
DECEMBER · 1946
electronics
A McGRAW-HILL PUBLICATION
OLDEST R-F
HEATING
APPLICATION


THESE AND
A HUNDRED OTHERS

electronics

A McGRAW-HILL PUBLICATION

DECEMBER • 1946

McGRAW-HILL PUBLISHING COMPANY INCORPORATED, JAMES H. McGRAW, Founder and Honorary Chairman • PUBLICATION OFFICE 99-129 North Broadway, Albany 1, N. Y., U. S. A. EDITORIAL AND EXECUTIVE OFFICES 330 West 42nd St., New York 18, N. Y., U. S. A.—Member A. B. P. Member A. B. C.

James H. McGraw, Jr., President; Curtis W. McGraw, Senior Vice-President and Treasurer; Nelson Bond, Director of Advertising; Eugene Duffield, Editorial Assistant to the President; Joseph A. Gerardi, Secretary; and J. E. Blackburn, Jr., Vice-President for circulation operations.
ELECTRONICS, December, 1946, Vol. 19; No. 12. Published monthly, with an additional issue in June, price 75c a copy. Directory Issue $1.00. Allow at least ten days for change of address. All communications about subscriptions should be addressed to the Director of Circulation.
Subscription rates—United States and possessions, $6.00 a year, $9.00 for two years, $12.00 for three years. Canada (Canadian funds accepted) $7.00 a year, $11.00 for two years, $14.00 for three years. Pan American countries $10.00 for one year, $16.00 for two years, $20.00 for three years. All other countries $15.00 for one year, $30.00 for three years. Please indicate position and company connection on all subscription orders. Entered as Second Class matter August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11, Ill.; 68 Post Street, San Francisco 4; Aldwych House, Aldwych, London, W.C. 2; Washington, D. C. 4; Philadelphia 2; Cleveland 15; Detroit 26; St. Louis 8; Boston 16; Atlanta 3, Ga.; 621 So. Hope St., Los Angeles 14; 738-9 Oliver Building, Pittsburgh 22.

Get 10,000 megohms insulation resistance after wet cycling... with RESINOX 490*

LAMINATING VARNISH

*Here for the first time is a laminating varnish that can deliver up to 10,000 megohms insulation resistance after wet cycling according to the JAN-P13 procedure.

In addition, Resinox 490 imparts to laminates excellent power factor, dielectric constant, and loss factor . . . also exceptionally good hot punching characteristics.

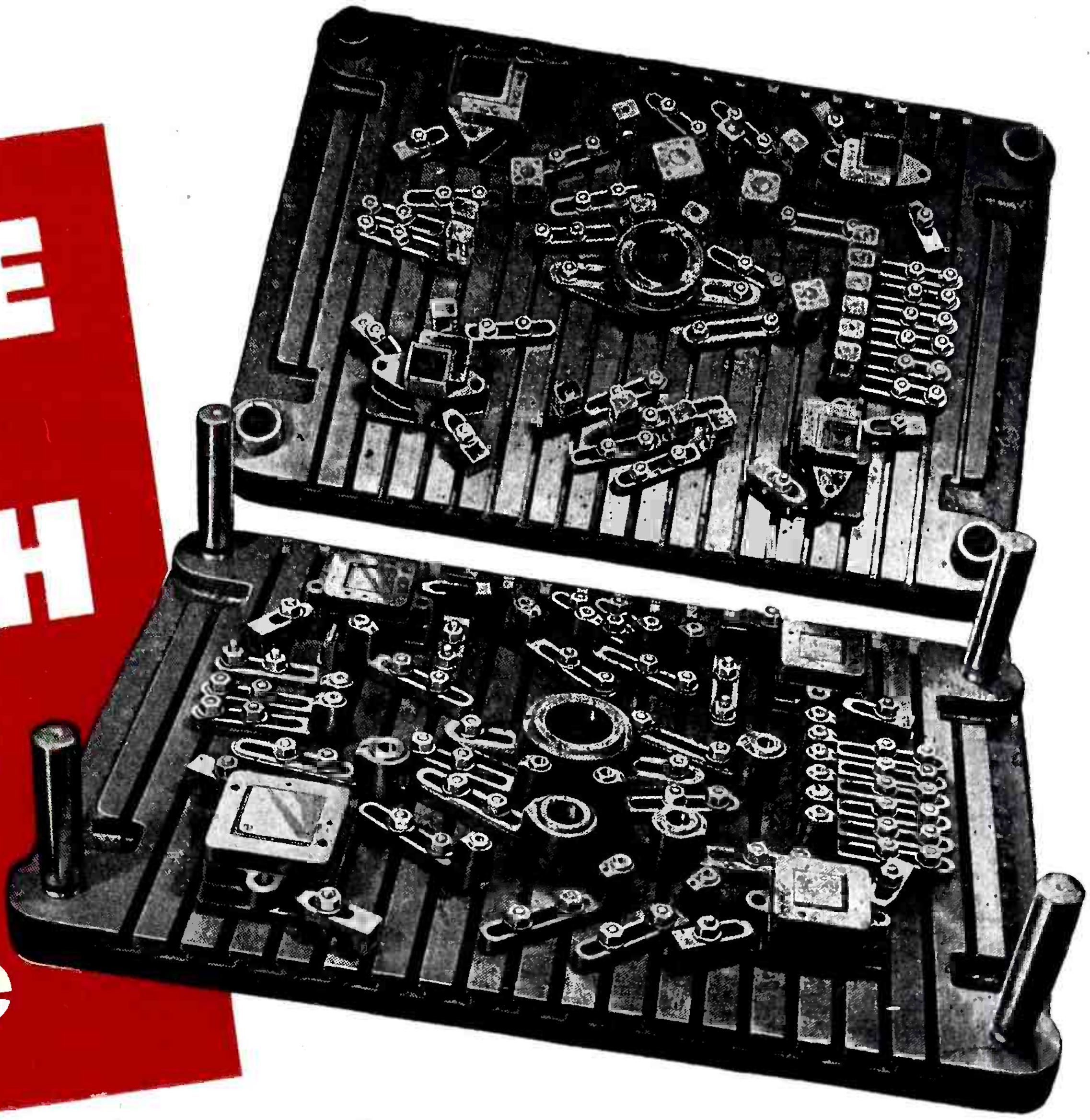
If you manufacture or use these materials, why not specify Resinox 490 as the laminating varnish . . . and take advantage of extra, important qualities. For complete data on this application or on other post-forming or general-purpose laminating varnishes . . . simply address: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts. In Canada: Monsanto Ltd., Montreal, Toronto, Vancouver.

MONSANTO CHEMICALS

SERVING INDUSTRY...WHICH SERVES MANKIND

Resinox: Reg. U. S. Pat Off.

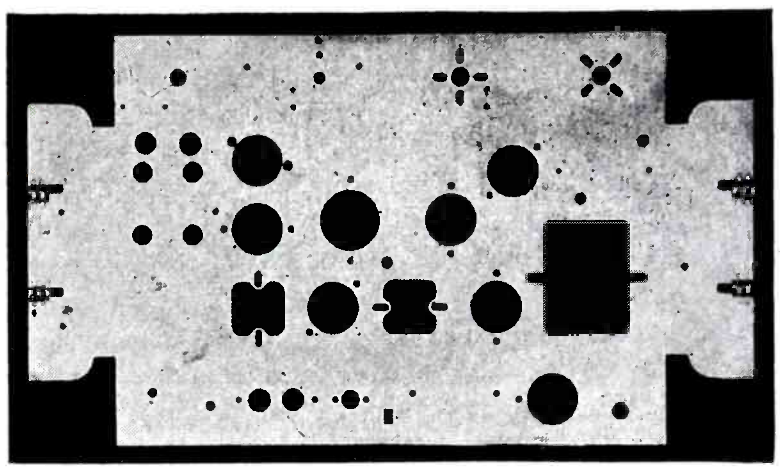
PIERCE and NOTCH at the same time



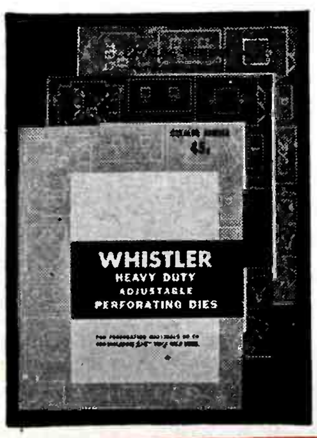
A typical set-up for notching and piercing.

with WHISTLER MULTI-USE Adjustable Dies

Pierced and notched with Whistler multi-use adjustable dies.



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



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

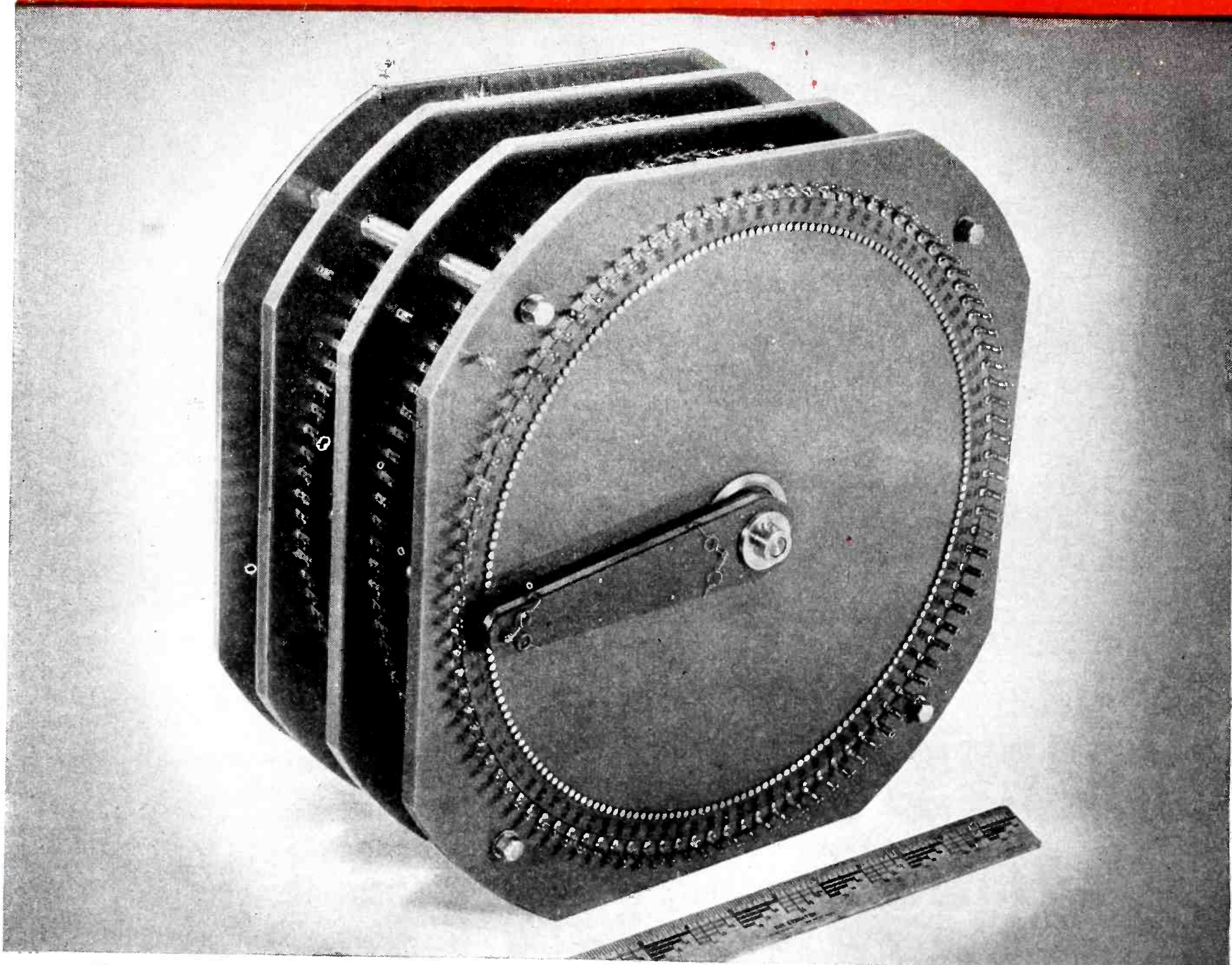
Re-arrange Whistler multi-use adjustable dies in as many different set-ups as your production calls for . . . you actually make up die sets from units in stock and reduce costs per job to an unbelievably low figure. All parts of like size are interchangeable.

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

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

WHISTLER MULTI-USE ADJUSTABLE PERFORATING DIES

LAMICOID LAMINATED PLASTIC



100-step switch made by the Daven Company, uses electrical grade XXXP Lamicoid for keeping circuits well separated.

Whether there are 100 steps, as in the switch illustrated, or only five connections for a tube socket base, you can depend upon Lamicoid to provide the right insulating qualities. For Lamicoid has high resistance to heat, humidity, high frequency, and low electrical loss characteristics.

But aside from the insulating properties, Lamicoid has excellent mechanical strength—useful when the insulation acts as a structural part in addition to being an insulating material. This strength means longer life for panels, tube sockets, etc.

Lamicoid is also an extremely versatile material. It can be sawed, punched, machined and easily cut to desired shapes. Some grades can be printed while other kinds engraved for circuit identification. Lamicoid is made with a large variety of fillers and resins depending upon the service requirements. For example, Fiberglas and Lamicoid offer great impact and fire resistance. Other grades are excellent for stamped or punched parts. Lamicoid and Buna S rubber are ideal for use as end seals on capacitors.

Sheets are available in standard 36″ x 42″ size and thickness from .010″ to 5½″. Tubes range from .090″ i.d. to 8″ and over.

Remember you can get from Mica Insulator Company a complete line of all insulating materials. This means unbiased recommendations based on over 50 years' experience in the business.

MUNSELL
MICA

MICANITE
REG. U. S. PAT. OFF.
BUILT-UP MICA

LAMICOID
REG. U. S. PAT. OFF.
LAMINATED PLASTICS

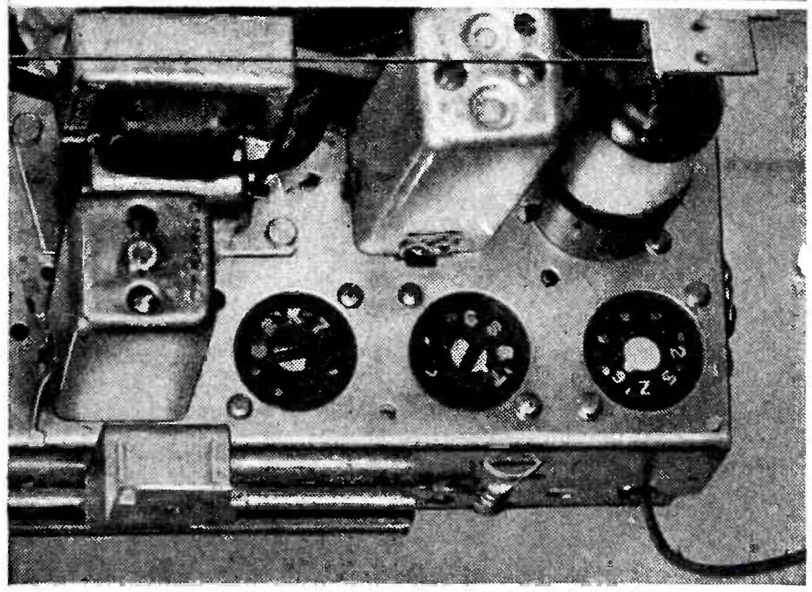
EMPIRE
REG. U. S. PAT. OFF.
VARNISHED CLOTHS AND TAPES

MICO
REG. U. S. PAT. OFF.
INSULATING SPECIALTIES

Keeps Electronic Circuits Separated

Lamicoid is available in wide variety of grades and forms that are readily punched, sheared, sawed, or machined for electrical or mechanical applications.

Lamicoid, combined with various grades of synthetic rubber is used for end seals on these electrolytic capacitors to keep out moisture and provide a non-corrosive seal.



Tube socket bases of this electronic assembly depend on exceptional strength and insulating properties of Lamicoid to protect product performance, lower maintenance costs.

MICA *Insulator* COMPANY

Schenectady 1, New York

SALES OFFICES: Boston • Chicago • Cincinnati • Cleveland • Detroit • New York • St. Louis • Philadelphia • Rochester
Western Fiberglas Supply, Ltd., San Francisco and Los Angeles

FABRICATORS: Lamicoid Fabricators, Inc., Chicago, Ill. • Insulating Fabricators, Inc., Watertown, Mass. • Insulating Fabricators, Inc., New York • Bakoring, Inc., Houston, Texas

Free! **New bulletin on Lamicoid Laminated Plastics, containing application data, NEMA grades and specifications, is yours for the asking. Mail coupon for your copy today!**

Mica Insulator Company, Dept. 22,
P. O. Box 1076, Schenectady 1, N. Y.

Gentlemen:

( ) Please rush my copy of your new bulletin on Lamicoid Insulation.
( ) Enclose price list.
( ) Please have your application engineer see me when in my vicinity.

Name____________________

Position____________________

Company____________________

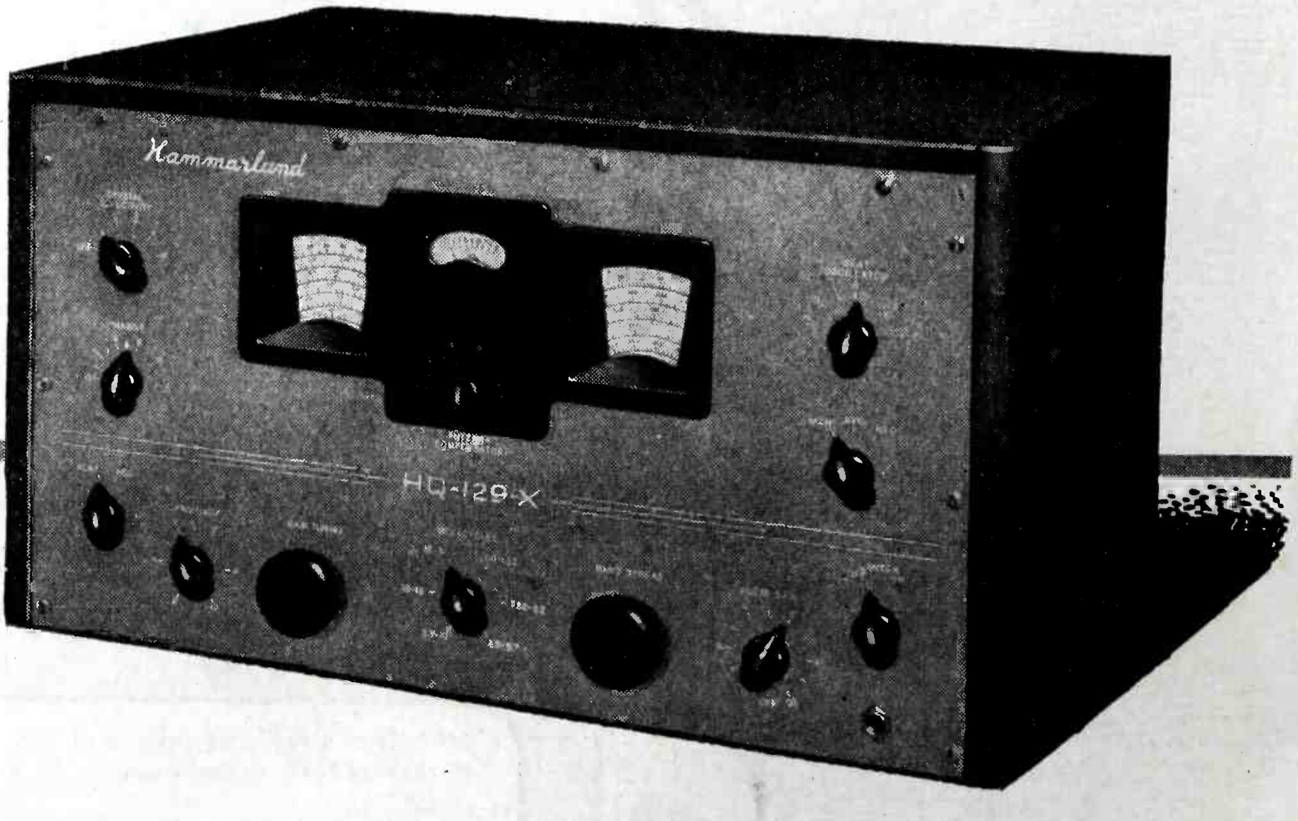
Address____________________

City____________________ State__________

HQ·129·X

backed by 36 years of know-how

Many thousands of amateurs are using the new HQ-129-X communications receiver. Rarely has a new product been so widely approved in so short a time. The reason is simple—36 years experience and a record of high accomplishment build confidence. The HQ-129-X is an outstanding value from the standpoint of performance and cost.



THE SIGN OF QUALITY

ESTABLISHED 1910

HAMMARLUND

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

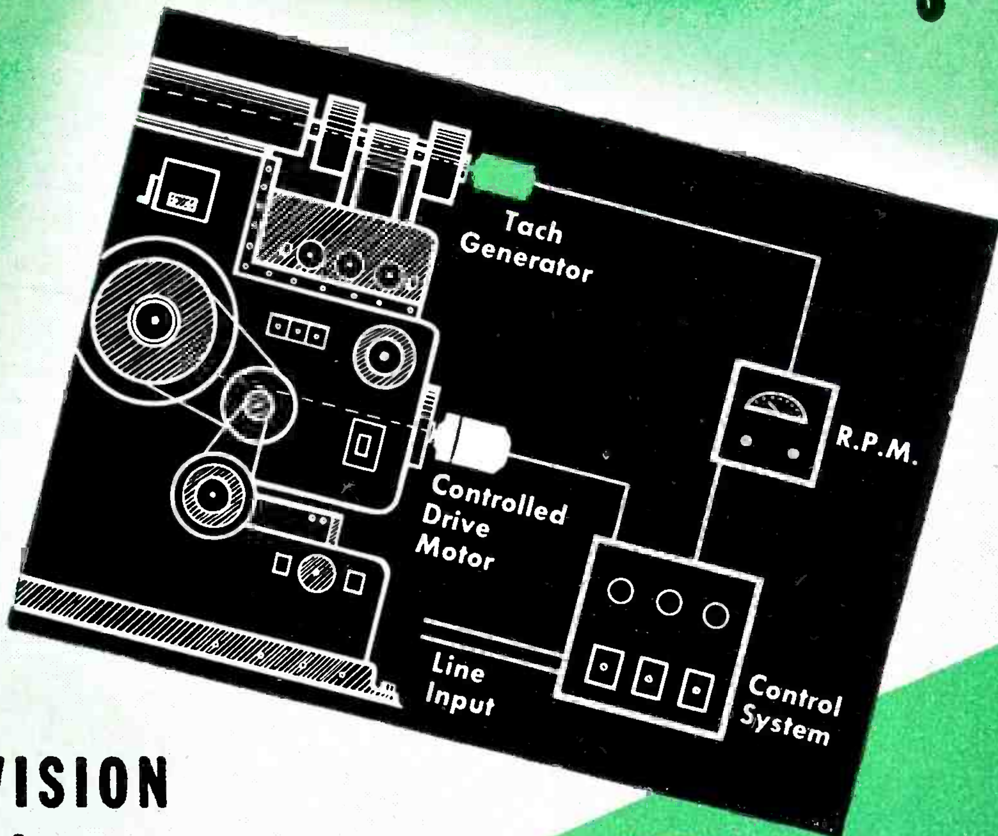
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

see the HQ-129-X at your dealer's.

