 per C
Octal Wafer	3¢ each	2.50 per C
7 Pin Min., Mica Filled	14¢ each	12.00 per C
Acorn Steatite	14¢ each	11.00 per C
7 Pin for 826, 829, etc.	29¢ each	25.00 per C

PRECISION RESISTORS

Any order for

100 pieces or more—10% off
1000 pieces or more—20% off

¼ WATT—30c

OHMS	Tol.	OHMS	Tol.	OHMS	Tol.
6.68	¼%	14.98	¼%	220.4	¼%
10.48	¼	16.37	¼	301.8	¼
10.84	¼	20.	1	366.6	¼
11.25	¼	62.54	¼	414.3	¼
11.74	¼	79.81	¼	705	1
12.32	¼	105.8	¼	2193	¼
13.02	¼	123.8	¼	3500	10
13.52	¼	125	¼	10,000	1
13.89	¼	147.5	¼	59,148	¼

½ WATT—30c

OHMS	Tol.	OHMS	Tol.	OHMS	Tol.
.250	1%	66.6	5%	2,5C0	1%
.334	1	75	1	2,850	1
.502	1	97.8	¼	3,427	¼
.557	1	125	¼	4,000	2
.627	1	18C	1	4,000	1
.76	1	210	1	4,300	2
1.01	½	235	2	4,451	¼
1.53	1	235	1	5,000	1
2.04	1	260	1	5,900	1
2.25	1	270	1	6,500	1
11.1	1	298.3	¼	7,000	1
13.15	1	320	1	7,300	2
20	1	400	1	7,500	1
46	1	723.1	¼	8,000	1
52	¼	900	5	8,500	1
55.1	1				

½ WATT—35c

OHMS	Tol.	OHMS	Tol.	OHMS	Tol.
10,000	1%	25,000	1%	100,000	1%
14,825	¼	30,000	1	100,000	5
15,000	1	37,000	1	150,000	½
15,750	1	50,000	2	180,000	5
17,000	1	50,000	1	500,000	3
20,000	1	68,000	5		

1 WATT—30c

OHMS	Tol.	OHMS	Tol.	OHMS	Tol.
.5	2%	5.21	1%	1,25C	1%
1.01	1	10.1	1	3,300	1
2.58	1	10.9	1	5,000	1
5	1	100	1	7,C00	1
3.39	1	270	1	9,000	1
5.05	1	420	2		

1 WATT—35c

OHMS	Tol.	OHMS	Tol.	OHMS	Tol.
12,000	2%	50,000	10%	68,000	5%
18,000	1	50,000	1	70,000	1
20,000	1	55,000	1	75,000	1
		56,000	10	84,000	2
		65,000	1		

1 WATT—45c

OHMS	Tol.	OHMS	Tol.	OHMS	Tol.
100,000	1%	158,000	2%	522,000	½%
120,000	1	160,000	1	525,000	1
125,000	1	180,000	1	600,000	1
128,000	1	250,000	1	700.000	1
130,000	1	320,000	1	1 meg	5
		470.000	1		

1 WATT—75c

OHMS	Tol.
1 meg	1%

HI VOLT DUAL X'FMR

WESTINGHOUSE

15 and 18 kv can be varied separately #CAY 30741-A

$39.50

2½ v @ 5 A built in rectifier socket

115 v, 60 cy

Sealed in Oil

OIL FILLED Condenser for above Transformer, .1mfd, 25,000v. dc $16.95

ONLY $2.25 ea.

SELSYN DIFFERENTIAL #C78249

115 V., 60 Cyc.

Used between two #C78248's as dampener. Can be converted to a 3600 RPM Motor in 10 Minutes. Conversion sheet supplied.

Also 50 V., 50 Cyc. $1.50 ea.