Need a Special PERMANENT MAGNET GENERATOR?

for

1. Process Control
2. High Frequency Power
3. Speed Indication



EAD

SPECIAL DESIGN DIVISION HAS IT.....OR WILL ENGINEER AND BUILD IT....

MODEL N2B
70 volts, 20 cycles, 2 pole, 1200 R.P.M. AC Generator 20 to 1000 cycles up to 50 watts.

MODEL N2A
115 Volts, 3 phase, 400 cycle AC Generator. Delivers 40 watts at 6000 R.P.M.

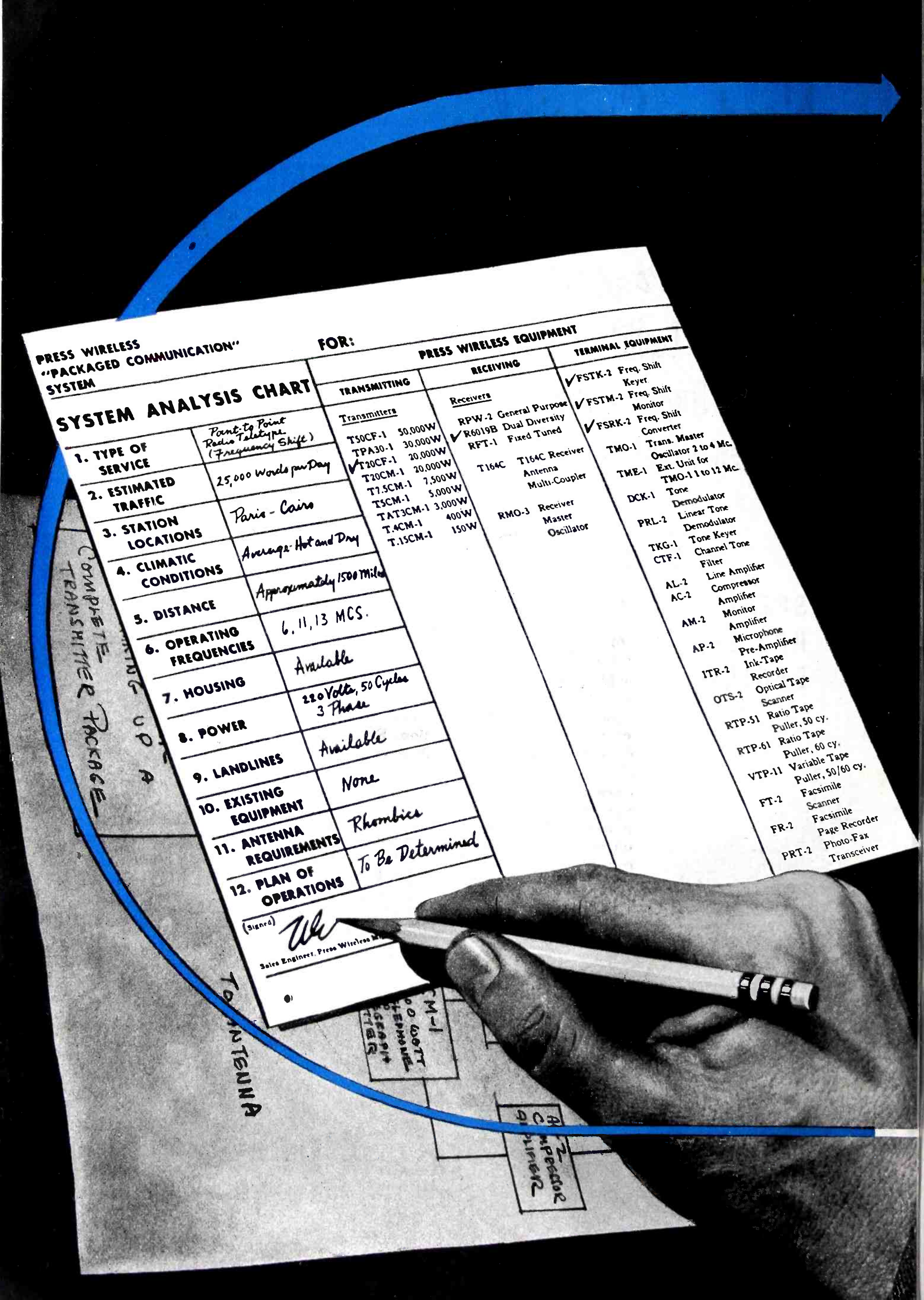
MODEL J36
DC Voltage Generator .02 volts per R.P.M. up to 5000 R.P.M. Voltage linear with speed within 1%.

MODEL N3B
6 volts, 1 phase, 20 cycles AC Generator at 1200 R.P.M. for Servo System Control.

Our war-won experience in the design of small Permanent Magnet Field AC and DC Generators equips us particularly well to engineer and build "special design" units in sizes up to 50 watts. These may be obtained in various voltages, frequencies and powers depending on speed and size.

SPECIAL DESIGN EAD DIVISION

EASTERN AIR DEVICES, INC.
130 FLATBUSH AVENUE
BROOKLYN 17, NEW YORK



PRESS WIRELESS
"PACKAGED COMMUNICATION"
SYSTEM
FOR:
SYSTEM ANALYSIS CHART
1. TYPE OF SERVICE
Point-to-Point Radio Teletype (Frequency Shift)
2. ESTIMATED TRAFFIC
25,000 Words per Day
3. STATION LOCATIONS
Paris - Cairo
4. CLIMATIC CONDITIONS
Average - Hot and Dry
5. DISTANCE
Approximately 1500 Miles
6. OPERATING FREQUENCIES
6, 11, 13 MCS.
7. HOUSING
Available
8. POWER
220 Volts, 50 Cycles 3 Phase
9. LANDLINES
Available
10. EXISTING EQUIPMENT
None
11. ANTENNA REQUIREMENTS
Rhombics
12. PLAN OF OPERATIONS
To Be Determined
(Signed)
Sales Engineer, Press Wireless
PRESS WIRELESS EQUIPMENT
TRANSMITTING
Transmitters
T50CF-1 50,000W
TPA30-1 30,000W
T20CF-1 20,000W
T20CM-1 20,000W
T7.5CM-1 7,500W
T5CM-1 5,000W
TAT3CM-1 3,000W
T.4CM-1 400W
T.15CM-1 150W
RECEIVING
Receivers
RPW-2 General Purpose
R6019B Dual Diversity
RFT-1 Fixed Tuned
T164C T164C Receiver Antenna Multi-Coupler
RMO-3 Receiver Master Oscillator
TERMINAL EQUIPMENT
FSTK-2 Freq. Shift Keyer
FSTM-2 Freq. Shift Monitor
FSRK-2 Freq. Shift Converter
TMO-1 Trans. Master Oscillator 2 to 4 Mc.
TME-1 Ext. Unit for TMO-1 1 to 12 Mc.
DCK-1 Tone Demodulator
PRL-2 Linear Tone Demodulator
TKG-1 Tone Keyer
CTF-1 Channel Tone Filter
AL-2 Line Amplifier
AC-2 Compressor Amplifier
AM-2 Monitor Amplifier
AP-2 Microphone Pre-Amplifier
ITR-2 Ink-Tape Recorder
OTS-2 Optical Tape Scanner
RTP-51 Ratio Tape Puller, 50 cy.
RTP-61 Ratio Tape Puller, 60 cy.
VTP-11 Variable Tape Puller, 50/60 cy.
FT-2 Facsimile Scanner
FR-2 Facsimile Page Recorder
PRT-2 Photo-Fax Transceiver
COMPLETE TRANSMITTER PACKAGE
TO ANTENNA

e's how we "pack
e PW package

PRESS WIRELESS

Christmas Lights or Television...

★ ANSONIA ★

Ankoseal

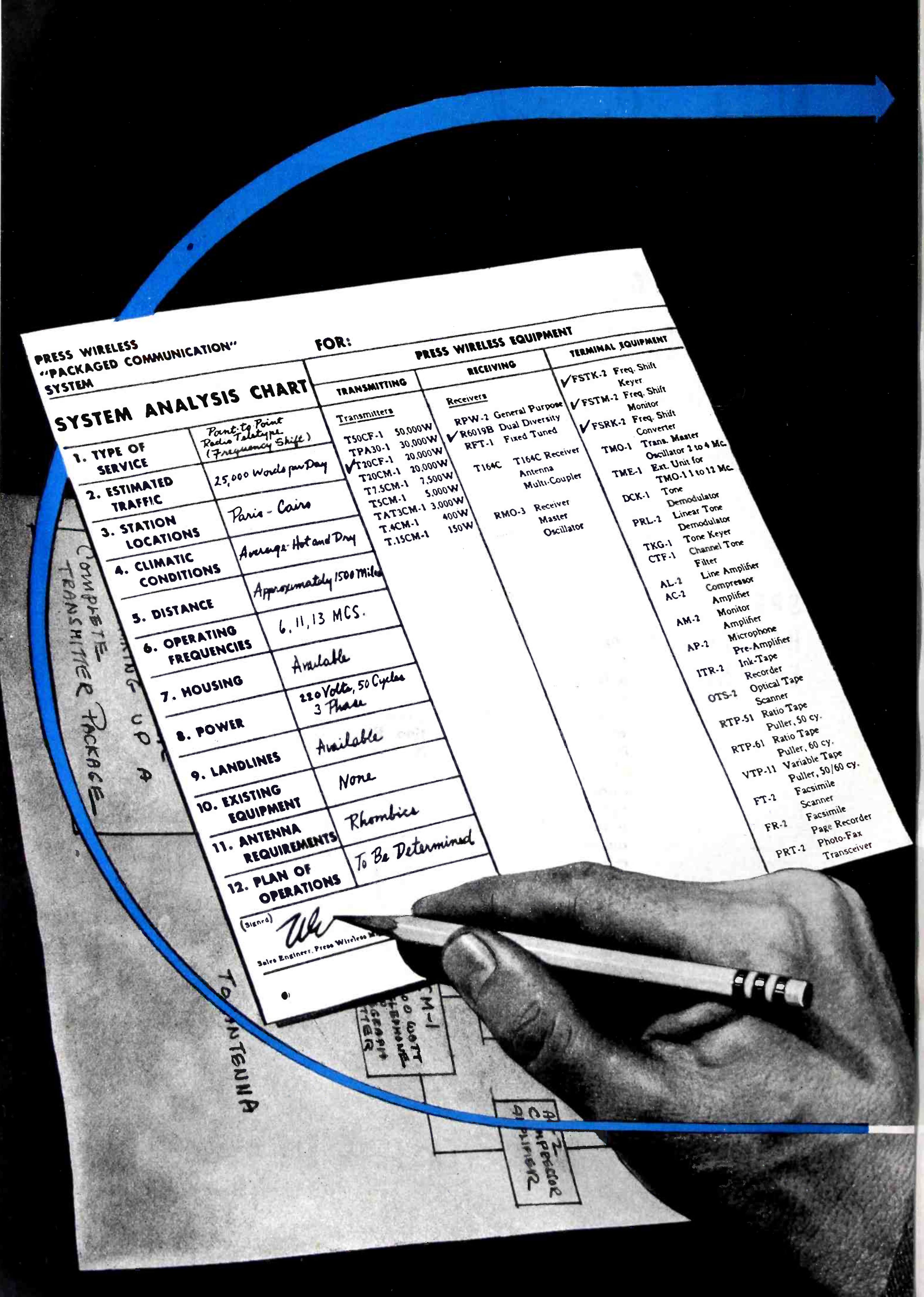
is Recommended Insulation

In tens of thousands of homes this Christmas, wiring for tree lights by Noma will be insulated with *Ansonia Ankoseal.* In case of fire, greater safety will be assured because Ankoseal is self-extinguishing. The wiring will be lighter weight, smaller in diameter, smoother, more flexible. And many a future Christmas will be served by these lights because Ankoseal resists wear, aging and heat — enemies of long life.

Ansonia Ankoseal is equally applicable to the solution of problems involving more complicated use such as television, truer FM radio tone and the transmission of high frequency power. Ankoseal flexibility, dielectric qualities, and serviceability under severe conditions recommend it for the above and other duties.

You are invited to discuss your cable problems with us. The successful production of cables to meet unusual or difficult situations is a major part of our business.

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



PRESS WIRELESS
"PACKAGED COMMUNICATION"
SYSTEM
FOR:
SYSTEM ANALYSIS CHART
1. TYPE OF SERVICE — Point-to-Point Radio Teletype (Frequency Shift)
2. ESTIMATED TRAFFIC — 25,000 Words per Day
3. STATION LOCATIONS — Paris - Cairo
4. CLIMATIC CONDITIONS — Average - Hot and Dry
5. DISTANCE — Approximately 1500 Miles
6. OPERATING FREQUENCIES — 6, 11, 13 MCS.
7. HOUSING — Available
8. POWER — 220 Volts, 50 Cycles 3 Phase
9. LANDLINES — Available
10. EXISTING EQUIPMENT — None
11. ANTENNA REQUIREMENTS — Rhombics
12. PLAN OF OPERATIONS — To Be Determined
(Signed)
Sales Engineer, Press Wireless
PRESS WIRELESS EQUIPMENT
TRANSMITTING
Transmitters
T50CF-1 50,000W
TPA30-1 30,000W
✓T20CF-1 20,000W
T20CM-1 20,000W
T7.5CM-1 7,500W
T5CM-1 5,000W
TAT3CM-1 3,000W
T.4CM-1 400W
T.15CM-1 150W
RECEIVING
Receivers
RPW-2 General Purpose
✓R6019B Dual Diversity
RFT-1 Fixed Tuned
T164C T164C Receiver Antenna Multi-Coupler
RMO-3 Receiver Master Oscillator
TERMINAL EQUIPMENT
✓FSTK-2 Freq. Shift Keyer
✓FSTM-2 Freq. Shift Monitor
✓FSRK-2 Freq. Shift Converter
TMO-1 Trans. Master Oscillator 2 to 4 Mc.
TME-1 Ext. Unit for TMO-1 1 to 12 Mc.
DCK-1 Tone Demodulator
PRL-2 Linear Tone Demodulator
TKG-1 Tone Keyer
CTF-1 Channel Tone Filter
AL-2 Line Amplifier
AC-2 Compressor Amplifier
AM-2 Monitor Amplifier
AP-2 Microphone Pre-Amplifier
ITR-2 Ink-Tape Recorder
OTS-2 Optical Tape Scanner
RTP-51 Ratio Tape Puller, 50 cy.
RTP-61 Ratio Tape Puller, 60 cy.
VTP-11 Variable Tape Puller, 50/60 cy.
FT-2 Facsimile Scanner
FR-2 Facsimile Page Recorder
PRT-2 Photo-Fax Transceiver
COMPLETE TRANSMITTER PACKAGE
TO ANTENNA

Here's how we "pack" the PW package

EVERY potential radio communication system presents problems peculiar to its individual requirements. Each problem must be approached with the proper attitude and answered methodically in orderly sequence. The PW System Analysis Chart serves as a valuable aid to both the client and the sales engineer . . . it enables both to work out the problem efficiently.

Peek over the shoulder of a PW sales engineer as he makes his first contact with a prospective client. Notice that only the basic units have been selected . . . those obviously essential, from the list of available PW equipment.

These basic units are then assembled together with whatever associated equipment is required to complete the proposed communication system. This system is engineered, from start to finish, by Press Wireless who for the past seventeen years has designed, built and maintained a globe-circling network of communication systems . . . transmitting better than 80 percent of the world's press traffic.

PW builds its own equipment. It has been pretested on our own world-wide communication circuits. There is no guess work when you submit your communication problem to PW. You obtain . . . from one source, under one contract . . . all the factors of analysis, design, engineering, manufacturing and erection that go to make up a successful communication system.

Why not take advantage of PW experience *today* and let us assist you with your communication problem. PW "packaged" communication equipment is your logical answer.

Please address inquiries to Dept. 708, Press Wireless Manufacturing Corporation, Executive Offices, 1475 Broadway, New York 18, N. Y., U. S. A.

UNITS IN THE PW "PACKAGE"

RADIO-TELEGRAPH
AND TELEPHONE TRANSMITTERS
FREQUENCY SHIFT
RADIO-PHOTO
COMMUNICATION RECEIVERS
PLUS
ASSOCIATED TERMINAL
EQUIPMENT

Your installation is engineered from any combination of the above standardized PW units

PRESS WIRELESS INC.

PRESS WIRELESS

First in "Packaged" Communications Equipment

Christmas Lights or Television...

★ ANSONIA ★
Ankoseal
is Recommended Insulation

In tens of thousands of homes this Christmas, wiring for tree lights by Noma will be insulated with *Ansonia Ankoseal.* In case of fire, greater safety will be assured because Ankoseal is self-extinguishing. The wiring will be lighter weight, smaller in diameter, smoother, more flexible. And many a future Christmas will be served by these lights because Ankoseal resists wear, aging and heat — enemies of long life.

Ansonia Ankoseal is equally applicable to the solution of problems involving more complicated use such as television, truer FM radio tone and the transmission of high frequency power. Ankoseal flexibility, dielectric qualities, and serviceability under severe conditions recommend it for the above and other duties.

You are invited to discuss your cable problems with us. The successful production of cables to meet unusual or difficult situations is a major part of our business.

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

every time we do this stunt—

A Manufacturer Cuts His Production Costs!

Bending over backwards for our customers is part of C-D's service. Actually though, designing a special type capacitor may not be so strenuous a job for us. Not because your capacitor problem is a breeze. It simply comes easier to us, than to most other manufacturers, to bend ourselves to specialized tasks.

For, in the course of designing and manufacturing over ¼ of a million different types of capacitors, our engineers have gathered a wealth of information, experience, or call it "know-how" that speeds the solution to every problem they handle. And the sooner your requirements are met . . . the more perfect the design — the greater are your savings. Typical of the many problems C-D engineers have successfully licked are the capacitor types shown below.

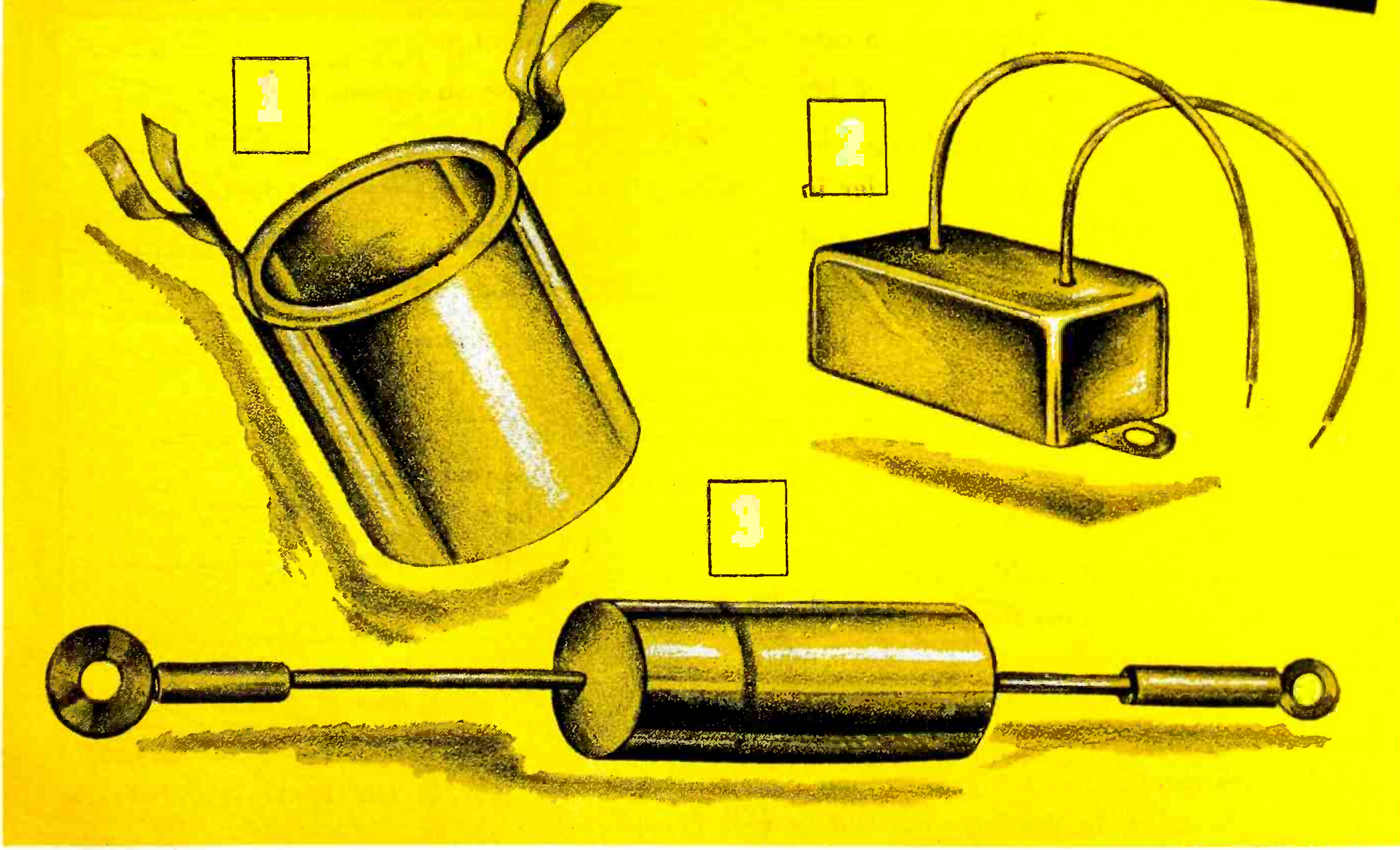
If your plans call for anything in capacitors, consult with our engineers. Catalog of standard types available on request.

Cornell - Dubilier Electric Corporation, South Plainfield, New Jersey. Five other plants in New Bedford, Providence, Worcester and Brookline.