FAMOUS MAKES—OIL FILLED CAPACITORS—BRAND NEW

.1 mfd	25000 V. DC	$16.95	.2 mfd	750 V. AC (2200 V. DC)	$.55
.1 mfd	7500 V. DC	1.75	4 mfd	2000 V. DC	3.00
.1–.1 mfd	7000 V. DC	2.45	.1 mfd	2000 V. DC	.80
.1 mfd	7000 V. DC	1.65	4 mfd	1000 V. DC	1.00
.02–.02 mfd	7000 V. DC	1.50	3 mfd	1000 V. DC	.90
.1 mfd	6000 V. DC	1.65	1 mfd	800 V. DC	.40
.02–.03 mfd	6000 V. DC	1.50	10 mfd	600 V. DC	1.25
.03–.03 mfd	6000 V. DC	1.50	1 mfd	600 V. DC	.35
.01 mfd	6000 V. DC	1.40	4 mfd	600 V. DC	.69
.1 mfd	3000 V. DC	.85			
4 mfd	2500 V. DC	3.50			

RELIANCE Merchandizing Company

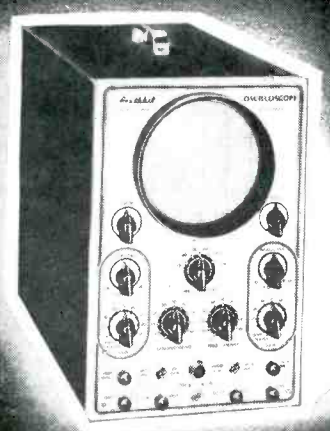
All Orders f.o.b. PHILA., PA.

Arch St. Cor. Croskey, Philadelphia 3, Pa.

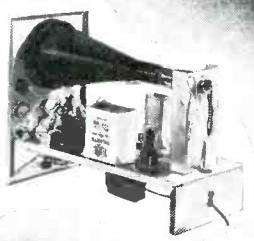
Telephone RIttenhouse 6-4927

MINIMUM $3 ORDER

Build YOUR OWN TEST EQUIPMENT



$39.50
Nothing ELSE TO BUY



NEW 1948 HEATHKIT
5" OSCILLOSCOPE KIT

A necessity for the newer servicing technique in FM and television at a price you can afford. The Heathkit is complete, beautiful two color panel, all metal parts punched, formed and plated and every part supplied. A pleasant evening's work and you have the most interesting piece of laboratory equipment available.

Check the features — large 5" 5BP1 tube, compensated vertical and horizontal amplifiers using 6SJ7's, 15 cycle to 30 M cycle sweep generator using 884 gas triode, 110V 60 cycle power transformer gives 1100 volts negative and 350 volts positive.

Convenient size 8½" x 13" high, 17" deep, weight only 26 pounds.

All controls on front panel with test voltage and ext. syn post. Complete with all tubes and detailed instructions. Shipping weight 35 pounds.

Order today while surplus tubes make the price possible.

$34.50
Shipping Wt., 13 lbs.

HEATHKIT SINE AND SQUARE WAVE
AUDIO GENERATOR KIT

The ideal companion instrument to the Heathkit Oscilloscope. An Audio Generator with less than 1% distortion, high calibration accuracy, covering 20 to 20,000 cycles. Circuit is highly stable resistance capacity tuned circuit. Five tubes are used, a 6SJ7 and 6K6 in the oscillator circuit, a 6SL7 square wave clipper, a 6SN7 as a cathode follower output and 5Y3 as transformer power supply rectifier.

The square wave is of excellent shape between 100 and 5,000 cycles giving adequate range for all audio, FM and television amplifier testing.

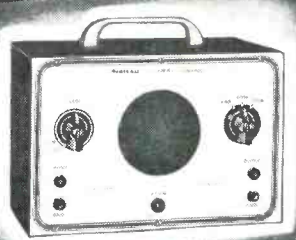
Either sine or square waves available instantly at a toggle switch. Approximately 25V of sine AC available at 50,000 ohm output impedance. Output +1 db. from 20 to 20,000 cycles. Nothing else to buy. All metal parts are punched, formed and cadmium plated. Complete with tubes, all parts, detailed blueprints and instructions.

HEATHKIT SIGNAL TRACER KIT

Reduces service time and greatly increases profits of any service shop. Uses crystal diode to follow signal from antenna to speaker. Locates faults immediately. Internal amplifier available for speaker testing and internal speaker available for amplifier testing. Connection for VTVM on panel allows visual tracing and gain measurements. Also tests phonograph pickups, microphones, PA systems, etc. Frequency range to 200 Mc. Complete ready to assemble. 110V 60 cycle transformer operated. Supplied with 3 tubes, diode probe, 2 color panel, all other parts. Easy to assemble, detailed blueprints and instructions

Small portable 9" x 6" x 4¾". Wt. 6 pounds. Ideal for taking on service calls. Complete your service shop with this instrument.