CORNELL-DUBILIER
world's largest manufacturer of
CAPACITORS

MICA • DYKANOL • PAPER • ELECTROLYTIC CAPACITORS

A FEW OF C-D's MADE-TO-ORDER CAPACITORS



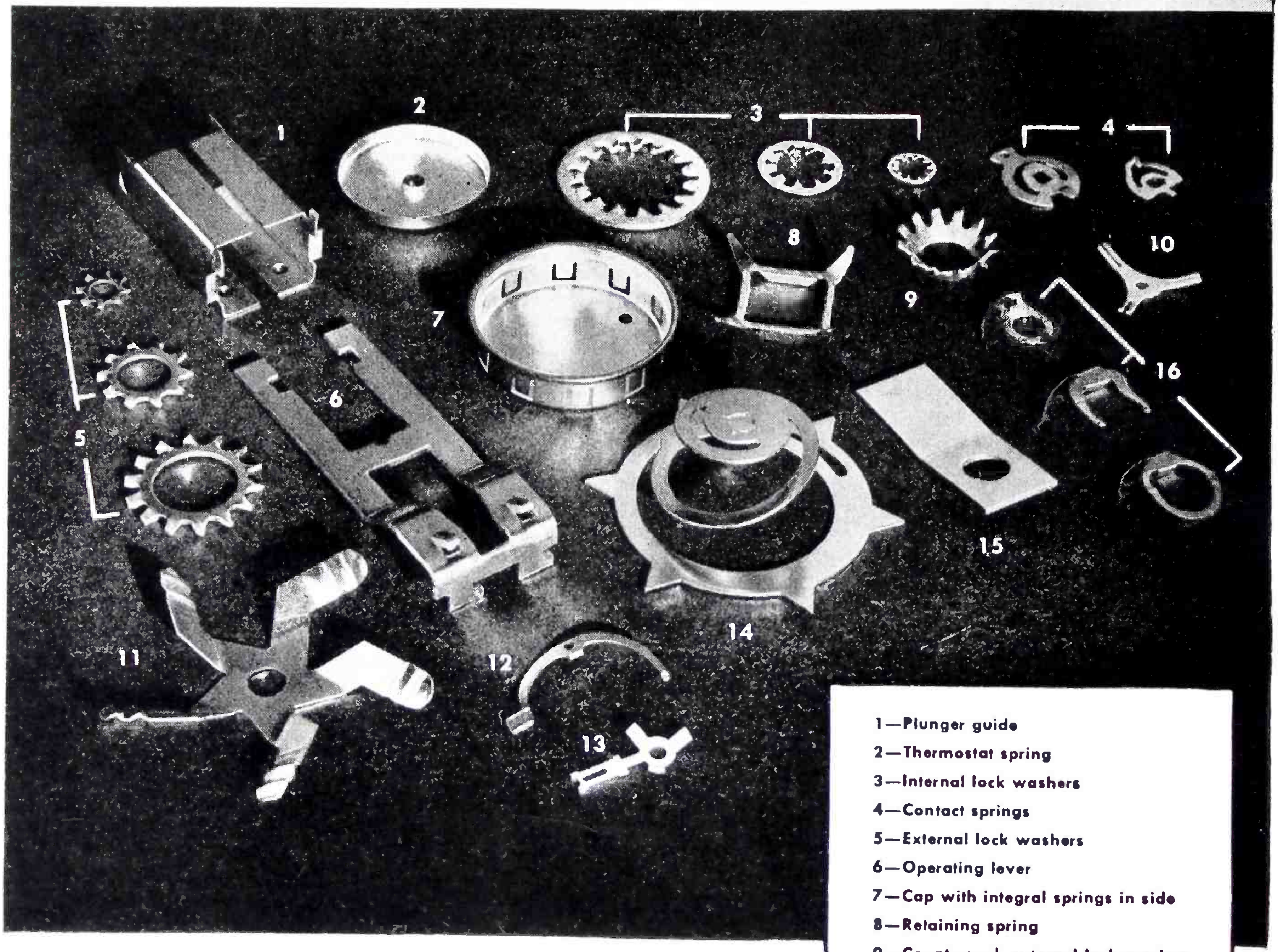
CAPACITOR #1. This capacitor unit was designed for a manufacturer of motors. Mounts directly on motor shaft.

CAPACITOR #2. Designed for spark suppressor applications in home appliance equipment. An inexpensive dependable unit for competitively priced mixers, juicers, grinders, etc.

CAPACITOR #3. Standard paper tubular capacitor adapted for automobile ammeter, oil pump, radio noise filter applications, etc.

REVERE PHOSPHOR BRONZES

OFFER MANY ADVANTAGES



1—Plunger guide
2—Thermostat spring
3—Internal lock washers
4—Contact springs
5—External lock washers
6—Operating lever
7—Cap with integral springs in side
8—Retaining spring
9—Countersunk external lock washer
10—Pressure spring for capacitor
11—Five-contact spring
12—Contact spring for radio part
13—Pressure spring and terminal
14—Involute spring
15—Contact point for solenoid
16—Contact springs
—made of Phosphor Bronze strip supplied by Revere

STRENGTH — Resilience — Fatigue Resistance — Corrosion Resistance—Low Coefficient of Friction—Easy Workability—are outstanding advantages of Revere Phosphor Bronzes, now available in several different alloys.

In many cases it is the ability of Phosphor Bronze to resist repeated reversals of stress that is its most valuable property. Hence its wide employment for springs, diaphragms, bellows and similar parts. In addition, its corrosion resistance in combination with high tensile properties render it invaluable in chemical, sewage disposal, refrigeration, mining, electrical and similar applications. In the form of welding rod, Phosphor Bronze has many advantages in the welding of copper, brass, steel, iron and the repair of worn or broken machine parts. Revere suggests you investigate the advantages of Revere Phosphor Bronzes in your plant or product.

REVERE

COPPER AND BRASS INCORPORATED

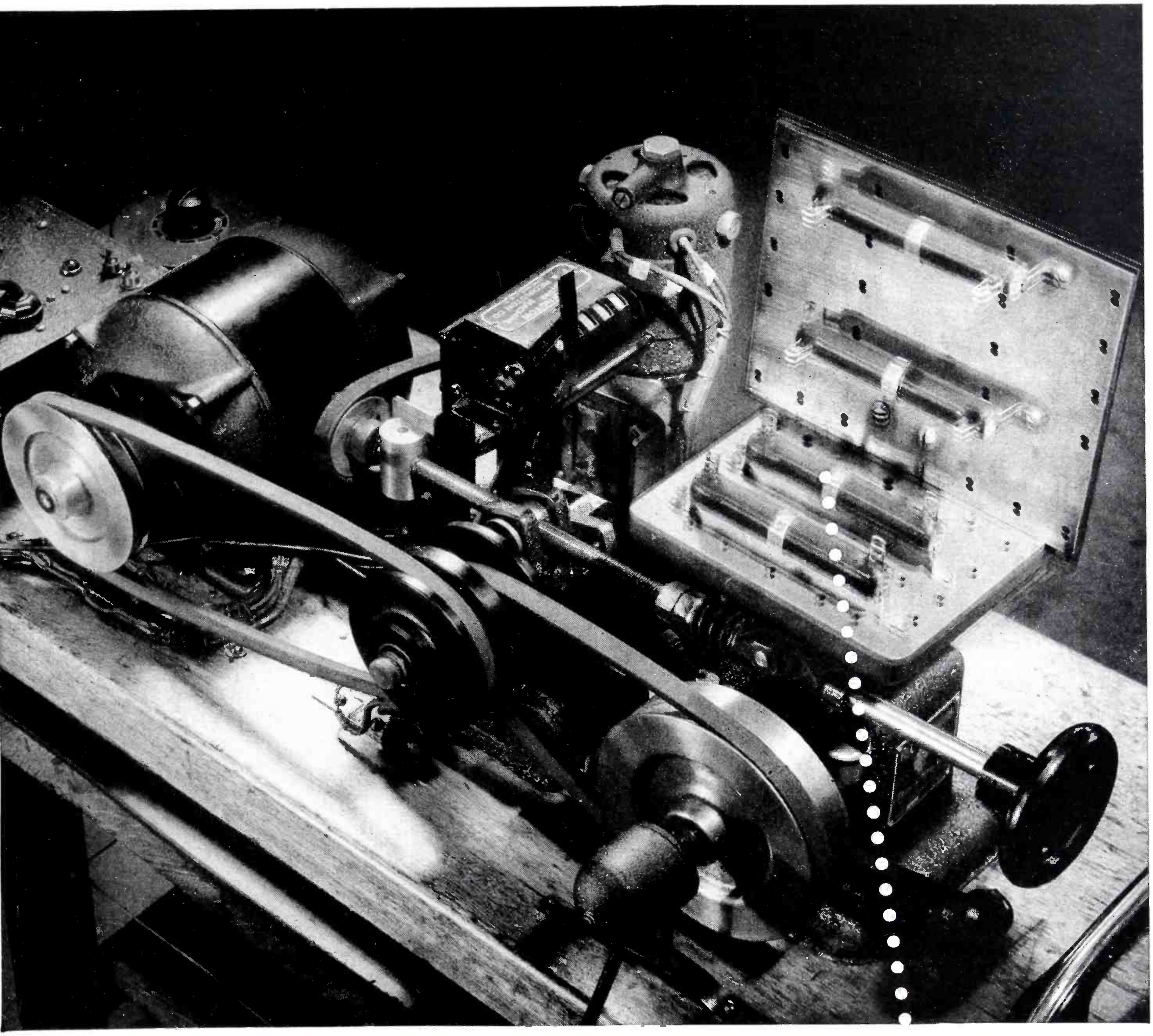
Founded by Paul Revere in 1801

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.

•

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p.m., EST.



A Vicious Vibration Test that Shakes Out the "Bugs"

On this vibrating table . . . throbbing 600 to 3,300 times a minute . . . Ohmite resistors are exposed to vibrations many times more punishing than those encountered on industrial machines, planes, automotive vehicles, railroads, and marine craft. First at the lower rate, then at a rate gradually increased to 3,300 vibrations per minute, these standard production-run Ohmite resistors and their resilient mounting brackets prove their ability to stand up for prolonged periods under terrific abuse. When you specify Ohmite resistors you can be sure of years of unfailing dependability—under practically any service.

Be Right with

OHMITE

RHEOSTATS • RESISTORS • TAP SWITCHES

Sealed in Vitreous Enamel for Life-Time Protection

OHMITE RESISTORS

RESISTS SHOCK, VIBRATION, COLD, HEAT, FUMES OR HUMIDITY

1 **VITREOUS ENAMEL COVERING** Special Ohmite vitreous enamel holds the winding rigidly in place and protects it from mechanical damage.

2 **STRONG CERAMIC CORE** Provides a strong base for the winding, unaffected by cold, heat, fumes, or high humidity.

3 **EVEN, UNIFORM WINDING** The unsurpassed uniformity of the resistance winding prevents "hot spots" and resultant failures.

4 **TINNED COPPER TERMINALS** Terminal lugs are tin-dipped for ease in soldering. The resistance wire is both mechanically locked and brazed to the terminal lugs, assuring a perfect electrical connection.

5 **RESILIENT MOUNTING BRACKETS** Mounting brackets hold the resistor firmly yet resiliently in place. They are simple to mount and can be easily removed by a slight upward pressure at the base.

6 **RATING STAMPED ON METAL BAND** Each resistor has a metal band upon which the resistance is stamped for clear and permanent identification.

OHMITE MANUFACTURING COMPANY — 4818 Flournoy St., Chicago 44, U.S.A.

Send for Catalog and Engineering Manual No. 40

Write now, on your company letterhead, for your copy of this valuable 96-page Ohmite catalog.

OHMITE

RESISTORS • RHEOSTATS TAP SWITCHES

★

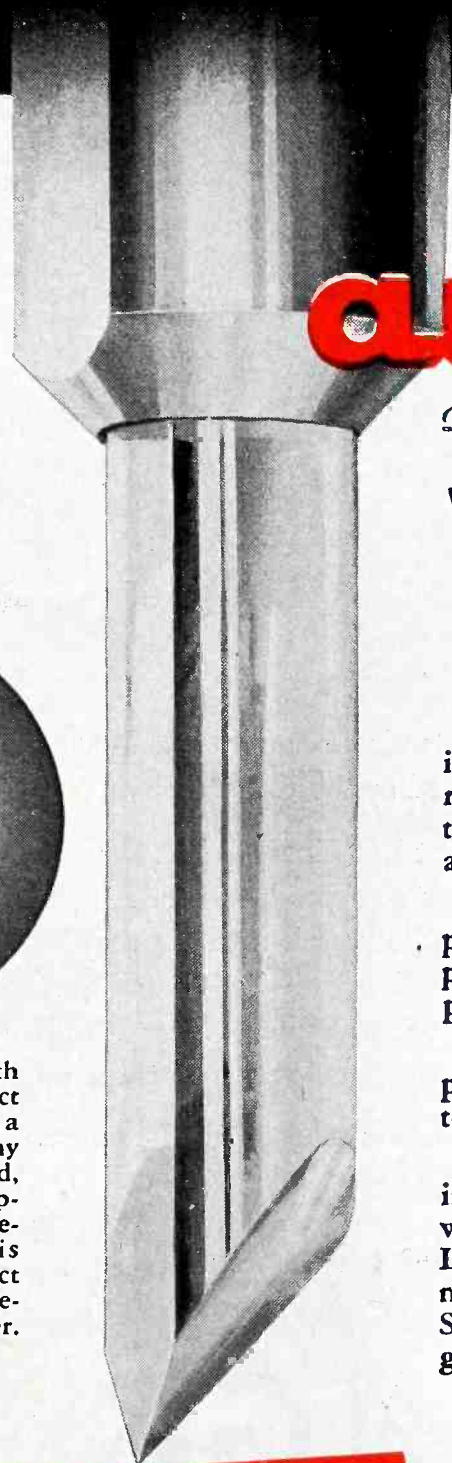
For Truly Fine Sound Recording

Professional Recordists Recommend . . .

Sapphire Recording

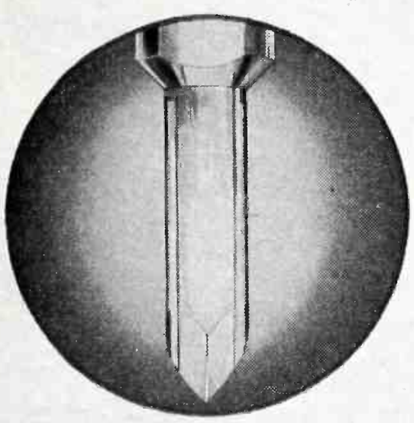
audiopoints

Designed for the professional - Guaranteed to do a professional job



With These Three Outstanding Features

- INDIVIDUALLY DISC-TESTED ON A RECORDING MACHINE.
- EXPERTLY DESIGNED TO INSURE PROPER THREAD THROW.
- A PRODUCT OF THE MANUFACTURER OF AUDIODISCS — AMERICA'S LEADING PROFESSIONAL RECORDING BLANKS.



The jewelled point, with 87° included angle, correct radius and fine polish, cuts a silent shiny groove for many hours. When dulled or chipped, these points may be resharpened several times. Each resharpened Audiopoint is disc-tested to insure perfect performance. For this service return points through your dealer.

Professional recording engineers know, from years of experience, that Sapphire Recording Audiopoints offer the ultimate in recording styli. Made by skilled craftsmen to most exacting specifications and individually tested in our laboratories, these Audiopoints are of consistent fine quality.

A good recording stylus requires a perfectly matched playback point. The Sapphire Audiopoint for playback fills this need completely. In materials, workmanship and design, it is the finest playback point obtainable. (Should not be used on shellac pressings.)

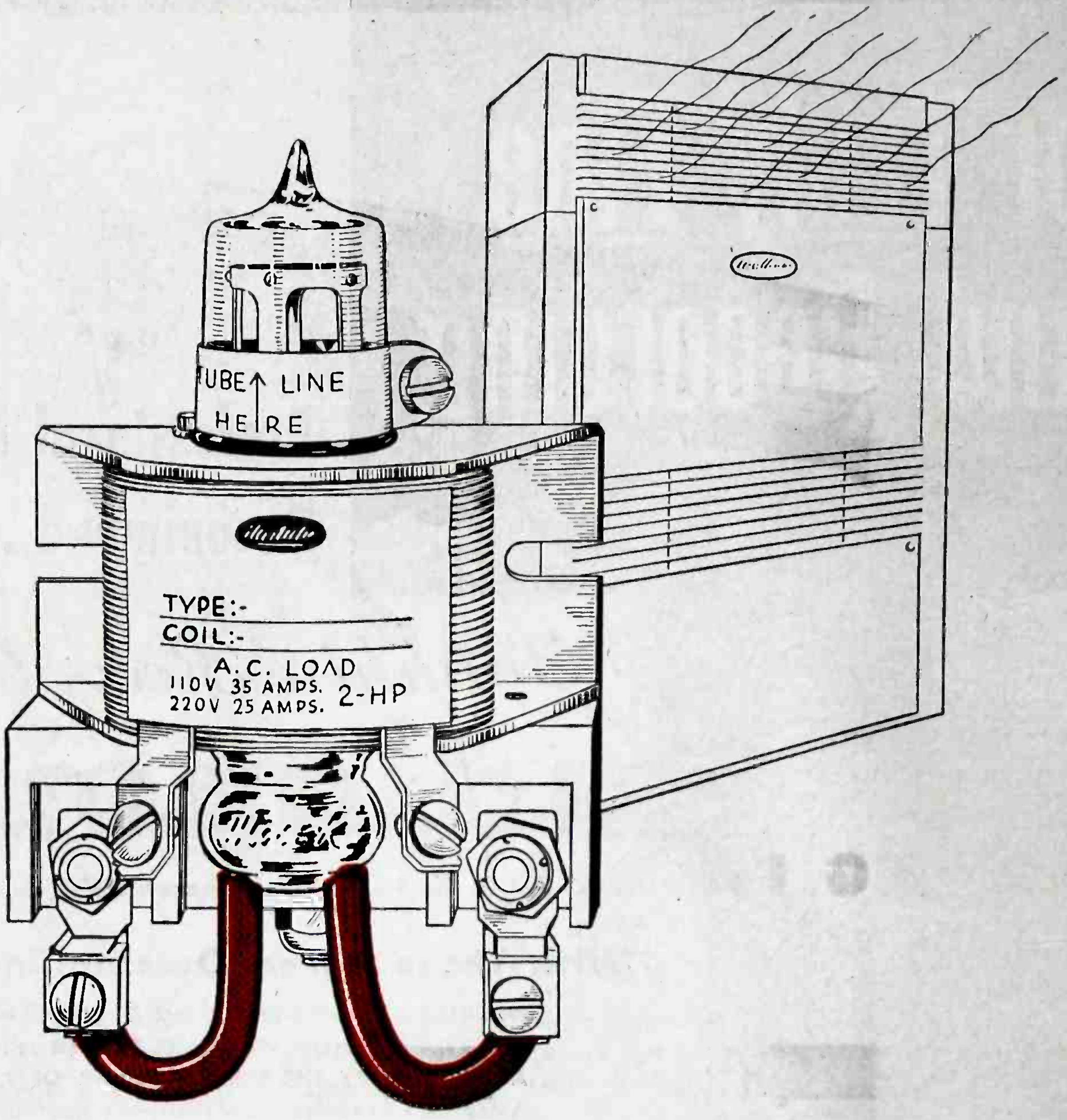
These Audiopoints are protectively packaged in handy cellophane covered cards—cards that are ideally suited for returning points to be resharpened.

OTHER POPULAR AUDIOPOINTS, that complete a full line of recording and playback styli, are: Stellite Recording Audiopoint, a favorite with many professional and non-professional recordists; Diamond-Lapped Steel Audiopoint, a recording stylus particularly adapted for non-professional recordists; Playback Steel Audiopoints (Straight Shank and Bent Shank), the most practical playback points for general use. One hundred per cent shadowgraphed.

For further information, see your Audiodiscs and Audiopoints distributor, or write

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

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



A manufacturer of electrical relays used in air conditioning units set up four requirements for insulation to be used in his product—heat resistance, elimination of fraying or cracking in assembly or use, color for "buy appeal", and ability to exceed Underwriters' specifications. Here is what he reported after using Bentley, Harris Fiberglas Sleeving:

"We use BH Non-Fraying Fiberglas Sleeving in this relay because it meets all of our requirements and stands up under the 50 per cent overload specified by the Underwriters' Laboratories."

Test BH Fiberglas Sleeving in your own plant, in your own product—under actual service conditions. Compare it with ordinary saturated sleeving. Learn why America's leading manufacturers of electrical equipment have standardized on BH Fiberglas Sleeving for post-war production.

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-5, Conshohocken, Pa.

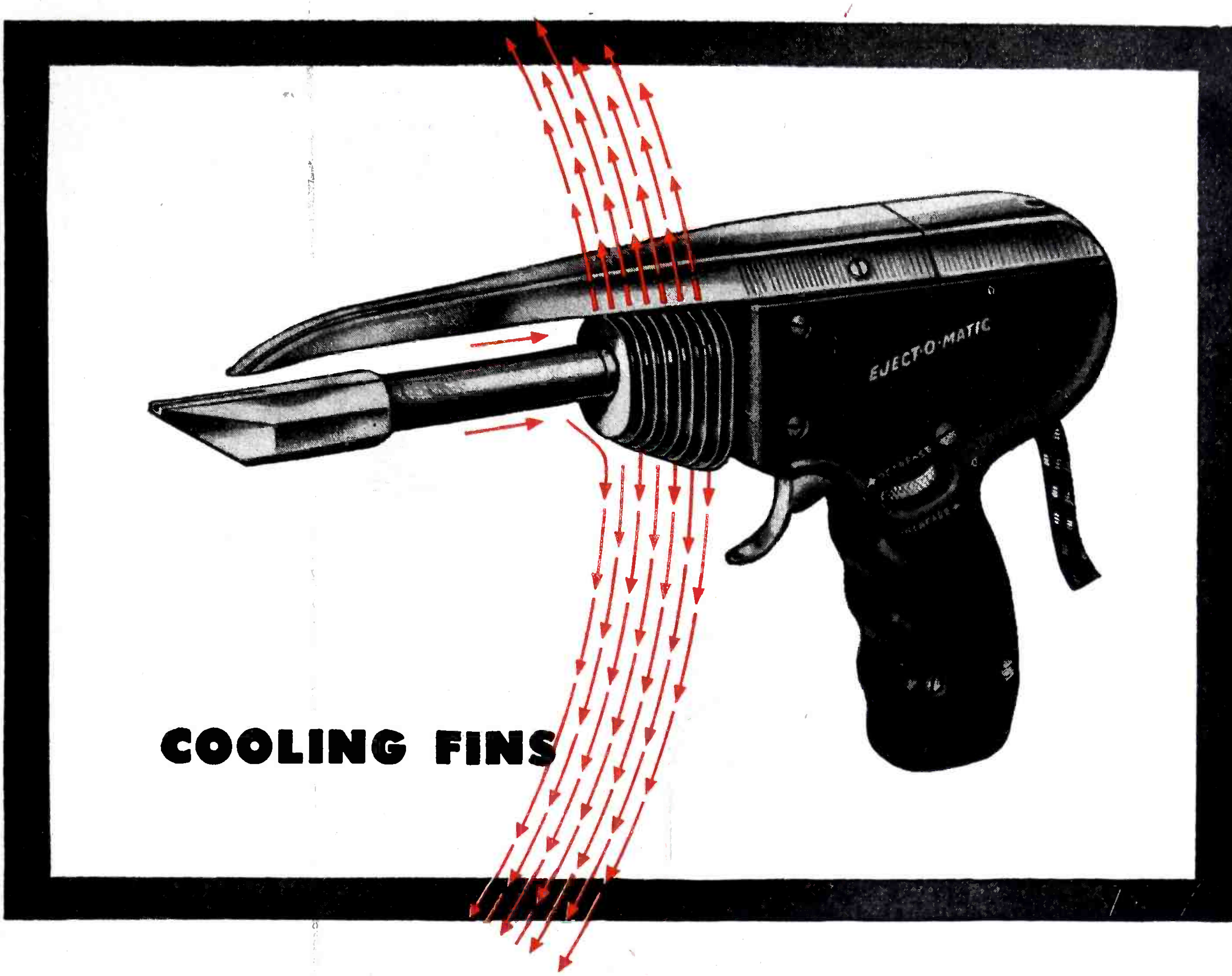
I am interested in BH Non-Fraying Fiberglas Sleeving ______ for ______________
(size) (product)
operating at temperatures of ____°F. at ____ volts. Send samples so I can see for myself how BH Non-Fraying Fiberglas Sleeving stays flexible as string, will not crack or split when bent.

NAME ______________________ COMPANY ______________________

ADDRESS ____

Send samples and prices on other BH Products as follows:

- ☐ Magneto Varnished Tubing Grade "A"
- ☐ Flexible Varnished Tubing Grade "B"
- ☐ Saturated Sleeving Grade C-1
- ☐ Saturated Sleeving Grade C-2
- ☐ Saturated Sleeving Grade C-3



Keep Tip at Proper Working Temperature

The Eject-O-Matic has 10 vertical cooling fins that dissipate unused heat and thus maintain proper working temperature at the tip. When soldering heavy work, the maximum flow of heat is to the tip and into the work. In light soldering, surplus heat develops. This unused heat is conducted back from the tip and out through the cooling fins. The efficiency of this simple cooling system is well established. Long-run tests show that the temperature of the Eject-O-Matic tip can be kept constant. Eject-O-Matic is available in 50, 75, 100 and 150 watt models.

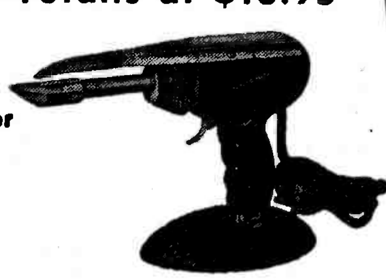
Approved by Underwriters' Laboratories, Inc.

"PLUS" FEATURES
FOR SPEEDIER SOLDERING:

- **Automatic feed**
- **Micrometer Control of amount of solder ejected**
- **Automatic Solder Retracting Feature**
- **Multi-clad, 400-hour Tip, no tinning, no filing**
- **Safety, Utility Base**

Model 19-S *(illustrated)* with base—retails at $18.95

Individually packed. Shipping wt. per carton of 12 units, approx. 42 lbs.
Send for literature



AUTOMATIC-FEED SOLDERING TOOL
EJECT-O-MATIC
HOUSES · MEASURES · EJECTS THE SOLDER

MULTI-PRODUCTS TOOL COMPANY, 123 SUSSEX AVENUE, NEWARK 4, NEW JERSEY

A NEW *Twist* to a BEDTIME STORY

A section of the heating element used in Simmons Electronic Blanket, showing waterproof insulation and rayon core. Light wire is D-H 99 Alloy, dark wire copper.

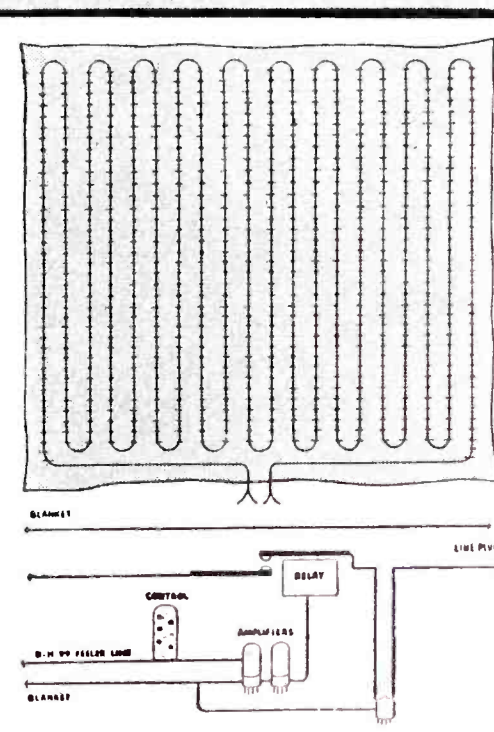
Controlled Sleeping Comfort Made Possible by a *New* Driver-Harris Alloy

SLIP beneath a new Simmons Electronic blanket, turn the control to the temperature desired and relax for a night of comfort.

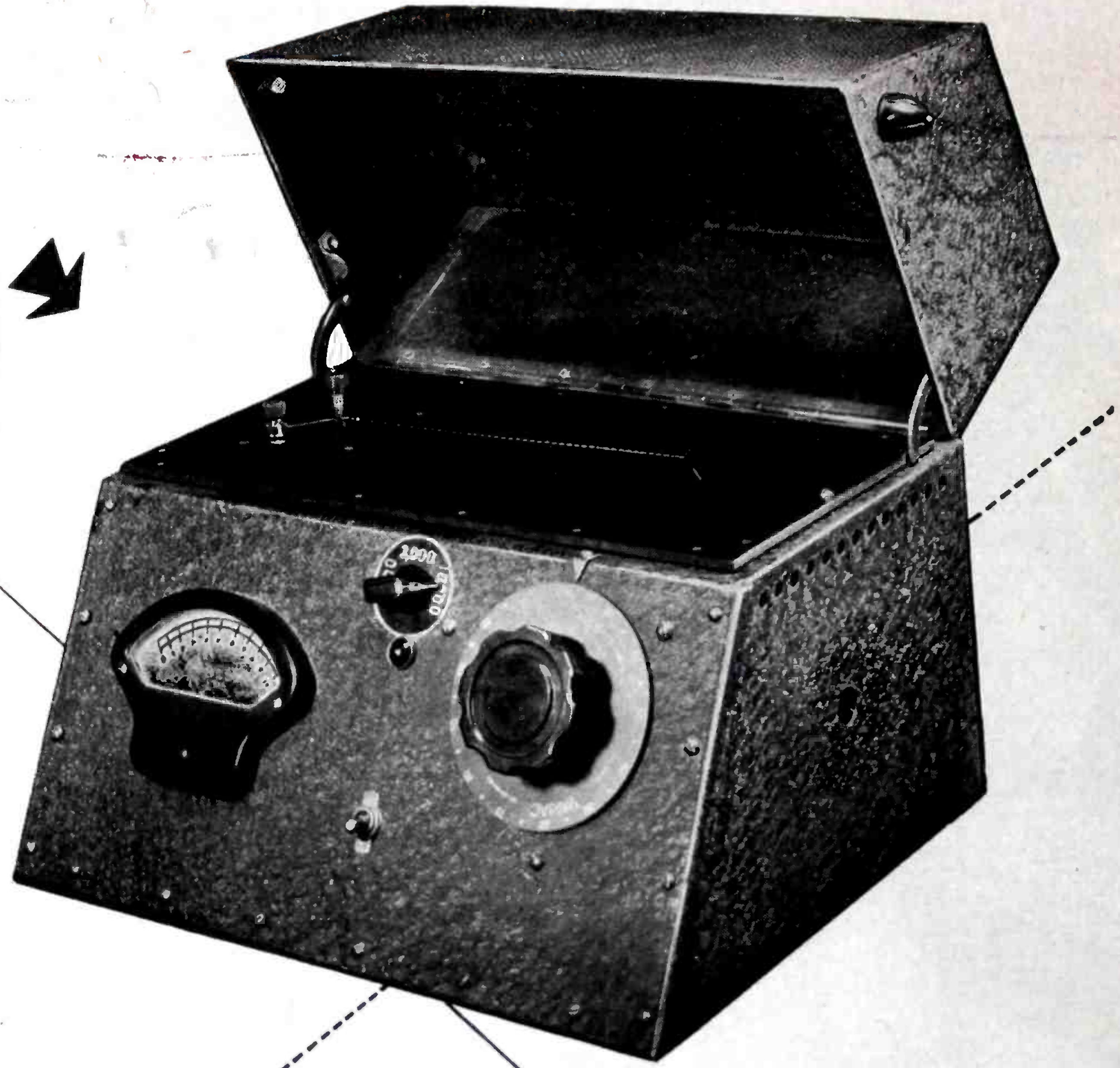
Separately insulated, but wound together on a rayon core and waterproofed, fine copper wire and even finer D-H 99 Alloy Wire form a network throughout the blanket. The copper wire supplies the heat — the D-H 99 Alloy wire controls it by flashing faint signals to an electronic control box whenever blanket temperature varies as little as 1° C.

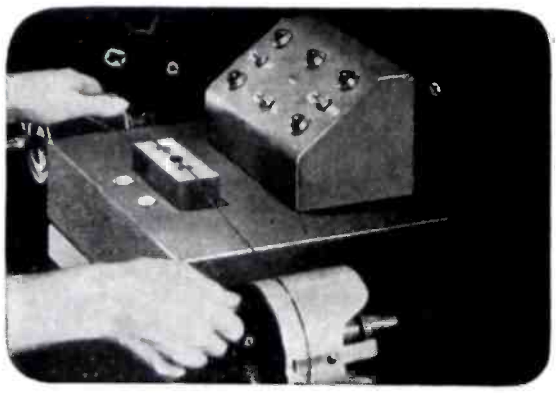
Simmons selected D-H 99 Alloy for this highly demanding application because it, alone, met or exceeded every specified requirement. D-H 99 Alloy had the corrosion resistance to withstand washing or cleaning, the fatigue resistance to withstand repeated folding and the constant sensitivity so vital to operating safety and comfort. Only .0039" in diameter, D-H 99 Alloy has a stable temperature coefficient of .00636 per degree C and is dependably uniform from spool to spool.

If your products or processes involve electrical circuits that require a high T. C. of resistance, you'll find D-H 99 Alloy unequalled for these applications.



Schematic diagram
Simmons Electronic Blanket





NOW THE 4X500A POWER TETRODE

Now, with the new 4X500A, the advantages of the Eimac-designed tetrode are brought to the 500-watt class.

The 4X500A includes the outstanding VHF performance, stability, ruggedness, and freedom from undesirable primary and secondary grid emission that have made the Eimac 4-125A and 4-250A the obvious choice of transmitter engineers for important sockets in both low-frequency and VHF applications.

Here is a transmitter-man's tube intended to make life more simple for the transmitter engineer. The 4X500A is designed for functional application; note the nearly perfect shielding between grid and plate circuits made possible by the low-inductance screen mounting disc which terminates in a contact ring on the envelope. The large low-inductance tubular control-grid lead within the envelope terminates at the center of the base. This design makes it easy to build coaxial tank circuits around the 4X500A. These are only two of its many features. Among others are the rugged 500-watt air-cooled anode, Eimac-processed grids, and silver-plated terminals pointed out below.

It isn't necessary to design your transmitter around promises. Eimac 4X500A tetrodes are available NOW. They'll deliver as much as 1750 watts useful output at 110 Mc. with but 25 watts driving power (two tubes). They'll deliver 3500 watts at the same frequency with 50 watts driving power (four tubes, push-pull-parallel). Complete operating information and ratings are in the technical data sheet for the 4X500A—now available on request.

1 External Anode, 500 watts dissipation, forced air cooled.

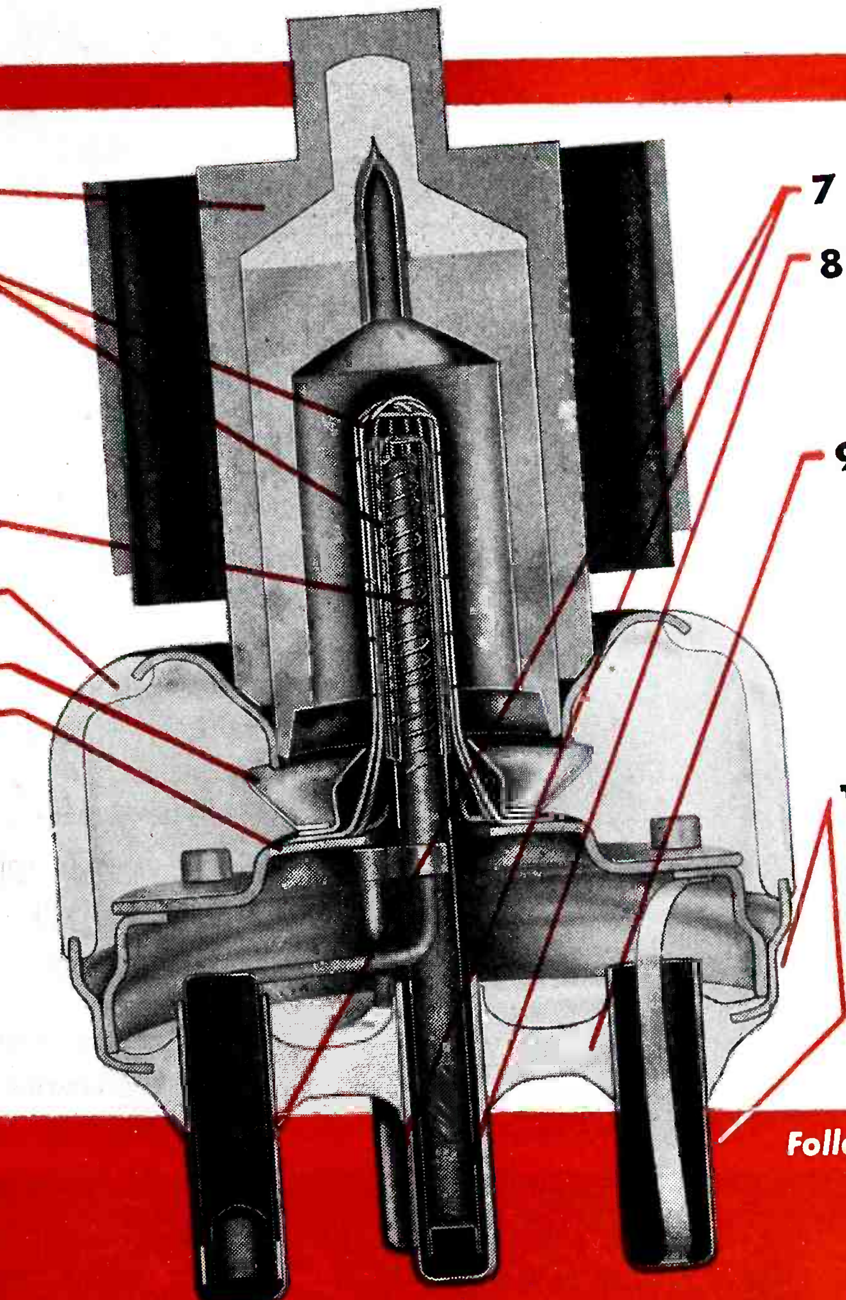
2 Control and screen grids precisely aligned—assures maximum plate efficiency and low control and screen grid currents. (Primary and secondary grid emission is positively controlled by exclusive Eimac grid processing.)

3 Double spiral filament—rugged, stable emission.

4 Hard glass envelope—ample r-f insulation.

5 Electron bombardment shield.

6 Rigid, low-inductance screen grid mount assures improved VHF operation and permanent alignment.



7 Filament terminals—heavy duty, large contact areas.

8 Control grid terminal—low inductance, logically placed for maximum isolation between input and output circuits. Centered for use in coaxial cavities.

9 Molded glass base—maintains precise alignment of all terminals for ease and simplicity of insertion in sockets. Makes possible compact design, and low inductance lead engineering. (All base terminals plus concentric screen grid terminals are silver plated for minimum r-f resistance.)

10 Concentric ring and pin type screen grid terminals for VHF and cavity circuits or pin sockets.

CROSS SECTION EIMAC 4X500A POWER TETRODE

ELECTRICAL CHARACTERISTICS

4X500A POWER TETRODE

Filament: Thoriated Tungsten
- Voltage . . 5.0 volts
- Current . . 13.5 amperes

Direct Interelectrode Capacitances (Average)
- Grid-Plate . 0.05 uufd
- Input . . . . 12.8 uufd
- Output . . . 5.7 uufd

Maximum D-C Plate Voltage . 4000 volts

Maximum D-C Plate Current . 350 ma.

Maximum Plate Dissipation . . 500 watts

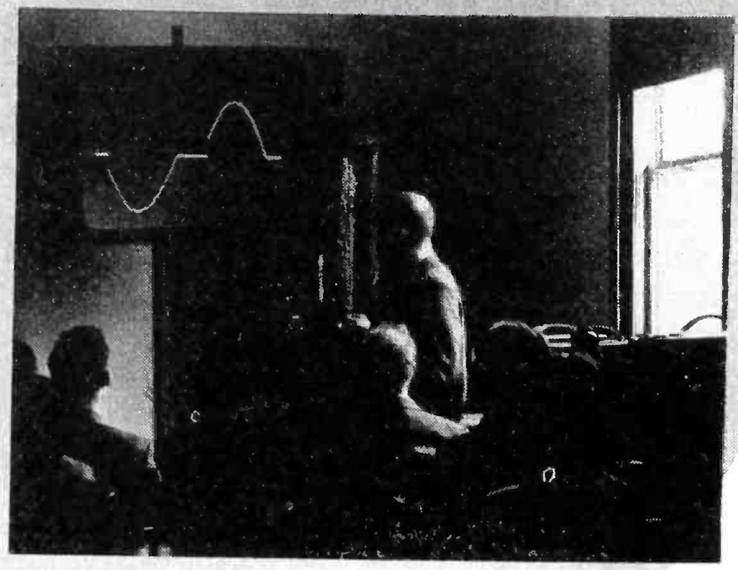
Follow the leaders to

Eimac TUBES REG. U. S. PAT. OFF.

THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

EITEL-McCULLOUGH, INC., 1313E San Mateo Ave., San Bruno, Calif.

Export Agents: Frazar and Hansen, 301 Clay Street, San Francisco 11, California, U. S. A.



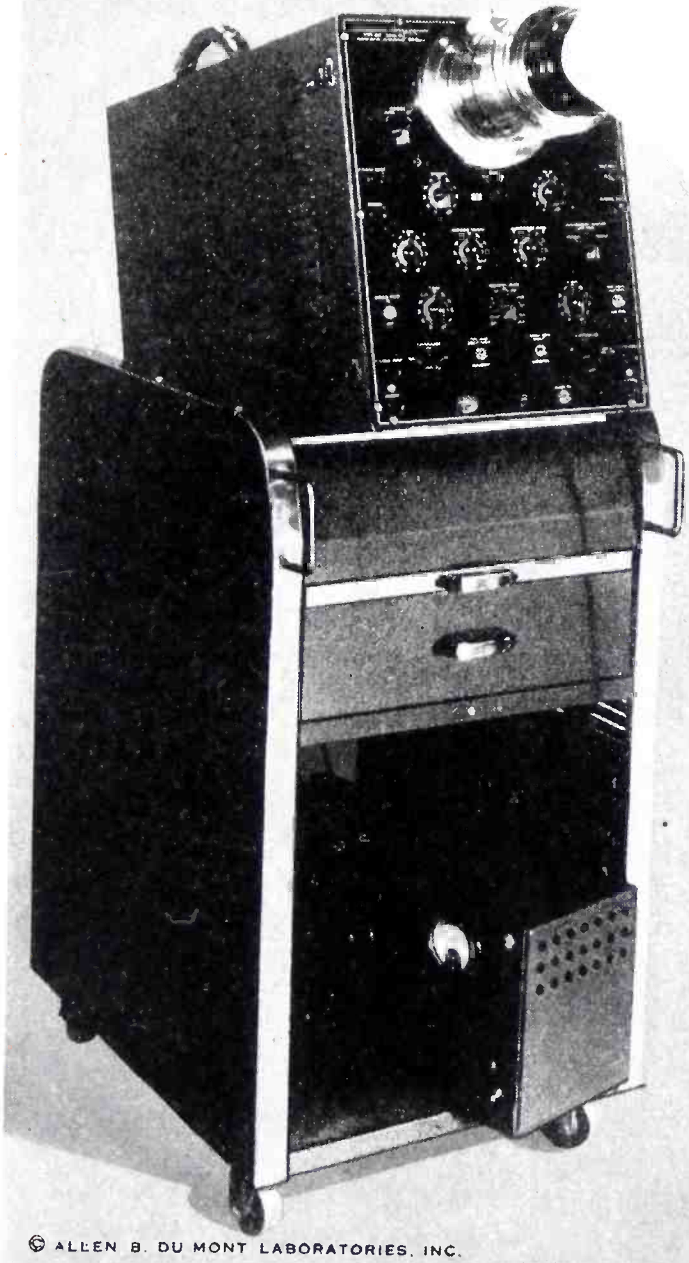
When projection lenses are available, you can project the oscillogram in a *well-lighted* room with *perfect* visibility, as in this unretouched photograph. Note open window.

PHOTOGRAPHS, PROJECTIONS, HIGH-SPEED TRANSIENTS ARE

Clear

if it's a

DU MONT Type 247-A
CATHODE-RAY OSCILLOGRAPH



Modified from the Type 247, this new Du Mont Type 247-A is such a startling success that phenomena hitherto totally invisible can now be *easily* seen. Such modification extends the range of the instrument tremendously in the field of transient studies or high-speed photographic applications.

The modification utilizes the new Type 5RP Cathode-Ray Tube operable at voltages up to 30 KV, producing sufficient brilliance for direct projection, if required.

Other features are: automatic beam blanking; choice of single or continuous sweep; sweep rates available from .5 cps to 50,000 cps; Z-axis amplifier with choice of output polarity; soundly engineered electrical and mechanical design.

Further details on request.

DUMONT *Precision Electronics & Television*

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

G.E. OFFERS
Lectrofilm Capacitors
at New Low Prices!

NEW LOW PRICES OF G-E LECTROFILM CAPACITORS†

					Cap Muf	Rated D-c Voltage
Quantity Case 65	1 to 9	10 to 99	100 to 999	1000 or more	.0001 .001 .01 .1	3000 3000 1000 500
Net Price	6.50	4.90	3.90	3.25		
Quantity Case 70	1 to 9	10 to 99	100 to 999	1000 or more	.0001 .001 .01 .1	5000 5000 2000 750
Net Price	8.45	5.85	4.55	4.25		

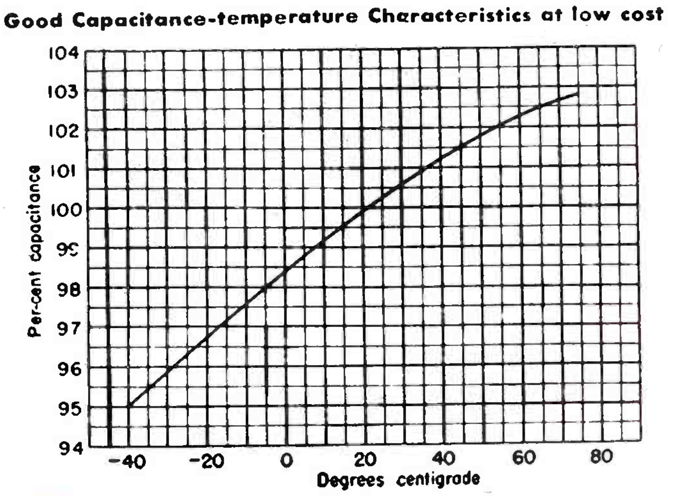
†Prices to manufacturers purchasing Lectrofilm Capacitors for use with their product will be supplied on inquiry.