$19.50
Nothing ELSE TO BUY

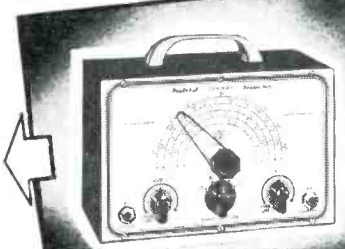


HEATHKIT SIGNAL GENERATOR KIT

Every shop needs a good signal generator. The Heathkit fulfills every servicing need, fundamentals from 150 Kc. to 30 megacycles with strong harmonics over 100 megacycles covering the new television and FM bands. 110V 60 cycle transformer operated power supply.

400 cycle audio available for 30% modulation or audio testing. Uses 6SN7 as RF oscillator and audio amplifier. Complete kit has every part necessary and detailed blueprints and instructions enable the builder to assemble it in a few hours. Large easy to read calibration. Convenient size 9" x 6" x 4¾". Weight 4½ pounds.

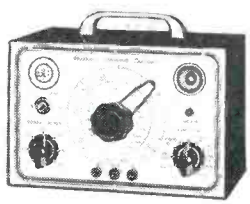
$19.50
Nothing ELSE TO BUY



THE NEW HEATHKIT VACUUM TUBE VOLTMETER KIT

The most essential tool a radio man can have, now within the reach of his pocketbook. The Heathkit VTVM is equal in quality to instruments selling for $75.00 or more. Features 500 microamp meter, transformer power supply, 1% glass enclosed divider resistors, ceramic selector switches, 11 megohms input resistance, linear AC and DC scale, electronic AC reading RMS. Circuit uses 6SN7 in balanced bridge circuit, a 6H6 as AC rectifier and 6 x 5 as transformer power supply rectifier. Included is means of calibrating without standards. Average assembly time less than four pleasant hours and you have the most useful test instrument you will ever own. Ranges 0-3, 30, 100, 300, 1000 volts AC and DC. Ohmmeter has ranges of scale times 1, 100, 1000, 10M and 1 megohm, giving range .1 ohm to 1000 megohms. Weight 8 lbs.

$24.50
Nothing ELSE TO BUY



$19.50

HEATHKIT CONDENSER CHECKER KIT

A condenser checker anyone can afford to own. Measures capacity and leakage from .00001 to 100 MFD on calibrated scales with test voltage up to 500 volts. No need for tables or multipliers. Reads resistance 500 ohms to 2 megohms. 110V 60 cycle transformer operated complete with rectifier and magic eye indicator tubes.

Easy quick assembly with clear detailed blueprints and instructions. Small convenient size 9" x 6" x 4¾". Weight 4 pounds. This is one of the handiest instruments in any service shop.

The HEATH COMPANY

DEPT. E . . . BENTON HARBOR, MICHIGAN

RADIOMEN'S HEADQUARTERS ✳ WORLD WIDE MAIL ORDER SERVICE ! !

GENERAL ELECTRIC 150 WATT TRANSMITTER

Cost the Government $1800.00 • Cost to You— BRAND NEW—$67.50

This is the famous transmitter used in U.S. Army bombers and ground stations, during the war. Its design and construction have been proved in service, under all kinds of conditions, all over the world. The entire frequency range is covered by means of plug-tuning units which are included. Each tuning has its own oscillator and power amplifier coils and condensers, and antenna tuning circuits—all designed to operate at top efficiency within its particular frequency range. Transmitter and accessories are finished in black crackle, and the milliammeter, voltmeter, and RF ammeter are mounted on the front panel. Here are the specifications: FREQUENCY RANGE: 200 to 500 KC and 1500 to 12,500 KC. (Will operate on 10 and 20 meter band with slight modification for which diagrams are furnished). OSCILLATOR: Self-excited, thermo compensated, and hand calibrated. POWER AMPLIFIER: Neutralized class "C" stage, using 211 tube and equipped with antenna coupling circuit which matches practically any length antenna. MODULATOR: Class "B"—uses two 211 tubes. POWER SUPPLY: Supplied complete with dynamotor which furnishes 1000V at 350 MA, from either 12 or 24 volts. Complete instructions are furnished to operate set from 110V AC. SIZE 21½x23x9¼". Total shipping wgt. 200 lbs., complete with all tubes, dynamotor power supply, seven tuning units, antenna tuning unit and the essential plugs.