RATINGS AT HIGH TEMPERATURE

Ratings are based on 25 C ambient temperatures. For other ambient temperatures the following derating factors must be used:

Ambient Temp. C	Per Cent Rated D-c Volt.	Per Cent Rated Superimposed RMS Sine Wave Current
25	100	100
30	99	95
35	98	85
40	97	80
45	96	75
50	95	70
55	94	60
60	93	50
65	92	45
70	91	35
75	90	15

Good Capacitance-temperature Characteristics at low cost



. . . Permits Use of Larger MUF Sizes in R-F Circuit Design without Cost Penalty

Here's a capacitor price reduction that really means something to circuit designers: *G-E offers all listed ratings of case-style 65 Lectrofilm* blocking and by-pass capacitors at one new price, approximately half of the previous level. Similarly, all listed ratings of case 70 designs are offered at one new, low price!*

This means that you no longer have to place cost ahead of good circuit design. It means that you now have complete freedom to use either *high* or *low* capacities in R-F blocking and by-pass applications—without paying a premium for higher capacity!

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

Write for Bulletin GEA-4295A, *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

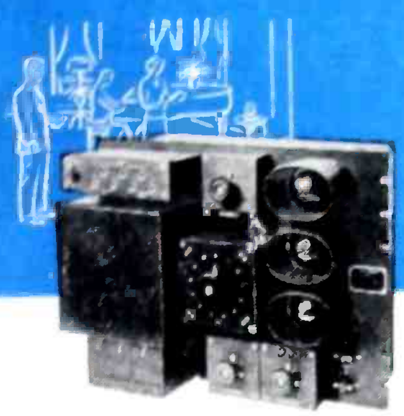
**Reg. U.S. Pat. Off.*

G-E Lectrofilm Capacitors for Radio and Industrial Electronic Equipment

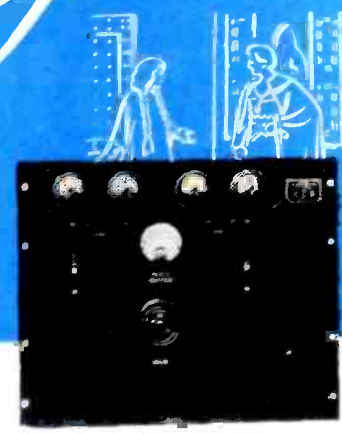
GENERAL ELECTRIC

407-115-6700

for *Quality* in Amplifiers



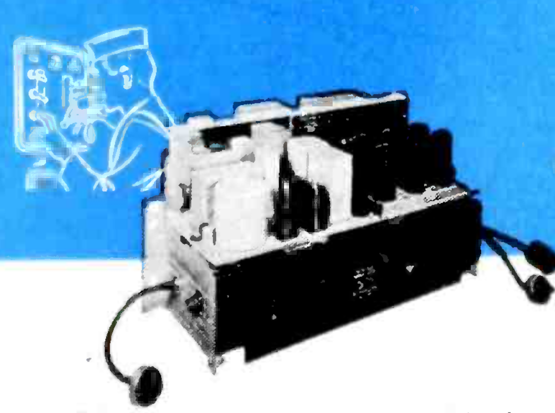
1922. The Western Electric 8A was the first commercial broadcasting amplifier. Today, 24 years later, some of these 8A's are still in use. This long life speaks volumes for the quality built into them.



1928. This ac operated amplifier, one of the first made, reduced maintenance costs and did away with cumbersome batteries and charging equipment. It was used to record some of the earliest sound motion pictures.

1934. Western Electric was an early leader in making compression type amplifiers to enable higher speech intensity between noise level and overload point. This equipment was used in overseas radiotelephony.

1946. The brand new 124H and J amplifiers for wired music and public address systems are small and light weight, yet deliver 20 watts. They are setting new standards of quality for music reproduction.



1942. This compact and powerful unit for battle announce systems is typical of Western Electric amplifiers designed during the war. It operated dependably when mounted a few feet from the largest guns.

1938. Negative feedback is another of Bell Laboratories' many contributions to amplifier design—now in general use. This amplifier for disc recording was able to supply as much as 50 db of feedback.

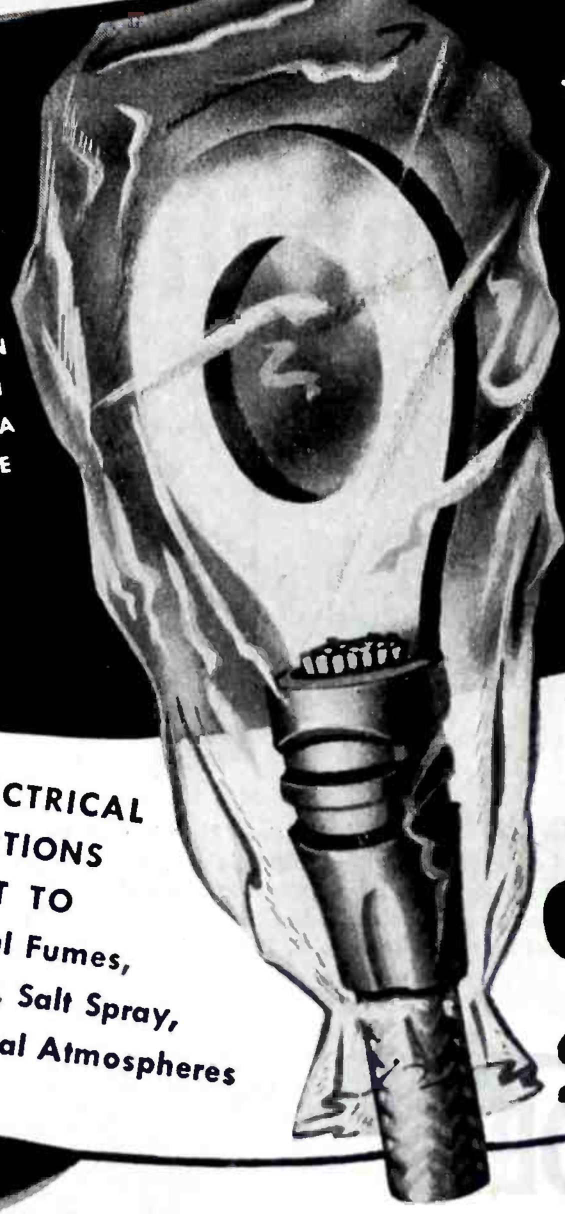
1946. The 1126C is the latest design of Western Electric's popular level governing amplifiers. In operation it acts as a program-operated gain control to prevent overmodulation in AM or FM broadcasting. It immediately reduces gain when an instantaneous peak exceeds a predetermined level, slowly restores it when the peak is passed.

Distributed by **GraybaR**

OFFICES IN 95 PRINCIPAL CITIES

PROTECTION AGAINST CORROSION

EVERY CONNECTION AS THOUGH SEALED IN A PROTECTIVE ENVELOPE



FOR ELECTRICAL CONNECTIONS SUBJECT TO Chemical Fumes, Salt Air, Salt Spray, Industrial Atmospheres

AMP CORROSION PROOFED *Solderless* TERMINALS

TYPICAL APPLICATIONS

Application	Corrosive Agent
Aircraft	Salt water, salt air, oil fumes, battery acid fumes.
Chemical and Process Industries Equipment	Any fumes or atmospheres in which insulated copper wire may be used, including ammonia, chlorine, hydrochloric acid, hydrogen sulphide, sulphur dioxide, sodium hydroxide, sulphuric acid, nitric acid, cyanide, and many others.
Electrical and Electronic Equipment	Salt spray, salt air, battery acid fumes, etc.
Food Processing Equipment	Atmospheric moisture, ammonia, organic and inorganic acids, alcohol, hydrogen sulphide, etc.
Furnace and Heat Treating Equipment	Coal gas, sulphur dioxide, ammonia fumes, hydrogen sulphide, cyanide fumes, etc.
Marine Equipment	Salt air and salt spray, ammonia fumes, battery acid fumes.
Mining Equipment	Salt air, sulphur dioxide, hydrogen sulphide.
Petroleum Refining Equipment	Hydrogen sulphide, sulphuric acid, sulphur dioxide, chlorine, ammonia, hydrochloric acid, butane, etc.
Pickling Equipment	Sulphuric acid fumes, sodium hydroxide, potassium hydroxide, nitric acid, acetic acid.
Pulp and Paper Making Equipment	Sodium hydroxide, nitric acid, sulphuric acid, chlorine, sulphur dioxide, sulphite baths, etc.
Sewage Disposal Equipment	Chlorine, hydrogen sulphide, organic acids.
Soap Manufacturing Equipment	Fatty acids, glycerol, potassium hydroxide, sodium hydroxide, etc.
Textile Equipment	Chlorine, sodium hydroxide, sodium silicate, aniline dyestuffs, etc.

Exclusive AMP "CORROSION PROOFING" TREATMENT DOES 3 THINGS:

1. Prevents *indefinitely* any measurable increase in resistance of the terminal, even under excessively corrosive conditions.

2. Increases the electrical conductivity of the connection.

3. Provides a corrosion-resistant, self-healing, protective film that not only re-forms over any break or abrasion, but covers exposed portion of wire, making a continuous metallic joint without interface that assures corrosion proofing for the entire connection.

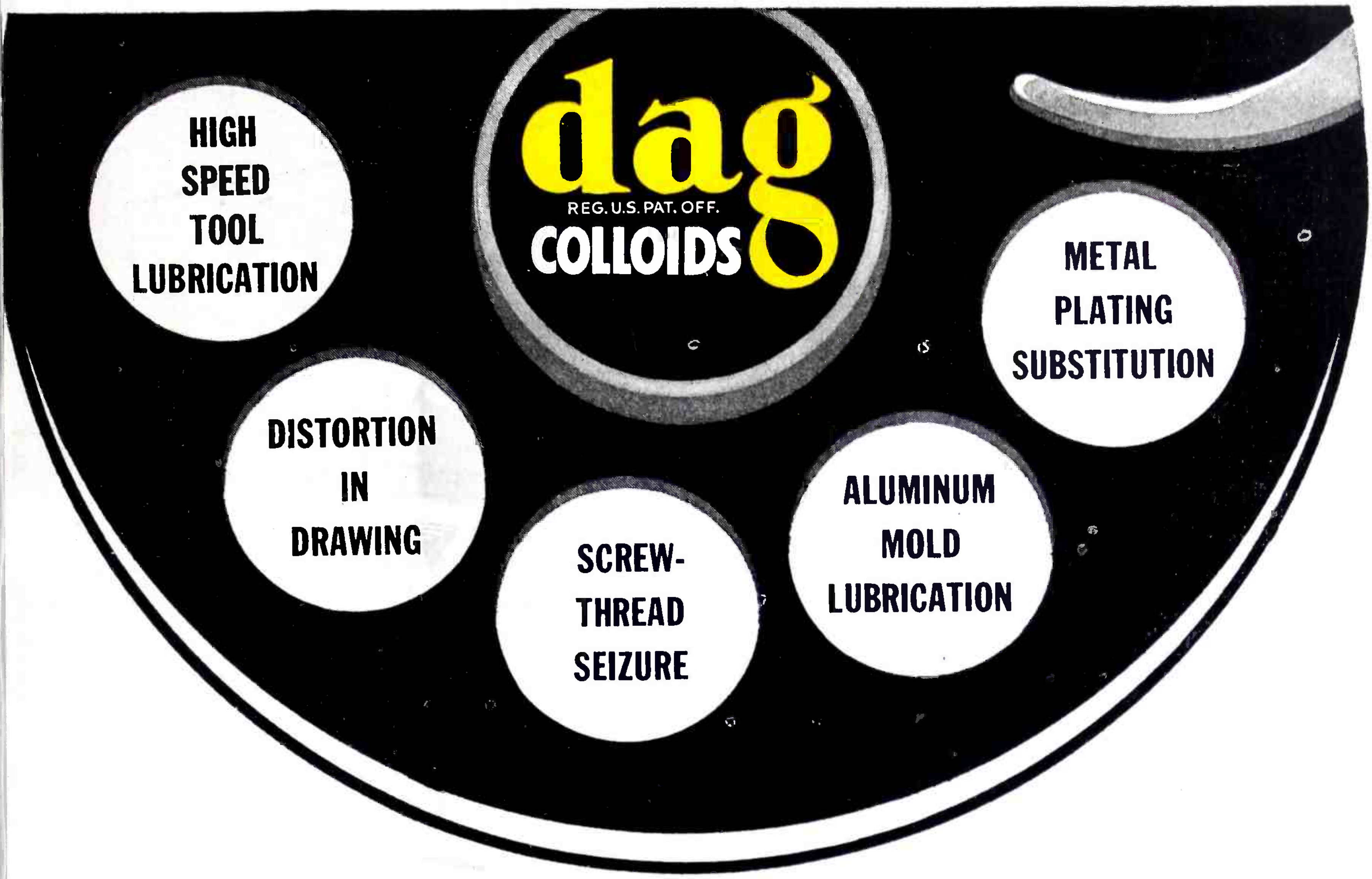
AMP Corrosion *Proofed* Solderless Terminals are a *MUST* wherever even slight changes in electrical resistance are detrimental. These terminals are especially valuable in critical applications demanding consistently low resistance connections, such as sensitive electrical and electronic instruments. Some of the many typical applications where AMP Corrosion Proofed Terminals are proving their merits will be found listed to the left.

Remember, AMP Corrosion Proofing can be applied to ANY of the many types of AMP Solderless Electrical Wiring Terminals.

WRITE or WIRE—TODAY for information, prices, and samples. If you have a particular corrosion problem, AMP engineers will be glad to help you solve it.

AMP

AIRCRAFT-MARINE PRODUCTS Inc.
1521-53 NORTH FOURTH STREET, HARRISBURG, PA.
In Canada: F. MANLEY CO., 82 Adelaide Street E., Toronto, Ont.



Put the "finger" on PROBLEMS like these!

How?—by selecting and applying the *right* **"dag"** dispersion for each job. And it's as simple as it sounds except for one fact: while most engineers and plant men do know what **"dag"** colloidal graphite is, many of them are unaware of *all* the dispersions available or *all* the diverse industrial applications for which they are designed.

Actually there are seventeen **"dag"** suspensions, in carriers as diverse as water, oils, alcohol and volatile hydrocarbons. Each possesses not only the many unique properties of graphite itself (in what amounts to true liquid form) but also the valuable special characteristics of its liquid carrier. As a consequence, uses are much more numerous than is generally known.

And that's just why the booklets listed below have been compiled—to tell the men who need to know exactly *how*, exactly *why* and exactly *where* **"dag"** colloidal graphite dispersions can profitably assist in specific industrial operations.

They're free, of course, and are mailed to you without obligation as part of Acheson Colloids' broad service activities.

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN

This new literature on "dag" colloidal graphite is yours for the asking:

460 A data and reference booklet regarding "dag" colloidal graphite dispersions and their applications. 16 pages profusely illustrated.

421 Facts about "dag" colloidal graphite for ASSEMBLING AND RUNNING-IN ENGINES AND MACHINERY.

422 Facts about "dag" colloidal graphite as a PARTING COMPOUND.

423 Facts about "dag" colloidal graphite as a HIGH TEMPERATURE LUBRICANT.

431 Facts about "dag" colloidal graphite for IMPREGNATION AND SURFACE COATINGS.

432 Facts about "dag" colloidal graphite in the FIELD OF ELECTRONICS.

JMLeoA-MM1

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN DEPT. MM 5

Please send me without obligation, a copy of each of the bulletins checked.

460 ☐ NAME ____
421 ☐ POSITION ____
422 ☐ FIRM ____
ADDRESS ____
423 ☐ CITY ____ ZONE ____ STATE ____
431 ☐ OUR PRESENT OIL SUPPLIER IS ____
432 ☐ (Lubricants containing "dag" colloidal graphite are available from major oil companies.)

HERE'S HELP in making FM and TELEVISION measurements

THE TYPE WV-75A VOLTOHMYST— a *new* member of the famous RCA line

Flat up to 250 megacycles!

A newly developed diode probe, with which it is possible to read peak-to-peak voltages up to 250 megacycles, makes the Advanced VoltOhmyst ideal for television, FM, and routine, high-frequency measurements. The diode response is also flat down to 30 cycles.

The WV-75A is calibrated in rms voltages up to 100 volts in 4 ranges. An adaptor is supplied for low-frequency measurements up to 1000 volts.

The WV-75A also measures d-c voltages up to 1000 volts in six ranges and resistances to 1000 megohms in six ranges.

A Quick Way to Get Details

Radio Corporation of America
Test and Measuring Equipment Section
Dept. 30-L, Camden, New Jersey

Please send me the bulletin on the

—*RCA Type WV-75A VoltOhmyst for high-frequency measurements.*

—*RCA Type 195A for low-frequency testing.*

Name____________________

Company____________________

Street Address____________________

City__________ Zone_____ State_____

TEST AND MEASURING EQUIPMENT

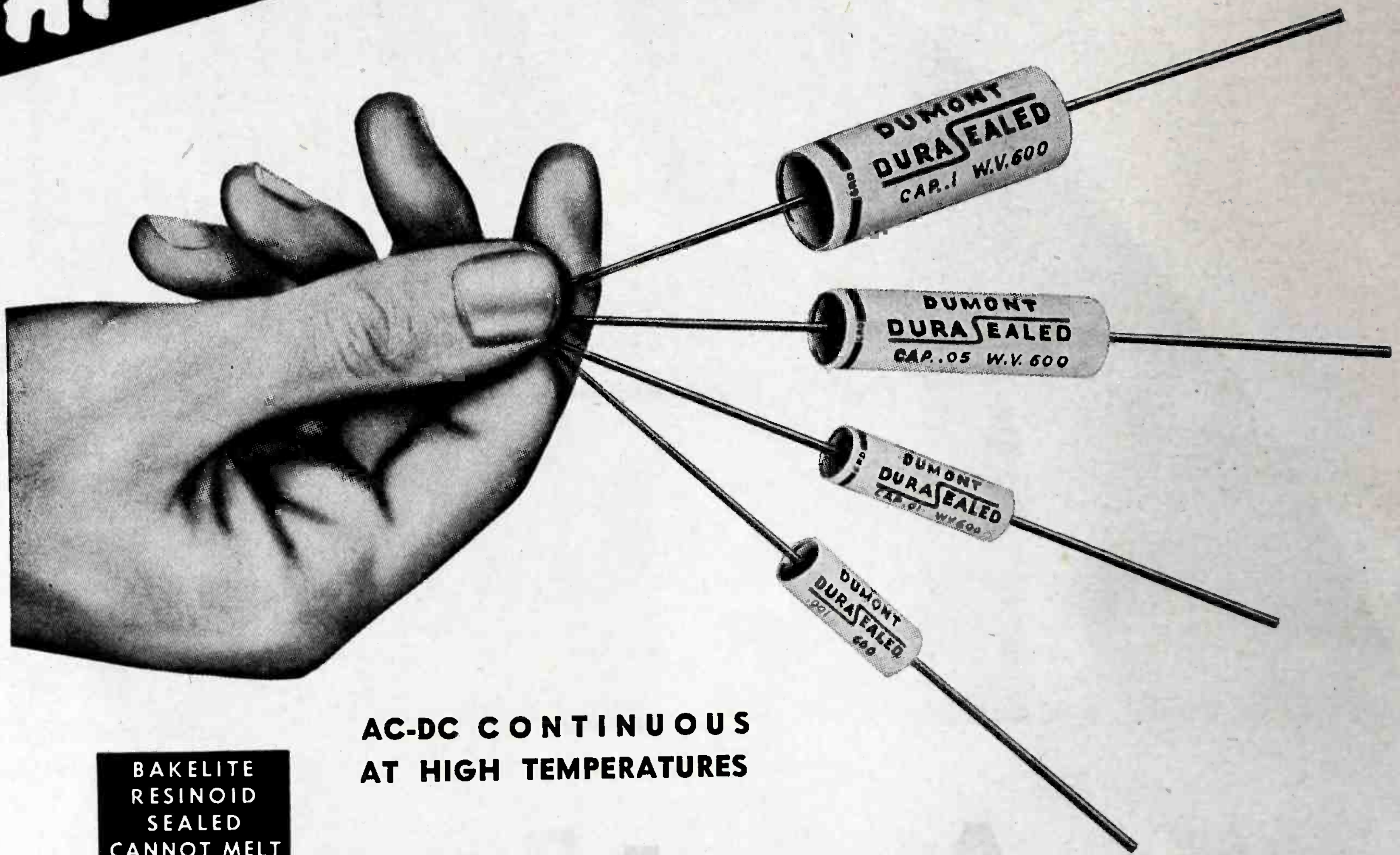
RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.


PRESTO RECORDING CORP. N.Y.
MADE IN U.S.A.
1409

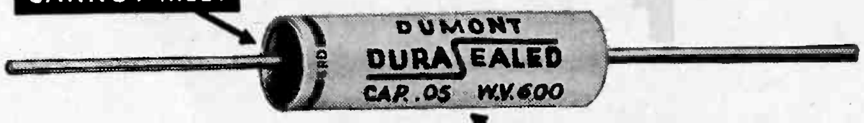
AT LAST!

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



AC-DC CONTINUOUS AT HIGH TEMPERATURES

BAKELITE RESINOID SEALED CANNOT MELT



BAKELIZED TUBES

PAT. PEND.

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

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

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

34 HUBERT STREET
NEW YORK, N. Y.

Relays Are Our Business!

Every effort of the Clare organization is directed toward the production of carefully designed relays, well manufactured from high quality materials, precisely adjusted for perfect operation.

Clare "custom-building" gives the flexibility of design and construction that meets your most exacting new requirements . . . allows you to design freely and rely on the skill of Clare engineers to give you the unusual, new and improved features to fit your purpose.

Where inches and ounces count, Clare gives you compact construction to fit modern streamlined design. Is your need for more efficient operation, greater ability to withstand vibration, new and different electrical characteristics? Clare engineers are ready to "custom-build" just the relay for the job.

Clare "custom-building" is a method of construction. It permits choice of a wide range of contact ratings . . . five different contact forms or any combination of them . . . either flat or hemispherical contacts which may be of rare metals or special alloys.

Clare Relays are built for applications where precise performance, long life, and dependability are prime requisites. Thousands of users attest to the value of Clare Relays and the Clare "Custom-Built" principle.

Clare sales engineers are located in principal cities to help you with your relay problems, show you how Clare "Custom-Built" Multiple Contact Relays are the effective answer to modern design problems. Send for the Clare Engineering Data Book today. Address C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable address: CLARELAY. In Canada: Canadian Line Material, Ltd., Toronto 13.