GENERAL ELECTRIC RT-1248 15-TUBE TRANSMITTER-RECEIVER

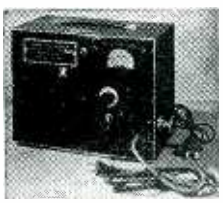
TERRIFIC POWER—(20 watts) on any two instantly selected, easily pre-adjusted frequencies from 435 to 500 Mc. Transmitter uses 5 tubes including a Western Electric 316 A as final. Receiver uses 10 tubes including 955's, as first detector and oscillator, and 3—7H7's as IF's with 4 slug-tuned 40 Mc. IF transformers, plus a 7H7, 7E6's and 7F7's. In addition unit contains 8 relays designed to operate any sort of external equipment when actuated by a received signal from a similar set elsewhere. Originally designed for 12 volt operation, power supply is not included, as it is a cinch for any amateur to connect this unit for 110V AC, using any supply capable of 400V DC at 135 MA. The ideal unit for use in mobile or stationary service in the Citizen's Radio Telephone Band where no license is necessary. Instructions and diagrams supplied for running the RT-1248 transmitter on either code or voice in AM or FM transmission or reception, for use as a mobile public address system, on 80 to 110 Mc. as an FM broadcast receiver, as a Facsimile transmitter or receiver, as an Amateur Television transmitter or receiver for remote control relay hookups, for Geiger-Mueller counter applications. It sells for only $29.95 or two for $53.90. If desired for marine or mobile use, the dynamotor which will work on either 12 or 24V DC and supply all power for the set is only $15.00 additional.

AT LAST YOU CAN AFFORD A LABORATORY STANDARD MICROVOLTER

The famous Measurements Corp. Model 78E, 5 Tube Laboratory Standard Signal Generator (that sold new, FOB, Boonton, N. J., for $310.00 net), is available in perfect condition for 25 to 60 cycles, 115V AC operation. Until now this is the sort of top-flight lab equipment that discriminating buyers have only vainly hoped would be released at a bargain price. Worth every cent the manufacturer asks, but available FOB Buffalo while our limited supply lasts for only $79.95.

Such companies as Admiral Corp. and John Meck, Inc., have ordered from us and repeated many times on these 78 generators for use in their labs and production line testing.

Uses 1,9002, 1-7Y4, 1-VR 150-30, 1-7C7, and 1-7C5 tubes. Output continuously variable from 0 to 100,000 Microvolts.



78E Standard Signal Generator. 50 to 70 Mc. Unmodulated or with 400 cycle modulation.

RECORDING AMPLIFIER, 3 stage, 110 V, 25 or 60 cycle high gain amplifier built by recently bankrupt manufacturer specifically for recording use. Transformer for low impedance wire recorder head or magnetic cutter included on chassis. Tone and volume controls and switches on chassis for playback, recording or use as public address amplifier. Complete with tubes-$9.95 Speaker-$2.40 Beautiful original portable case $5.95. Mike Stand $5.95.

BENDIX SCR 522—Very high Frequency Voice Transmitter-Receiver—100 to 156 MC. This job was good enough for the Joint Command to make it standard equipment in everything that flew, even though each set cost the Gov't $2500.00. Crystal Controlled and Amplitude Modulated—HIGH TRANSMITTER OUTPUT and 3 Microvolt Receiver Sensitivity gave good communication up to 180 miles at high altitudes. Receiver has ten tubes and transmitter has seven tubes, including two 832's. Furnished complete with 17 tubes, remote control unit, 4 crystals, and the special wide band VHF antenna that was designed for this set. These sets have been removed from unused aircraft and are guaranteed to be in perfect condition. We include free parts and diagrams for the conversion to "continuously variable frequency coverage" in the receiver.
The SCR 522 complete with 24 volt dynamotor sells for only $37.95. The SCR 522 is also available with a brand new 12 volt dynamotor for only $42.95.