CLARE RELAYS

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

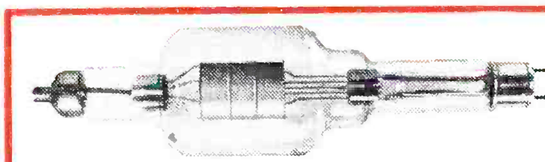

Measured in COLD CASH...HERE'S HOW
AMERICAN PHILLIPS SCREWS
Pay Off to Refrigerator-Makers...
and to Refrigerator-Users, too
TO MANUFACTURERS: American Phillips Screws pay off in many ways, whether you build refrigerators or miniature trains. They speed up handling, increase worker-proficiency by building confidence, cut down losses from dropped screws, "drunken driving," scarred work-surfaces, spoiled material, and lost time from self-inflicted wounds. All because American Phillips Screws make power driving safe, easy, non-fatiguing . . . *and automatically straight.* Now total up the pay-off . . . and you'll find TOTAL TIME-SAVINGS RUN AS HIGH AS 50%.
TO CUSTOMERS: American Phillips Screws add the merchandising lure of handsome, modern, workman-like appearance, inside and out . . . a look of quality that helps to make the prospect say: "That's for me!" This modern, cost-cutting method of fastening is actually *sales-promotion plus sales-protection.* Are *you* in on this payoff? Write American for recommendation of the type and metal of American Phillips Screws which will do the best job at lowest cost.
4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS
AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND
Chicago 11: 589 E. Illinois St. *Detroit 2:* 502 Stephenson Building
AMERICAN PHILLIPS Screws
ALL TYPES
ALL METALS: Steel, Brass, Commercial Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

BACK OF THIS LINE OF RECTIFIER TUBES . . .
50 YEARS OF HIGH-VOLTAGE EXPERIENCE

LOW internal drop, long filament life, and rugged mechanical construction characterize the Machlett line of high-voltage rectifier tubes. Machlett has devoted half a century to the design and manufacture of high-voltage electron tubes, and this long experience is reflected in today's Machlett rectifiers. Thus they incorporate such other assurances of long useful life as complete outgassing, ability to withstand high electrostatic stresses, and high plate dissipation to minimize the danger of back or secondary emission. In all Machlett tubes the glass envelopes are specially processed and minutely inspected to eliminate conditions that might lead to punctures.

For whatever purpose required—electrostatic precipitation, paint spraying, detearing, high-voltage testing of dielectrics and cables, or for research work requiring a reliable source of high-voltage D-C, there is a Machlett High-Voltage Rectifier designed and built to assure long, reliable performance.

Machlett Rectifiers are available up to 200 kv inverse, and in addition to a complete line of air-cooled tubes, there are types for oil-immersion designed for use in modern shockproof housings. The Machlett catalog, containing detailed descriptions and technical data, will be sent on request. Machlett Laboratories, Inc., Springdale, Connecticut.



ML-5575/100

Filament Voltage	20.0 volts
Filament Current	24.0 amperes
Maximum Peak Inverse Voltage	150 kv
Peak Anode Current	1.0 ampere
Internal Drop $I_b = 1.0$ Amp. $E_f = 20.0$ Volts	550 volts

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES
ITS 50 YEARS OF ELECTRON TUBE EXPERIENCE

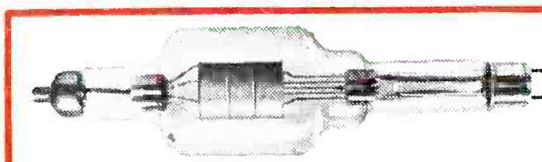

Measured in COLD CASH...HERE'S HOW
AMERICAN PHILLIPS SCREWS
Pay Off to Refrigerator-Makers...
and to Refrigerator-Users, too
TO MANUFACTURERS: American Phillips Screws pay off in many ways, whether you build refrigerators or miniature trains. They speed up handling, increase worker-proficiency by building confidence, cut down losses from dropped screws, "drunken driving," scarred work-surfaces, spoiled material, and lost time from self-inflicted wounds. All because American Phillips Screws make power driving safe, easy, non-fatiguing . . . and automatically straight. Now total up the pay-off . . . and you'll find TOTAL TIME-SAVINGS RUN AS HIGH AS 50%.
TO CUSTOMERS: American Phillips Screws add the merchandising lure of handsome, modern, workman-like appearance, inside and out . . . a look of quality that helps to make the prospect say: "That's for me!" This modern, cost-cutting method of fastening is actually sales-promotion plus sales-protection. Are you in on this payoff? Write American for recommendation of the type and metal of American Phillips Screws which will do the best job at lowest cost.
4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS
AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND
Chicago 11: 589 E. Illinois St. Detroit 2: 502 Stephenson Building
AMERICAN PHILLIPS Screws
ALL TYPES
ALL METALS: Steel, Brass, Commercial Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

BACK OF THIS LINE OF RECTIFIER TUBES . . .
50 YEARS OF HIGH-VOLTAGE EXPERIENCE

LOW internal drop, long filament life, and rugged mechanical construction characterize the Machlett line of high-voltage rectifier tubes. Machlett has devoted half a century to the design and manufacture of high-voltage electron tubes, and this long experience is reflected in today's Machlett rectifiers. Thus they incorporate such other assurances of long useful life as complete out-gassing, ability to withstand high electrostatic stresses, and high plate dissipation to minimize the danger of back or secondary emission. In all Machlett tubes the glass envelopes are specially processed and minutely inspected to eliminate conditions that might lead to punctures.

For whatever purpose required—electrostatic precipitation, paint spraying, detearing, high-voltage testing of dielectrics and cables, or for research work requiring a reliable source of high-voltage D-C, there is a Machlett High-Voltage Rectifier designed and built to assure long, reliable performance.

Machlett Rectifiers are available up to 200 kv inverse, and in addition to a complete line of air-cooled tubes, there are types for oil-immersion designed for use in modern shockproof housings. The Machlett catalog, containing detailed descriptions and technical data, will be sent on request. Machlett Laboratories, Inc., Springdale, Connecticut.



ML-5575/100

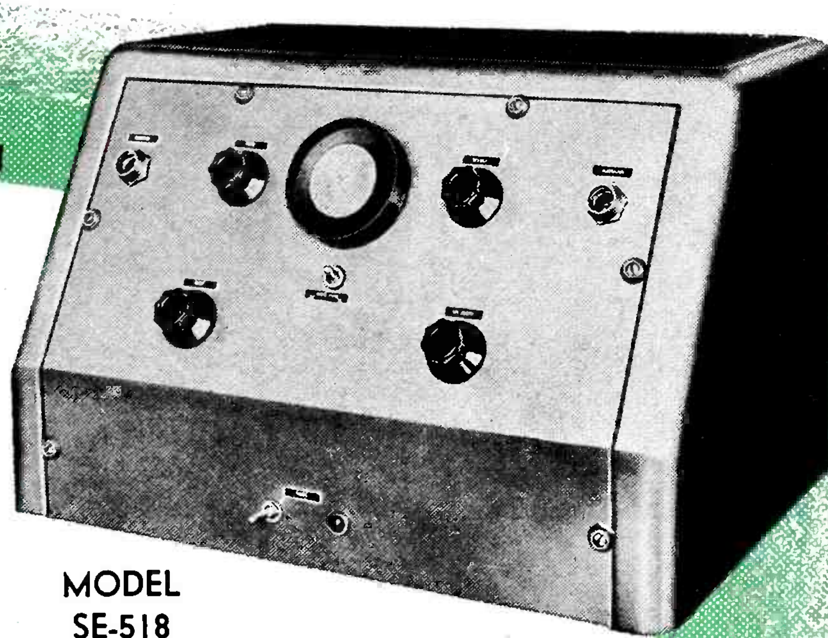
Filament Voltage	20.0 volts
Filament Current	24.0 amperes
Maximum Peak Inverse Voltage	150 kv
Peak Anode Current	1.0 ampere
Internal Drop $I_b = 1.0$ Amp. $E_f = 20.0$ Volts	550 volts

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES
ITS 50 YEARS OF ELECTRON TUBE EXPERIENCE

NEW!

The SHERRON RF NULL DETECTOR



MODEL
SE-518

Visual Indication PERMITS EFFECTIVE OPERATION IN NOISY AREAS

SPECIFICATIONS:

FREQUENCY .... **1 MC**

GENERATOR OUTPUT ..... **0-5 Volts**

DETECTOR GAIN .... **500,000 plus**

HARMONIC SUPPRESSIONS — **2nd down more than 100 db**

POWER CONSUMPTION — **115 Volts-60 Cycle 120 Watts**

The new Sherron R. F. Null Detector is designed to be used with R. F. Bridges and other impedance measuring devices, such as the twin "T" network. Both generator and detector are included, and are housed in the same cabinet. The unit may be used as a signal generator to provide power at 1 MC or as a sensitive detector at the same frequency.

The Detector is equipped with a Cathode Ray indicator so that its response to changes of signal level is instantaneous. The use of visual indication permits this unit to be operated in noisy locations where aural indications may be useless.

The Detector has a logarithmic response so that the gain is high for a weak signal, and large signals can be handled without overloading. Thus, an input of 25 microvolts gives noticeable deflection—while a signal of more than 1 volt will not overload the Amplifier.

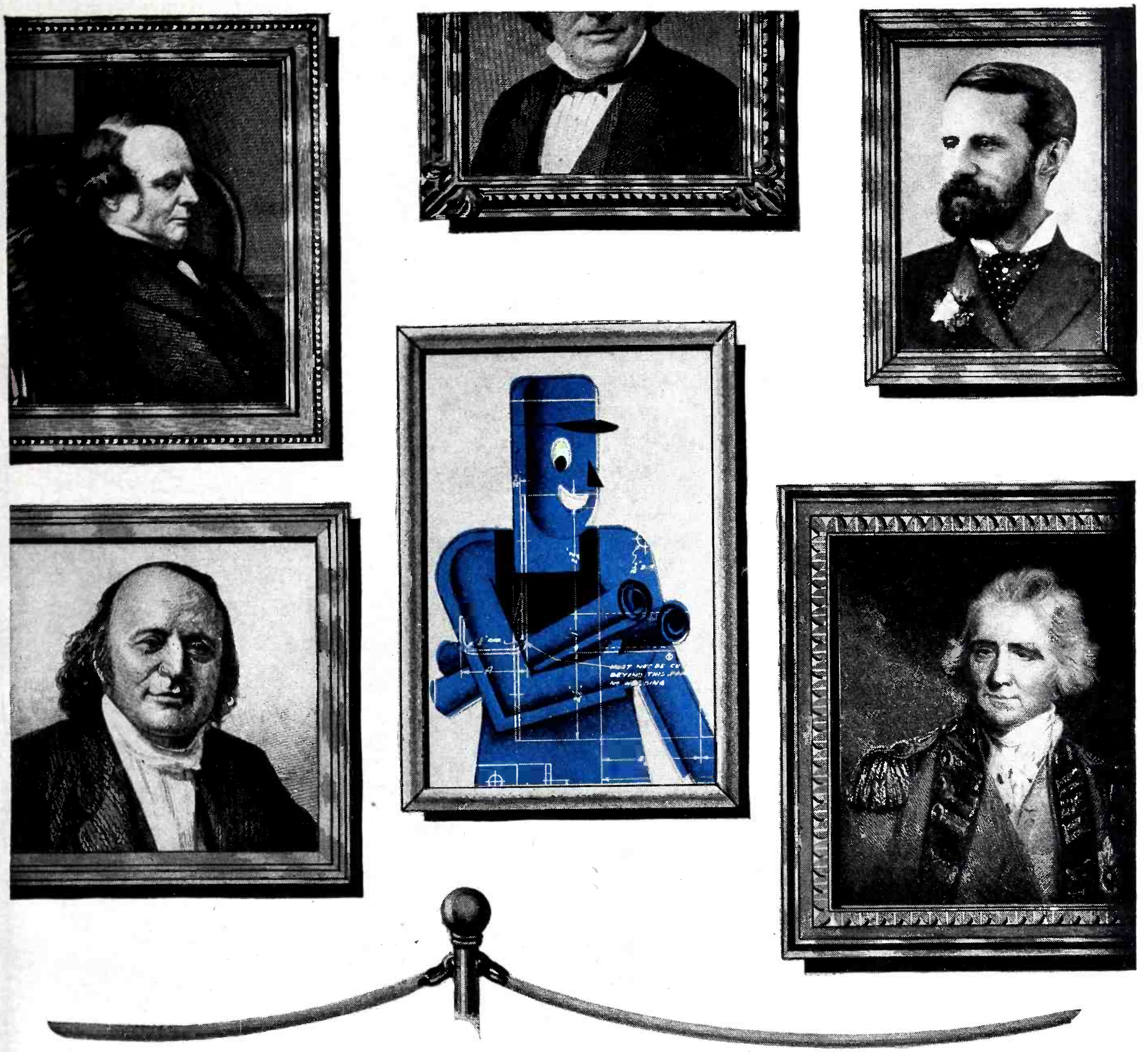
Sherron Electronics W2XDK

SHERRON ELECTRONICS COMPANY

DIVISION OF SHERRON METALLIC CORPORATION

1201 FLUSHING AVENUE BROOKLYN 6, NEW YORK

West Coast Sales Office: Mechanics Institute Building, 57 Post St., San Francisco, Calif.



GOOD COMPANY

WE'RE not pretending we belong in any Gallery of the Great. It's just our way of calling attention to the fact that a manufacturing organization, as well as a famous personage, can have character and individuality.

Through the years the Karp organization has become known as a good company to do business with—a company with a likeable personality—a company that understands and practices cooperative service.

Because our experience and craftsmanship in sheet metal fabrication mean good business for our customers, our services are preferred by many of the "great names" in American industry. We're extremely proud of the outstanding firms we serve.

They like our work. They like the sound value our work represents. They find their relations with us helpful and pleasing.

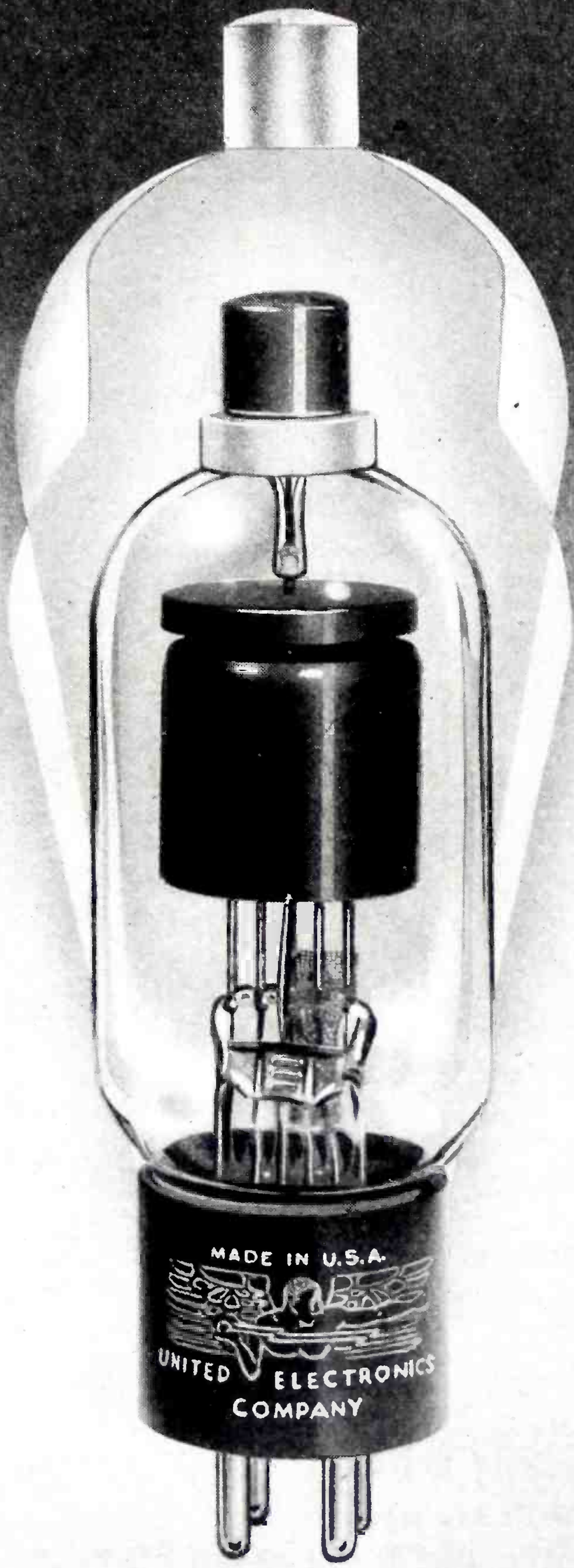
If you are not already on our list of customers, let's get acquainted. Consult us for superior craftsmanship in cabinets, housings, chassis, racks, boxes, enclosures or any type of sheet metal fabrication.

WRITE FOR OUR NEW CATALOG.

KARP METAL PRODUCTS CO., INC.

Custom Craftsmen in Sheet Metal

124 — 30th STREET, BROOKLYN 32, N. Y.



50% smaller
SAME POWER

New UNITED Z-225

Mercury Rectifier

- *Saves Power Supply Space*
- *Solves Temperature Problems*

A compact version of the type 866-A with identical characteristics and ratings, UNITED Z-225 is the exclusive solution for power supply problems wherever space and weight factors are of importance. Overall clearance dimensions considered, it occupies less than ½ the cubic space required for types 866-866A and permits good engineering practice rather than space limitations to govern circuit selection.

In contrast with tubes into which mercury is "dumped," the UNITED Z-225 is entirely free of excess mercury. Casual examination will reveal little or no mercury. Wherever 866-866A tubes are crowded and operating under poor temperature conditions the use of the Z-225 is indicated. In such cases it permits greater space for free circulation of air and consequently cooler operation.

Type Z-225 is another outstanding development of UNITED ELECTRONICS COMPANY—notable producers of mercury rectifiers and graphite anode tubes with the famous "Isolated Getter Trap."

$1.95 ea.

866-866A silhouettes and new Z-225 shown actual size.

Filament Rating	2.5 Volts—5 amps.
Voltage Drop	10-15 Volts
Condensed Mercury Temperature —Range 25 to 60 C.	
Supply Frequency up to 150 cycles	
Max. Peak Inverse Voltage	10,000
Max. Peak Plate Current	1.0 amp.
Average Plate Current	.25 amp.

UNITED ELECTRONICS CO.

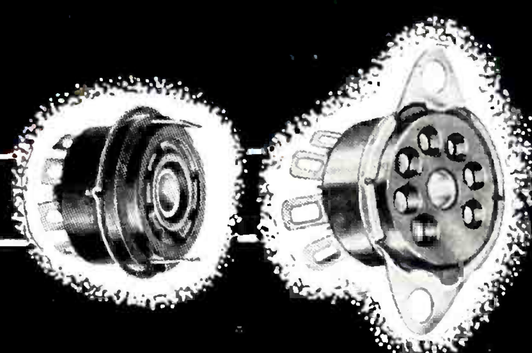
NEWARK, 2 NEW JERSEY

Transmitting Tubes EXCLUSIVELY Since 1934

Franklin QUALITY *Sockets*

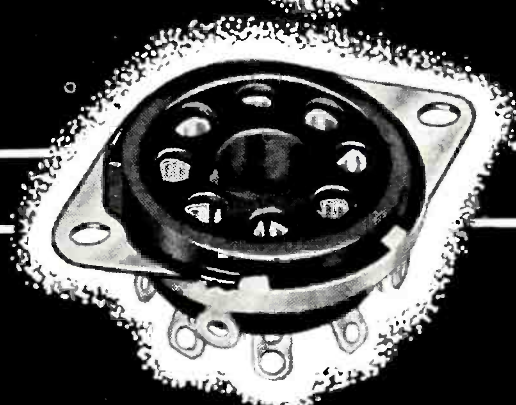
for Personal . . . Broadcast . . . Television Receivers