TERRIFIC VALUE— PORTABLE ELECTRIC DRILL

(Sold at less than established factory price so we cannot mention brand name)
Only $19.95 equipped with ¼" Jacobs Geared Chuck and Key.
Not an intermittent duty drill, but a full size rugged tool.
Most convenient type switch, natural grip handle, and balance like a six shooter.
Precision cut gears—turbine type cooling blower—extra long brushes.
No stalling under heaviest pressure because of powerful 110 Volt AC-DC motor and multiple ball thrust bearing.
Other bearings self-aligning lifetime-lubricating Chrysler Oilite type.
Made for toughest year-in and year-out service in plant or on construction jobs.
Amazing perpetual factory guarantee assures you of a lifetime of trouble-free use.
25% deposit on C.O.D.'s. Full refund (you pay transportation) if not pleased with drill after trial.

STEATITE VARIABLE CONDENSERS

Ideal for high-frequency applications in receivers and low power transmitter stages. All types have standard ¼" dia. shafts.

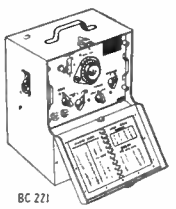
				Screw Driver Adjustment			
10 mmf	$.35—10 for	$2.90—100 for	$23.00	$.20—10 for	$1.80—100 for	$16.00
15 mmf	$.35—10 for	$2.90—100 for	$23.00	$.20—10 for	$1.80—100 for	$16.00
25 mmf	$.35—10 for	$2.90—100 for	$23.00	$.20—10 for	$1.80—100 for	$16.00
35 mmf	$.40—10 for	$3.40—100 for	$28.00	$.25—10 for	$2.30—100 for	$20.00
50 mmf	$.45—10 for	$3.70—100 for	$30.00	$.25—10 for	$2.30—100 for	$20.00
75 mmf	$.50—10 for	$4.40—100 for	$38.00	$.30—10 for	$2.70—100 for	$25.00
100 mmf	$.55—10 for	$4.50—100 for	$39.00	$.40—10 for	$3.60—100 for	$32.00
140 mmf	$.80—10 for	$7.40—100 for	$64.00			
160 mmf	$1.00—10 for	$8.50—100 for	$70.00			
140–140 mmf	$1.60—10 for	$12.50—100 for	$100.00			

Butterfly condensers, rotor has two ball bearings and a ¾" shaft.

15 mmf. per section $.50—10 for $4.50—100 for $40.00
30 mmf. per section $.60—10 for $5.50—100 for $50.00
50 mmf. per section $.70—10 for $6.50—100 for $60.00

Manufacturers and distributors write for prices on larger quantities.
WE HAVE OVER 250,000 VARIABLE CONDENSERS IN STOCK.

BC-221 FREQUENCY METERS



BC 221

with calibrating Crystal and calibration charts. A precision frequency standard that is useful for innumerable applications for laboratory technician, service man, amateur, and experimenter at the give away price of only $36.95.

Auto Radio Dealers! Attention!

Nationally advertised brand of 1948 car radio which will fit practically any car and every pocketbook. Six tube superheterodyne with three gang condenser and 6½" speaker. **$32.20 for sample, or Dealer price $29.97 each, in lots of two or more.**
Here is an item that no serviceman who repairs auto radios should be without. Nationally advertised ATR battery eliminator that supplies perfectly filtered 6 VDC at 14 amps, from 110 AC.....$36.00

CONDENSERS—PAPER TUBULAR 600 WV—.001, .002, .005—8c; .01, .05—9c; .1—10c; .25—23c; .05—35c; **ELECTROLYTICS:** 8mfd 200v—20c; 10mfd 35v—20c; 30mfd 150v—23c; 20/20mfd 150v—35c; 30/20 150v—46c; 50mfd 150v—43c; 8mfd 475v—34c; 16mfd 350v—65c; **OIL CONDENSERS:** 4mfd 600v 49c; 2mfd 600v—29c; 3X.1mfd 600v—29c.

SPEAKERS—These PM speakers are the finest that are available. All have heavy oversize Alnico V magnets.

3½"		$1.15	6 for	$6.60
4"		$1.15	6 for	$6.60
5"		$1.10	10 for	$9.50
6"		$1.50	6 for	$8.70
7" (Car Radio Size)		$4.50	6 for	$21.50
8"	10 oz.	$3.95	6 for	$20.50
8"	21 oz.	$4.95	6 for	$26.50
10"	21 oz.	$5.50	6 for	$30.00
12"	21 oz.	$7.95	6 for	$42.00

MIDGET 1 WATT RIG supplied complete with polystyrene coil forms for 3 ham bands. Size overall 3"x1"x2½" high. Includes practically all necessary parts. Details on page 62 of January 1948 QST. Your cost.....$1.50
Battery pack for the 1 watt transmitter supplying 90 volts "B" and 1.5 volts "A".....$1.50
110 V. AC power supply kit for the 1 watt transmitter.....$3.50
ltT1655. An 11 tube crystal controlled superhet receiver for 24-28V DC operation. Beautiful chassis and cabinet. Uses latest tube types including 7 miniature 6AJ5's. Tubes and schematic supplied. Only a few available at $14.95.

SELENIUM RECTIFIERS. All types are rated at 130 V.A.C. **Do not assort to make quantity.**

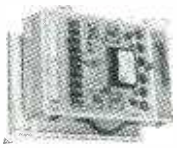
75 MA	.70	10 for	6.50	50 for	$31.00
100 MA	.75	10 for	7.00	50 for	32.50
150 MA	.80	10 for	7.50	50 for	35.00
200 MA	1.05	10 for	10.00	50 for	47.50
250 MA	1.25	10 for	12.00	50 for	57.50

RT1711 Brand New 12 Tube, 110 Volt Receiver-Indicator-Oscilloscope complete with all tubes and power supply. Has telescoping hood over scope tube, which is equipped with a detachable calibrated screen. Has centering and amplitude controls and two video inputs. A natural for television.....$39.95

UNIVERSAL MICROPHONE CO.'S latest model recorder platform with high quality recording amplifier complete with all necessary controls for volume, tone, playback, record, and public address applications. Unit features crystal playback and magnetic recorder head attached by special pantographic arrangement for making absolutely linear recordings. Complete with all tubes and matched speaker. Everything supplied but the cabinet for.....$46.95

1948 MODEL MUTUAL CONDUCTANCE TUBE TESTER

with new 9 pin socket to handle all future tube developments **$49.95**



No possibility of good tubes reading "Bad" or bad tubes reading "Good" as on dynamic conductance testers or other ordinary emission testers. Attractive panel and case equal to any on the market in appearance . . . Large 4½" meter . . . Calibrated micromho scale as well as a Bad-Good scale . . . Front panel fuse . . . Individual sockets for all tube base types—voltages from .75 volts to 117 volts and complete switching flexibility allow all present and future tubes to be tested regardless of location of elements on tube base . . . Indicates gas content and detects shorts or opens on each individual section of all loctal, octal and miniature tubes including cold cathode, magic eye and voltage regulator tubes as well as all ballast resistors. Name of the nationally known manufacturer withheld because of special price offer. $49.95
Model "C"—Sloping front counter case..... 54.95
Model "P"—Handsome hand-rubbed portable case.....
Built-in roll chart with either of above $5.00 extra.

Cable Address: BUFRAD

Minimum order $3.00—All prices subject to change—25% deposit with COD orders.

BUFFALO RADIO SUPPLY, 219-221 Genesee St., Dept. 6-E BUFFALO 3, N. Y.

SURPLUS COMMERCIAL TRANSMITTERS

Immediate Delivery from Stock

2-KW Hi-Frequency Transmitter: 4-Bands, 2 to 18 mc. Model H-2000, mfd by Radio Laboratories, Inc. Consists of P.A. unit using 2—833A tubes, in cabinet 36x36x74¼" high, and Power Supply using 4—872A and 2—866 tubes, in cabinet 24"x36"x74¼" high. Operates from 110 or 220 volts, 50-60 cycles, 1-phase AC. Driving power required, 70-125 watts. New, with tubes. **COMPLETE**.....$2,100.00

BC-325 Transmitter. 400W.-A1, 100 W.-A2 & A3. 1.5 to 18.0 mc. M.O. or X'tal control on 6 frequencies. **Operates from 110/220/1/60c. AC.** With tubes, in excellent condition. **Price, each $700.00**

BC-447, 300 W. A1, 2-Channel Transmitter. Complete and self-contained in one cabinet, 36x29x72 H., includes RF sections, power supplies, and control equipment. Freq. range 4.0 to 13.4 mc. Operates from 110/220V/1/50-60 c. AC. With tubes. Excellent condition. **PRICE EACH**.....$600.00

Model 600-B, 600 Watt Radiotelephone transmitter, mfd. by Temco. 600 watts on phone, 1 KW on CW; frequency range 1.5 to 20.0 mc. Provision for multi-channel operation. Includes separate Remote Control and Speech Amplifier unit. Operates from 220 volts, 1-phase, 50-60 cycles AC. With tubes—no spares. Price.....$2,000.00