PERSONAL RECEIVERS

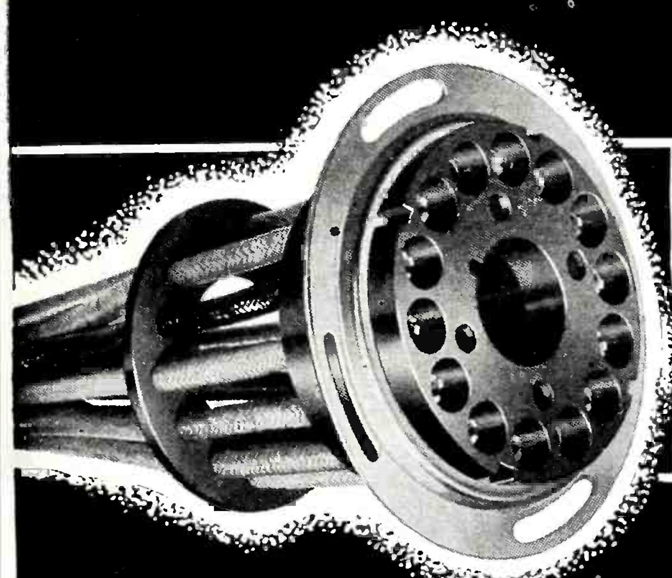


SERIES 55A4 MINIATURE MOLDED

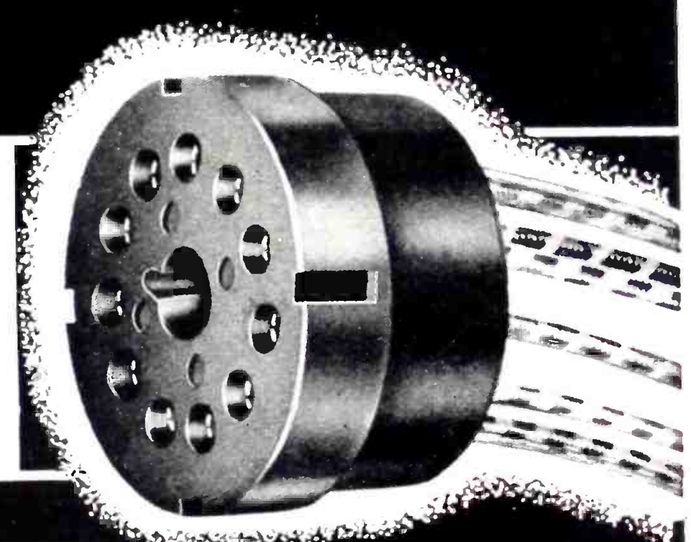
BROADCAST RECEIVERS



SERIES 60 MOLDED OCTAL



TELEVISION
ONE PIECE SOCKETS
DUO-DECAL
DIHEPTAL
MAGNAL



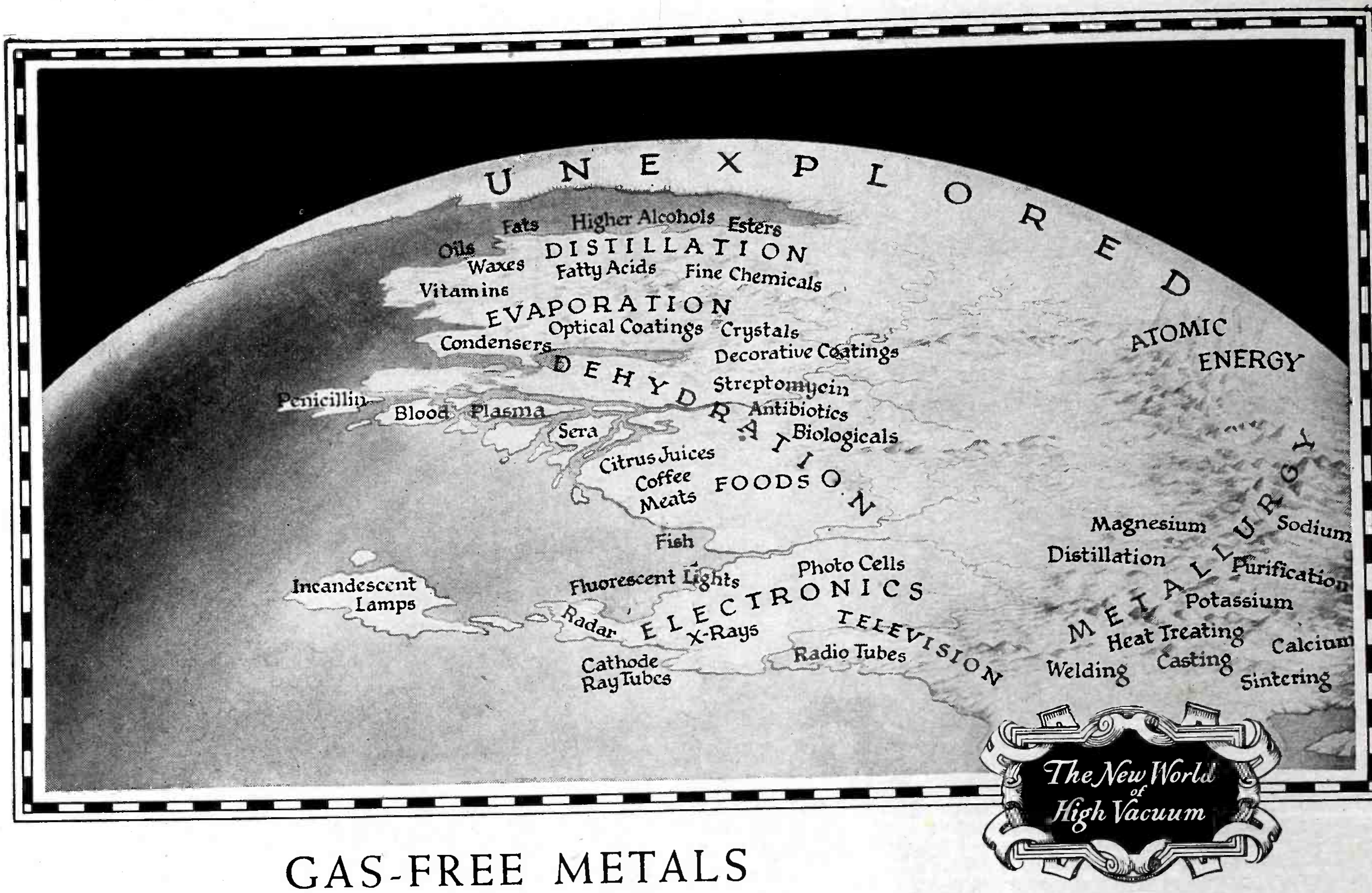
. . . and for general purposes, the Series 39 Socket, with patented bow spring action contacts (with or without a soldering tab to eliminate wiring to ground) is the favorite of all time. Automatically machine made, tens of thousands are being delivered to the radio industry to enable peak production of standard receivers. The millions in use give testimony to its being the favorite socket of pre and post war receivers.

ELECTRONIC COMPONENTS

A.W. FRANKLIN MANUFACTURING CORP.
175 VARICK ST., NEW YORK 14, N. Y.

In California: A. W. FRANKLIN Mfg. Corp. of CALIFORNIA, 2216 West 11 th St., Los Angeles 6, Calif.

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



GAS-FREE METALS

High Vacuum offers to industry a vast new area, virtually unexplored. No one knows its extent or its resources. No one, for instance, can list now all the advantages there may be in the use of vacuum metals, but National Research Corporation has found many and is busy in the search for others.

Of the many new fields we are investigating, few hold the promise of Vacuum Metallurgy.

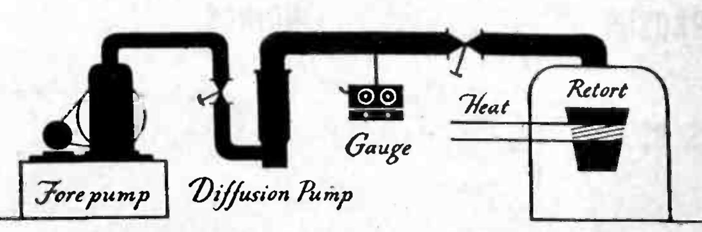
Metals prepared according to common practice contain volumes of dissolved gasses equal to, or greater than, the volume of the metal itself. Removal of the last trace of occluded gasses and volatiles shows a marked effect on the physical properties of a metal. Thermal and electrical conductivity, density and ductility are increased. Resistance to heat and corrosion of certain alloys may be improved. In many instances degrees of purity can be obtained which were hitherto impossible. Thus materials with new virtues and new possibilities are evolved.

Our development extends far into this field. In addition to research for the Manhattan Project, we helped to put the wartime production of magnesium, by means of vacuum thermal reduction, on a large-scale basis. We have separated and purified metals in high vacuum fractionating towers. Our own self-imposed and self-sustained research program has embraced the preparation of calcium, lithium, sodium, potassium and many other metals.

The pilot phase of many operations is now passed. We are melting and casting metals in ton lots per day at 10^{-5} mm. to 10^{-3} mm. Hg., and are prepared to furnish vacuum-treated metals in any desired quantity.

We believe that we are now the world's only commercial source of gas-free metals.

What can the world do with metals purer, finer, denser than any nature has furnished? What can you do with metals that point to a whole new territory full of unexplored possibilities? The opportunity for discovery and accomplishment is yours. If you feel that there is a promise for you in High Vacuum Metallurgy, get in touch with us.



VACUUM ENGINEERING DIVISION, National Research Corporation, Boston 15, Massachusetts.

We engineer Plant installations and manufacture High Vacuum Gauges, Valves, Seals, Diffusion Pumps, Stills, Furnaces, Coating Equipment and Dehydration Equipment.

HIGH VACUUM FOR INDUSTRY

NATIONAL RESEARCH CORPORATION

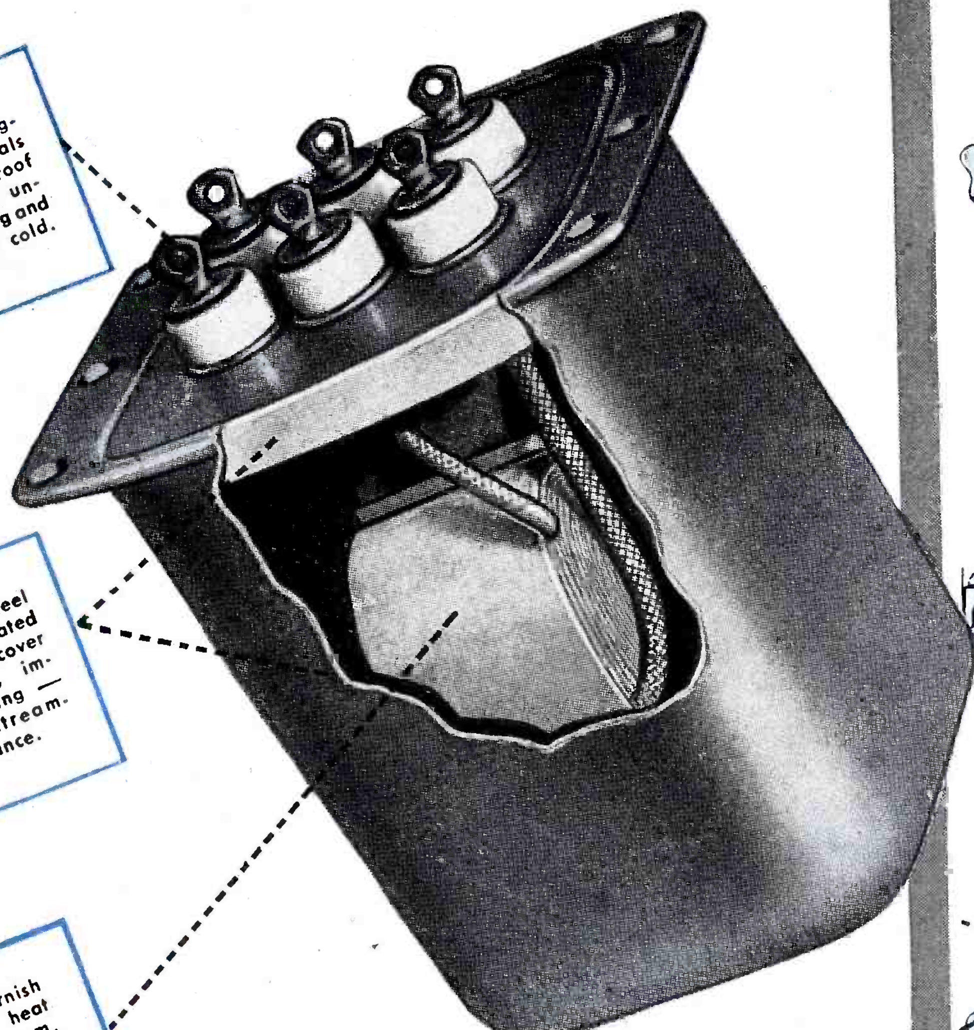
Vacuum ENGINEERING DIVISION

For an Extra Margin of

DEPENDABILITY
UNDER ALL OPERATING CONDITIONS

CASE TYPE

CHICAGO TRANSFORMERS
Sealed in Steel



Exclusive C. T. bushing-gasket seal at terminals is permanently proof against moisture, is unimpaired by soldering and by climatic heat or cold.

Seamless drawn steel case and C.T.-innovated "Deep-Seal" base cover provide a strong, impenetrable housing — rust-proofed, streamlined in appearance.

Coil is wax and varnish impregnated under heat and alternating vacuum, pressure, to remove moisture, prevent its re-entrance during assembly of unit.

Sealed AGAINST ATMOSPHERIC MOISTURE AND INDUSTRIAL FUMES

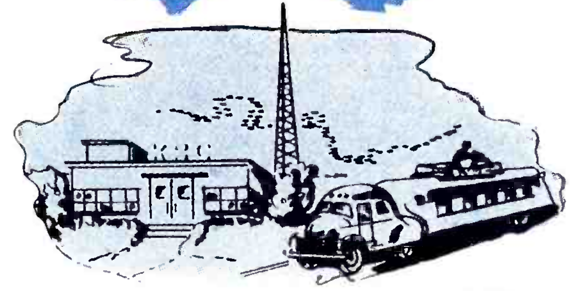
THUS ***Sealed*** AGAINST CORROSION OF COPPER COIL WINDINGS

STAY ***Sealed*** IN EXTREMES OF HEAT AND COLD!

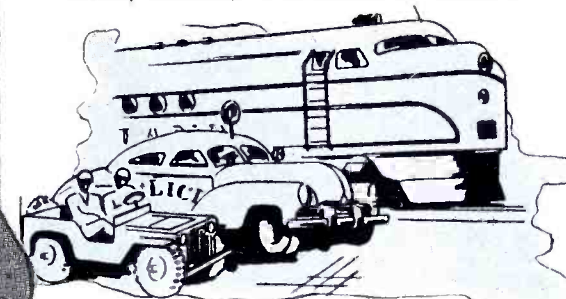
FITTED TO THE APPLICATIONS WHERE COMPONENT DEPENDABILITY IS ESSENTIAL TO

Avoid

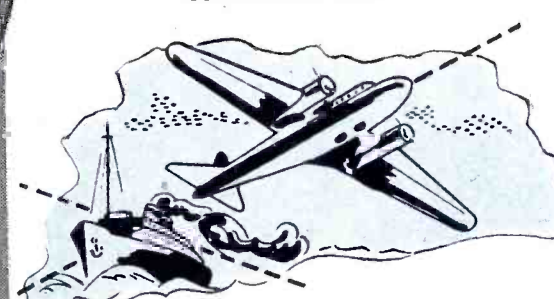
~~COSTLY MAINTENANCE~~
~~LOSS OF LIFE~~
~~DISRUPTION OF A VITAL SERVICE~~



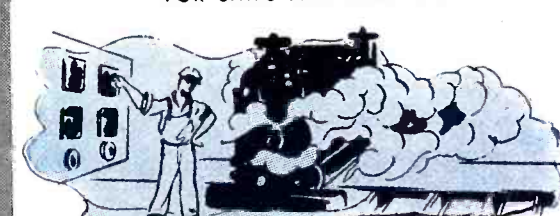
RADIO AND TELEVISION BROADCASTING
FIXED, MOBILE, & SATELLITE EQUIPMENT



MILITARY, POLICE, AND RAILROAD COMMUNICATIONS



ELECTRONIC NAVIGATIONAL AIDS FOR SHIPS AND AIRLINES



INDUSTRIAL CONTROLS

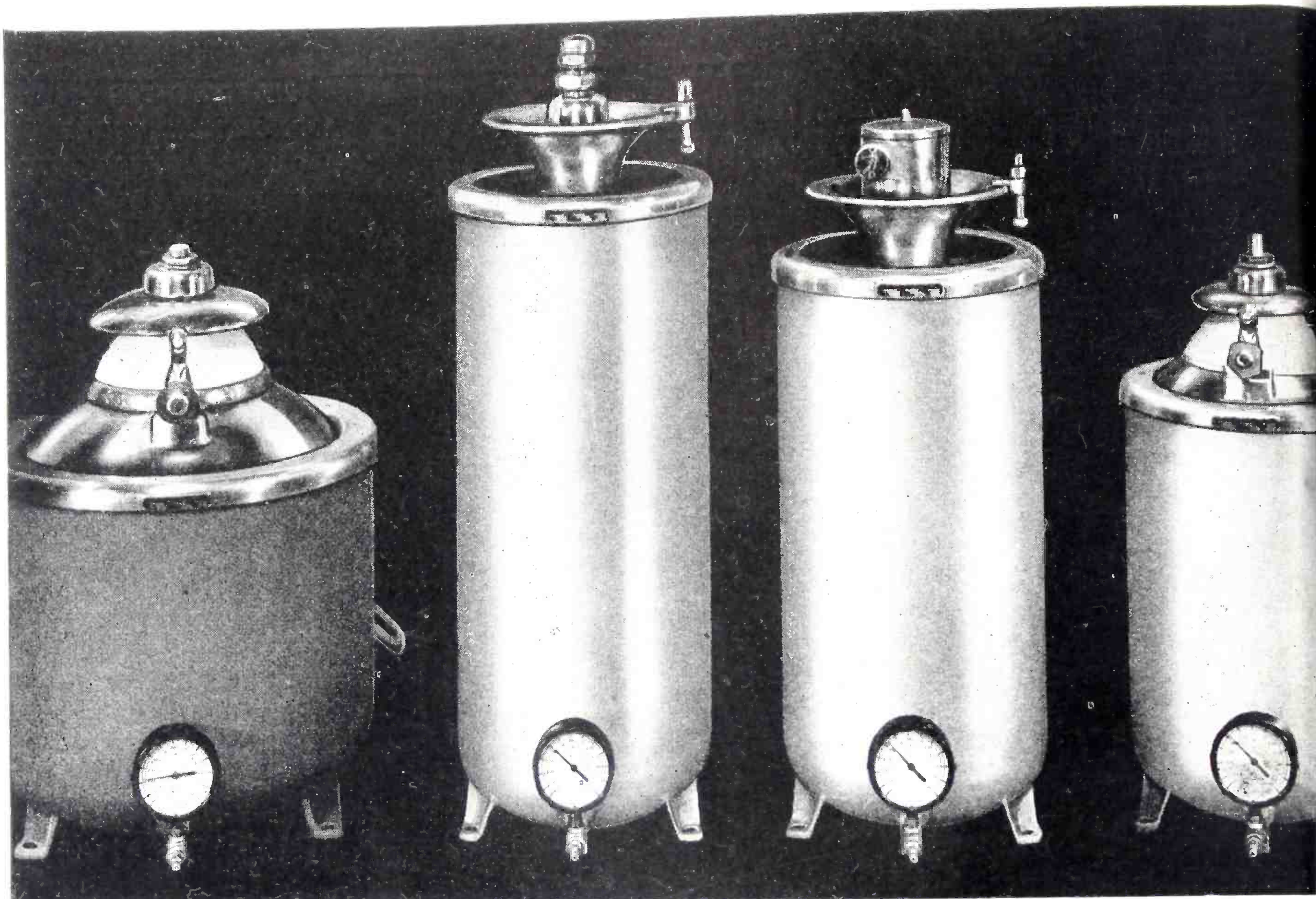
★ In these and many other transformer applications, economy, as well as efficiency, is best served by Chicago Transformer's *Sealed in Steel* construction.

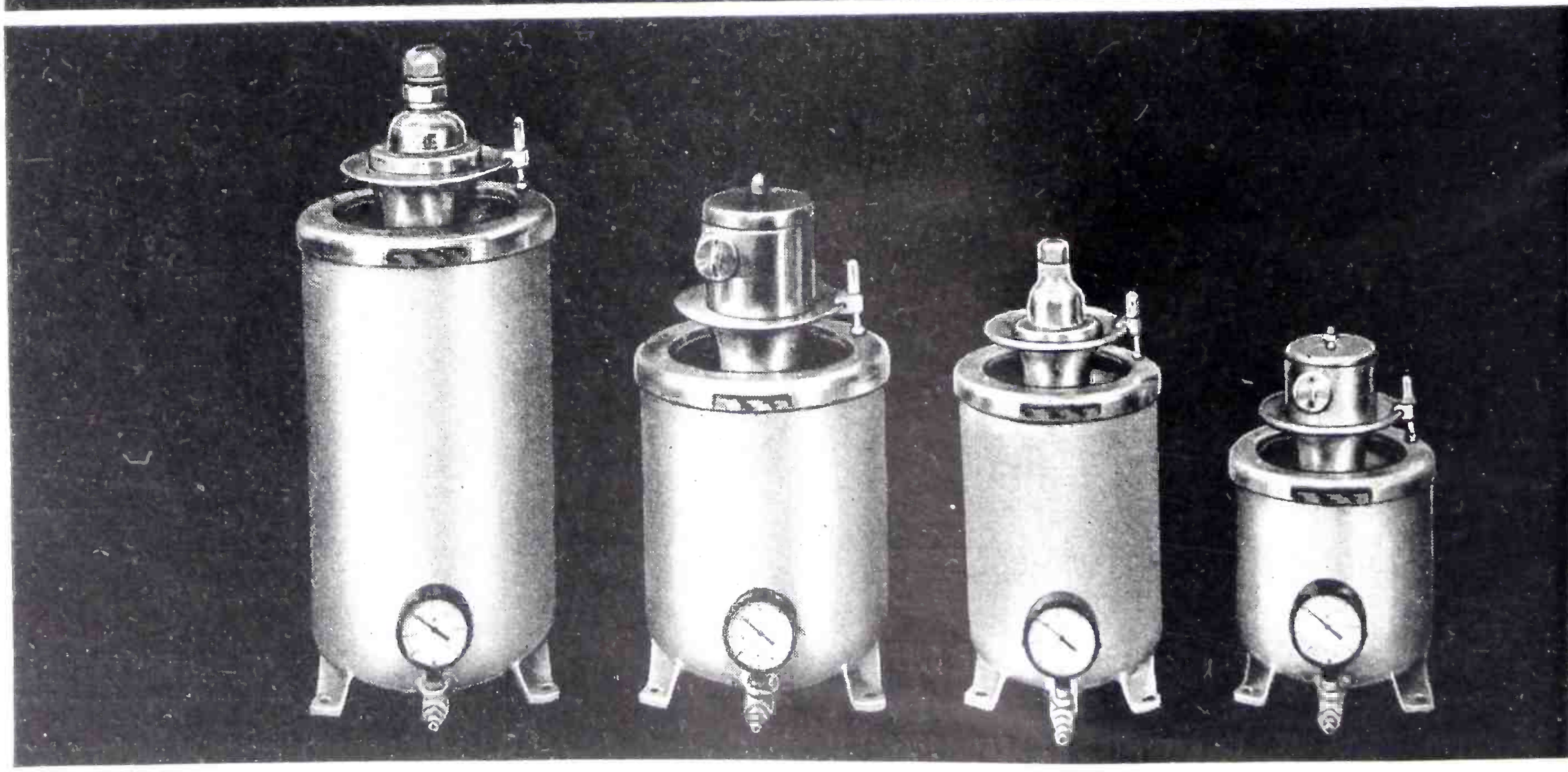
Let its assurance of long-lasting transformer reliability help make your electronic product free of component replacements and expensive servicing regardless of adverse operating conditions.

CHICAGO TRANSFORMER
DIVISION OF ESSEX WIRE CORPORATION

CHICAGO TRANSFORMER — CTC — TRADE MARK REG

3501 ADDISON STREET • CHICAGO 18, ILLINOIS





Lump

CAPACITANCE

LAPP GAS-FILLED CONDENSERS FOR HIGH POWER, HIGH CURRENT CIRCUITS

Designed particularly to the requirements of electronic power sources for radio broadcast, induction heating, and other high current applications, Lapp Gas-Filled Condensers offer a soundness of design and construction that spells *dependable performance.* No "warm up" is required; there is no change of capacitance with change in temperature. Losses are lower than in solid-dielectric circuits—power consumption is reduced. The dielectric is an inert gas, which precludes possibility of deteriora-tion or puncture. Variable, adjustable, and fixed units are available, in power ratings up to 60 Kv peak, current to 500 amperes R.M.S. Your inquiry is solicited.

Lapp

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

ELECTRONICS

Designers

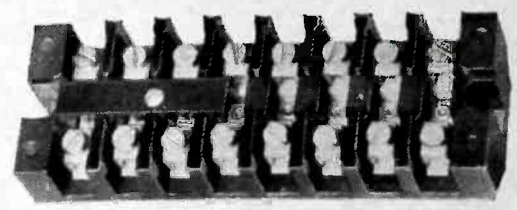
ACCURATE TIME AND CURRENT CONTROL
for bench welders

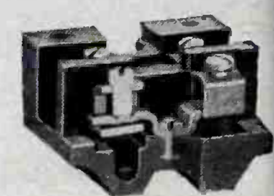
To cut welding time on small-part fabrication, such as welding solid or stranded conductors to terminals, welding electronic tube elements, or other small parts, look into the possibilities of the Thyratron-controlled bench-or-tong, low-capacity spot welder.