Collins 75 Watt Autotune Transmitter. Model TCB, 10-channels instantly available by dial-telephone selection at transmitter or remote position. A1, A2, or A3 emission. Freq. range 1.5 to 12.0 mc. Operates from 110 volts, 1-phase, 50-60 cycles AC. Complete with all spares (tubes, capacitors, etc.), remote operating unit, handsets, etc. Excellent condition. Priced way below cost at.....$600.00

50 WATT RADIOTELEPHONE MODEL ATD

Designed for airplane installation. 4 channels. Useful also for ship, shore, or ham installation. Conservatively rated at 50 watts output, A1, A2, and A3. Instant selection of any one frequency in 3 bands, 540 to 1500, 1500 to 3000, and 3000 to 9050 Kc. Complete with 24 to 28 v.d.c. dynamotor, remote control, channel indicator unit, plug connectors, spares, instruction book. Uses high-level plate modulation for A2 and A3. **PRICE COMPLETE EACH, NEW** $110.00

RC-263 RADIO TRANSMITTING EQPT.

For Airport or Marine installation. 75 watts CW, 50 watts phone. 4-channels, motor tuning—selection by telephone dial, freq. coverage 1.5 to 10.0 mc. Consists of BC-1100-A Transmitter, RM-40-A Remote Control, all tubes, microphone, and instruction book. **ALL NEW EQPT, export packed.** Operates from 100 to 260 volts, 25 to 60 cycles, 1-phase AC. **PRICE, EACH, COMPLETE $575.00**

RADAR EQUIPMENT

Navy Model SF, NEW and Complete with all spares and accessories. **Price, Complete Set**....$2,500.00
SCR-717-B, Army-Bomber Type, PPI. New and Complete with all spares and accessories. **EACH** $850.00
Radar Transmitter Type CRV-52AAY, for SD-3, excellent condition but less tubes. **EACH**..$150.00
Model YJ Automatic-Responder Radar Beacon, RF and Power Supply Units only (transmitter) with tubes. Good condition..**PRICE EACH**....$150.00

All Prices F.O.B. N.Y.C. **All Material Offered Subject to Prior Sale**

TELEMARINE COMMUNICATIONS COMPANY

Phone—Watkins 4-7021 **533 W. 24th N. Y. 11, N. Y.**

BRAND NEW! TS-13 HANDSETS

● **Standard size and type. Surplus Black Bakelite. Low-impedance mike, 3000-ohm receiver. 6-ft. cord with two plugs. Brand New. In original factory-sealed cartons** .....**$2.85 ea. net.**

EIMAC VT-127A TUBES

● **Capable of 1-KW on 6 meters for a pair. 5v. 10a. Fil. Platinum Grid. Brand New. Original cartons. Surplus. $2.85 ea. net. Brass Filament Clips 25¢ pair.**

25-Watt P-A Re-Entrant Speakers - Brand New!!

● **9-pound magnet. 13" bell. 21" long. UTC line-matching xmfr. 250, 500, 1000, 2500 ohms. Our best seller. Few left. Surplus Item. Original Cartons. $21.60.**

VACUUM CAPACITORS

● **Surplus. Brand New. Original Boxes. 17,000 peak volts up to 50uuf sizes; 10,000 peak volts for larger sizes. 6uuf. $2.80; 12uuf. $3.50; 50uuf. $4.50; 100uuf. $7.65; 150uuf. $11.60; 200uuf. $14.60; 250uuf. $17.30.**

OFFENBACH & REIMUS CO.

372 Ellis St., San Francisco 2, Calif.
Telephone: ORdway 3-8551

CLARE RELAYS

No. R30 3500 ohm 6MA SPDT 3a cont **$70/c**
No. R13 200 ohms 24v SPST N.O.....**$20/c**
No. R58 150 ohm 12v DPDT & SPST Norm clsd 3a cont...**$45/c**

ALLIED RELAYS

No. RO4 230 ohms 24v DPDT 10A cont **$23/c**
No. RO6 230 ohms 24v SPDT Dble Br 2A cont **$24/c**
No. 66 150 ohms 12v DPST N.O....**$45/c**
G.M. Relay No. R16 240 ohms 24v 4PDT 10A cont **$60/c**
No. R31 40 ohms 12v SPST N.O....**$18/c**

TRANSFORMERS & CHOKES

Pwr Trans: 1500v C.T. at 150ma, 6.3v 2.5a, 6.3v 1.6a, 5v 3a. 115v 50-60c pri .....**$5.25 ea.**

Fil Trans: 6.3v 8a, 115v 50-60c pri .....**$1.95 ea.**

10 hy 50ma 350 ohms 2"d x 2½" h **$25/c**

20hy 15ma 975 ohms G.E. Herm Sealed 2¼" x 1⅞ x 2¼" **$22.50/c**

3 hy 5ma 325 ohms 1 9/16"d x 1¼" h **$19.00/c**

MISCELLANEOUS

PILOT LAMPS 12v 0.1 A Min Bay Base T 3¼ Bulb **$39/M**
VIBRATORS 115v DC to 90cy AC 115v OAK No. V6429 6 prong.....**$23/M**

SLUG TUNED R-F & ANT-COILS CERAMIC FORM

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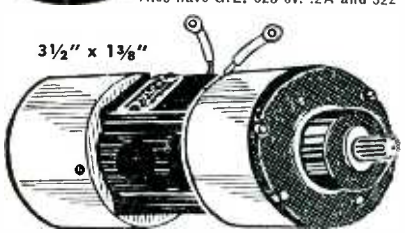

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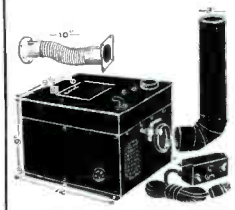

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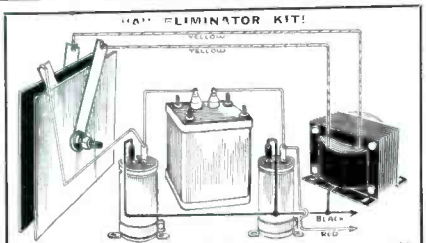

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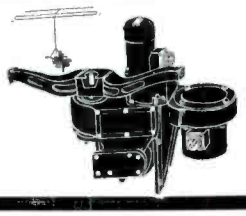

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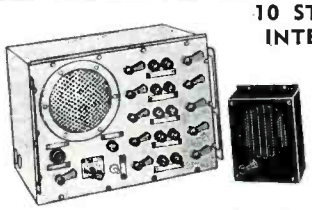

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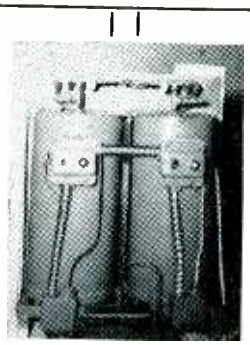

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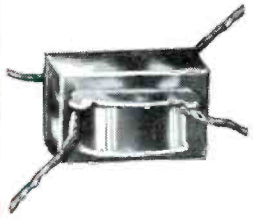

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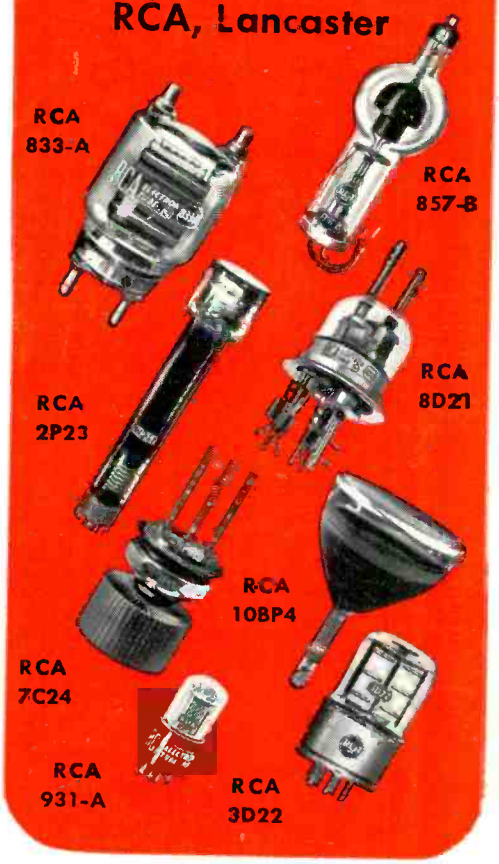

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