These alert, accurate controls, with a suitable transformer, have recorded a two-to-one advantage over soldering and rivet fabrication. Because of Thyratron welding controls' accuracy and split-cycle response, rejects drop to a new low. They are designed for either 230v or 460v, 60-cycle operation, and are rated 77 amperes peak on a duty cycle not exceeding 10 per cent. Equipment for 50-cycle operation is also available. Write for Bulletin GEA-4175A.

ONE AND A HALF INCHES
of instrument accuracy

General Electric's 1½-inch panel instruments include direct-current, radio-frequency, and audio-frequency types, in both conventional and watertight construction. All feature the compact, internal-pivot element and Textolite cases; will withstand 50 G's shock, and are accurate to within ±2 per cent. The conventional, direct-current instrument is supplied self-contained for current measurements from 100 microamperes to 10 amperes and for voltage measurements up to 150 volts. For other requirements, combinations of instruments and accessories can be had. Write for Bulletin GEA-4380.



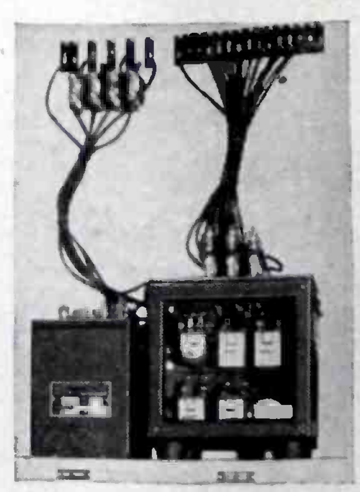


TERMINAL BOARDS *to cut wiring time*

There's less motion and more wiring speed when terminal boards are G-E Type EB-2. Strip the wire-end, insert it in the connector, tighten a screw, and the connection is made. Each of these solderless, pressure connectors will accommodate one No. 8 stranded conductor, two No. 12 stranded conductors, or three No. 12 solid conductors, all AWG.

Type EB-1 differs from EB-2 only in its terminals, which are the conventional washer-headed screw type. Both boards are molded from strong, long-lasting Textolite, both are available in 4-, 6-, 8-, and 12-pole sizes, and are equipped with marking strips. Covers are optional. Write for Bulletin GEA-1497A.

Fast Hook-ups that stay put with FLAMENOL WIRE

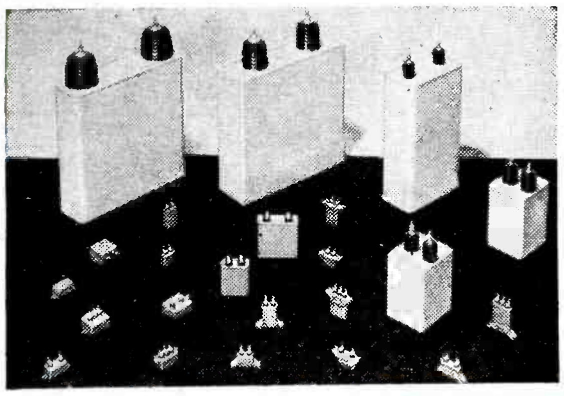


Flamenol hook-up wire's tough, plasticized-polyvinyl-chloride insulation strips clean, bends without cracking, and is available in seven different colors. Normally, it needs no bulky armor-braid for protection. As a result, Flamenol speeds up wiring operations on electronic apparatus, where voltages do not exceed 600. Flame-resistant, corrosion-resistant, non-oxidizing, and unaffected by most hydrocarbon solvents, mild acids and alkalies, Flamenol rarely needs either attention or replacing. Its glossy finish looks new, and stays that way. Write for Bulletin GEA-4352.

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS



NEW D-C PYRANOL* CAPACITORS

with new quality, sizes, ratings

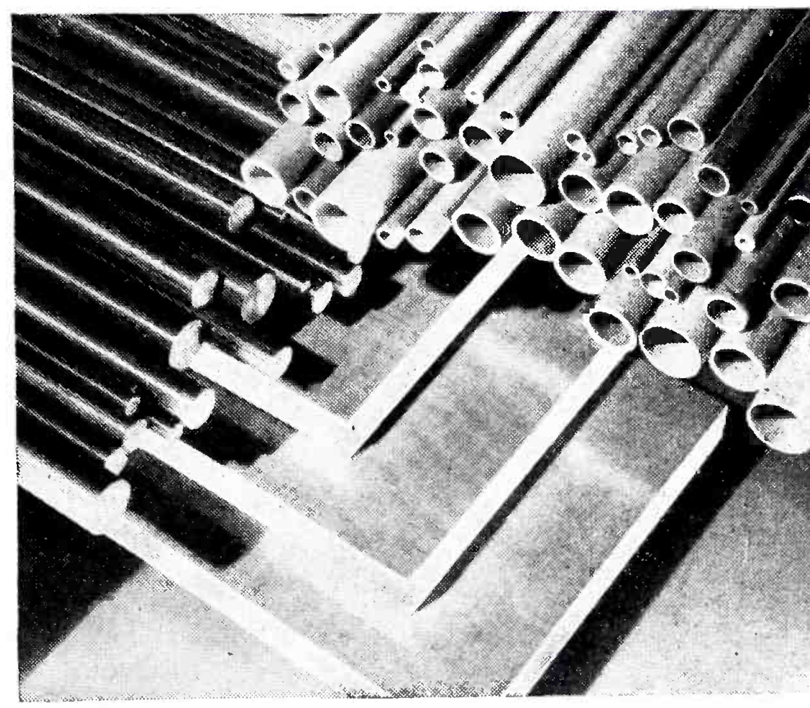
New materials, new manufacturing techniques and strict quality control, which were so important in the excellent records d-c Pyranol capacitors made during the war, are now incorporated into a new line of d-c Pyranol capacitors built to meet exacting commercial requirements.

This new line of d-c Pyranol capacitors has a broader range of sizes, ratings, and mounting arrangements, with characteristics that allow operation through the temperature range from –55C up to 85C, at altitudes as high as 7,500 feet. Sizes range from "bathtub" up to large, welded-steel case sizes, capacitance from .01 muf to 100 muf, and voltages from 100v to 100,000v. Write *Transformer Division, General Electric Company, Pittsfield, Mass.*

*Reg. U. S. Pat. Off.

MORE "KNOW" MEANS *better "do"!*

To help train new technical personnel, and make supervisory and production men's jobs mean more, G.E. offers this 12 part talking slide film, prepared to teach even non-technical personnel the elements of electronics. It comes complete with 12 slide films and records, 300 review books, instructor's manual and carrying case; price of the kit is $100. Call your local G-E office, or order direct from *Apparatus Dept., Sect. 642-13, General Electric Co., Schenectady 5, N. Y.*



FITS AND FIT FOR

any laminated-plastic job

Because it can be fabricated with machine tools into practically unlimited numbers of shapes, G-E Textolite sheet, tube, and rod stock adds flexibility to electronic apparatus design. Over fifty different grades — each with an individual combination of electrical, mechanical, chemical, and thermal properties — assures you that tube bases, coil forms, bus-bar supports and other components will be exactly right for your job. For additional information on G-E Textolite, write to *Plastics Divisions, Chemical Department, General Electric Company, Pittsfield, Mass*

General Electric Company, Sect. 642-13
Apparatus Department, Schenectady 5, N. Y.

Please send me

............GEA-1497A (Terminal Boards)
............GEA-4175A (Thyratron Welding Controls)
............GEA-4380 (Small Panel Instruments)
............GEA-4352 (Flamenol)

Note: More data available in Sweets File for product designers.

Name ____________________

Company ____________________

Address ____________________

City ____________________ State ____________

ıaking of Millions of Switches
ICRO SWITCH Products...

ːxplosion-Proof Switch

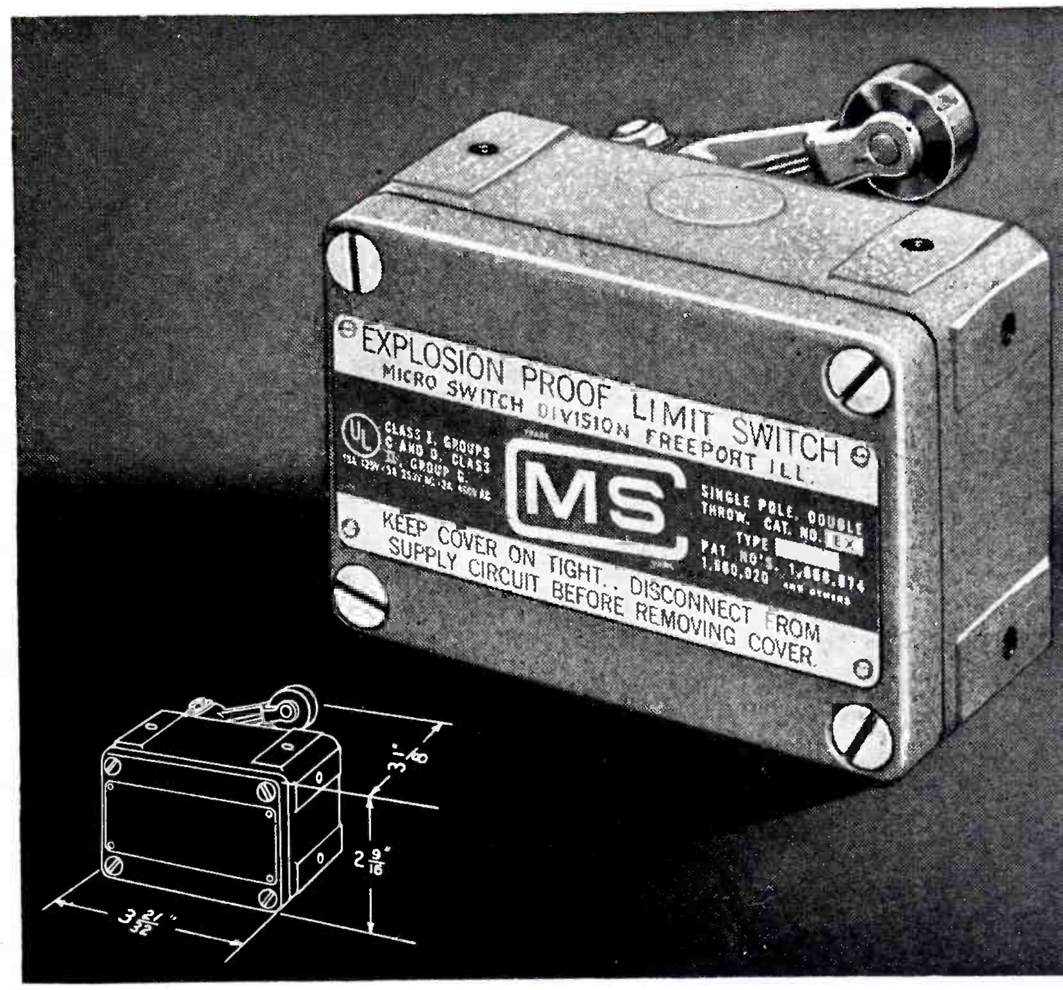
inds a definite place on equipment ı hazardous locations

quipment going into chemical plants, paint or starch ıctories, flour mills, oil refineries, grain elevators, or gas lants can use the Explosion-Proof Snap-Action Switch ɔ advantage to meet the needs for precision electrical ontrol problems.

'his switch can be used as a general limit switch, safety witch, door switch, or hook switch, as well as for other ses under conditions made hazardous by the presence f vapors, explosive gases, or grain dust.

'his Explosion-Proof Switch is Underwriters' Labora-ories listed for hazardous locations Class I, Groups C nd D, and Class II, Group G.

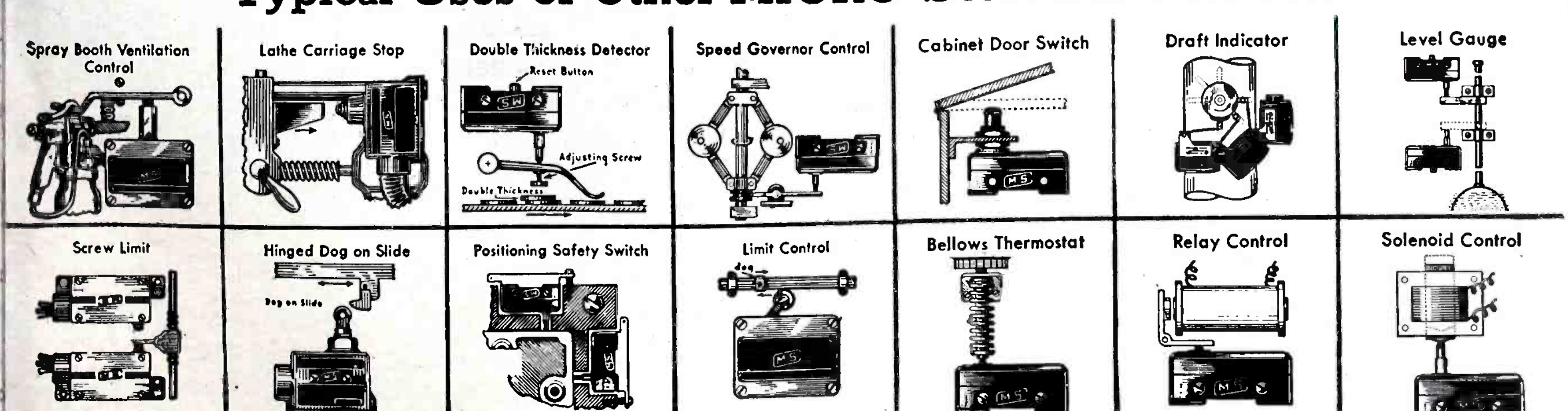
ıctuators are either plunger or roller arm type. The ılunger type actuator is of case-hardened steel and moves ı a long zinc plated hexagonal bushing, while the roller rm actuator is adjustable through 360 degrees with a :lockwise movement of the arm. The roller is of non-parking material and is fitted with an oil impregnated ɔearing.



Locations Where Commonly Used

Equipment used in the following plants are now using Micro Switch Explosion-Proof Switches: Gasoline Plants . . . Power Plants . . . Flour Mills . . . Varnish Factories . . . Spray Booths . . . Distilleries . . . Gasoline Pumps . . . Grain Elevators . . . Paint Factories . . . Pyroxylin Factories . . . Hospitals . . . Printing Plants . . . and other industrial concerns where danger of explosion is present.

Typical Uses of Other MICRO SWITCH Products



ɨitches Made by . . .

MICRO SWITCH TRADE MS MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILLINOIS, U. S. A.

Sales Offices in Principal Cities

10,000,000,000 OHMS

for leakage resistance measurements at low potentials

WILL INDICATE:

Insulation Properties

Leakage Resistance

Conductivity of Insulating Materials

Leakage due to moisture absorption and surface moisture

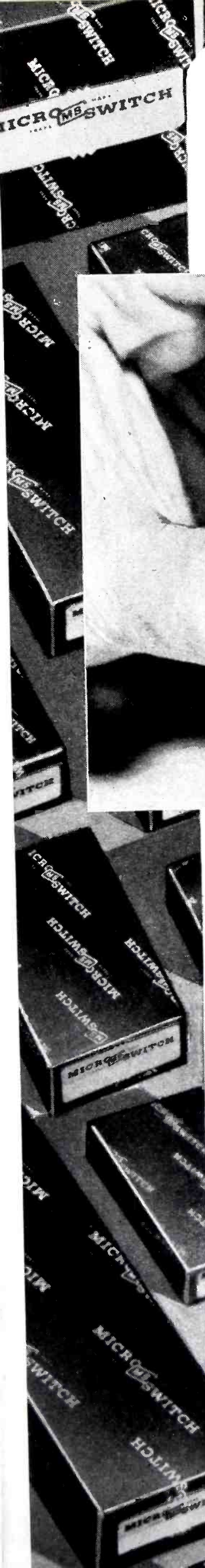
★WESTON (MODEL 799)
INSULATION TESTER

● A compact, one-hand operated Insulation tester . . . range .1 to 10,000 megohms . . . easily read scale . . . test potential less than 50 volts d-c. Ideal for testing electrical components, devices, materials, and new and existing Installations. Details from the WESTON representative near you, or write for bulletin.

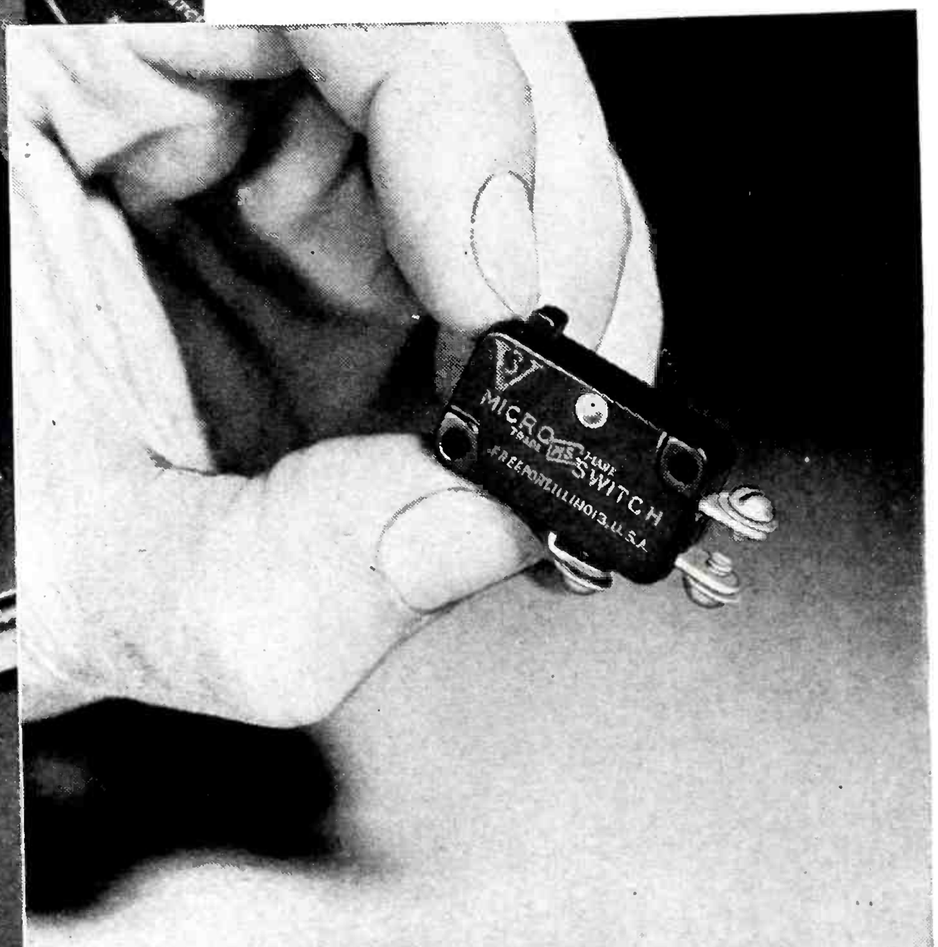
Weston *Instruments*

Weston Electrical Instrument Corp., 618 Frelinghuysen Ave., Newark 5, New Jersey,

Albany·Atlanta·Boston·Buffalo·Chicago·Cincinnati·Cleveland·Dallas·Denver·Detroit·Jacksonville·Knoxville·Los Angeles·Meriden·Minneapolis·Newark·New Orleans·NewYork·Philadelphia·Phoenix·Pittsburgh·Rochester·SanFrancisco·Seattle·St. Louis·Syracuse·InCanada,NorthernElectricCo.,Ltd.,PowerliteDevices,Ltd.



The Experience gained in th
is Behind the Manufacture o



The V3-1 Switch . . .

Not much bigger than the end of your thumb—but a two-fisted worker on the job . . .

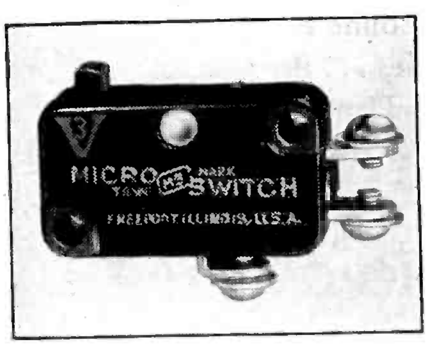
Don't be fooled by that convenient small size, for behind it are high capacity snap-action with high resistance to vibration, and accurate duplication of operating point from operation to operation. It can be used singly or it can be ganged on 13/32-inch centers. The switch is a single pole, double throw unit with wide contact separation, giving it good capacity on low potential direct current, as well as on alternating current loads.

Ratings are:
10 amperes— 110 volts, a.c.
5 amperes— 220 volts, a.c.
6 amperes—28.5 volts, d.c.

The actuating plunger on this small switch is insulated. Additional actuators are available as illustrated below.

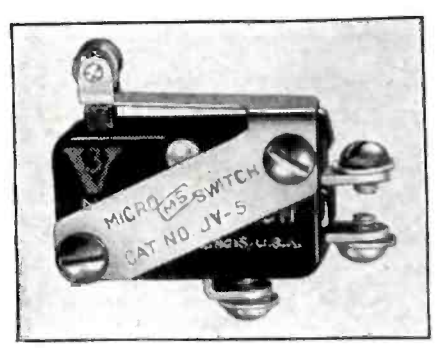
Many new products can incorporate the new V3-1 switch to advantage. It will pay to consider it.

Various Types of Actuators



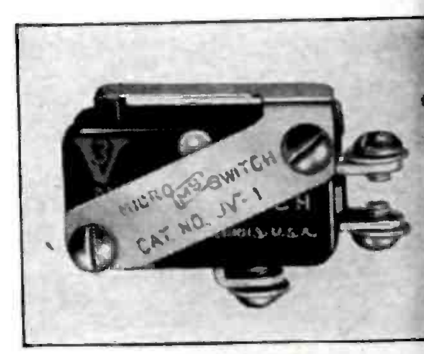
Plunger Type Actuator

The actuating plunger is insulated, adding another desirable qualitv.



Roller Leaf Type Actuator

This actuator adds only 0.012-inch to the thickness.

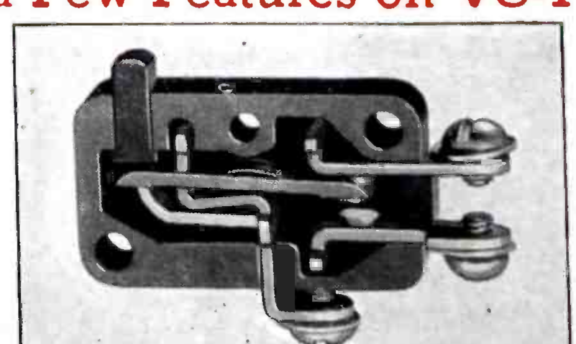


Spring Leaf Type Actuator

A separate actuator for use wi cams, slides, etc.

Here Are a Few Features on V3-1 Switches

- Thin construction. It occupies small space.
- Insulated plunger.
- One elongated mounting hole. (Exclusive with Micro Switch)



- Screw type terminals. (Can be used as solder lugs.
- Bosses around mounting h
- Beryllium copper spring— electrical capacity.

This Trade Mark MS is a Sign of Genuine Precision Snap-A

Iaking of Millions of Switches

IICRO SWITCH Products...

Explosion-Proof Switch

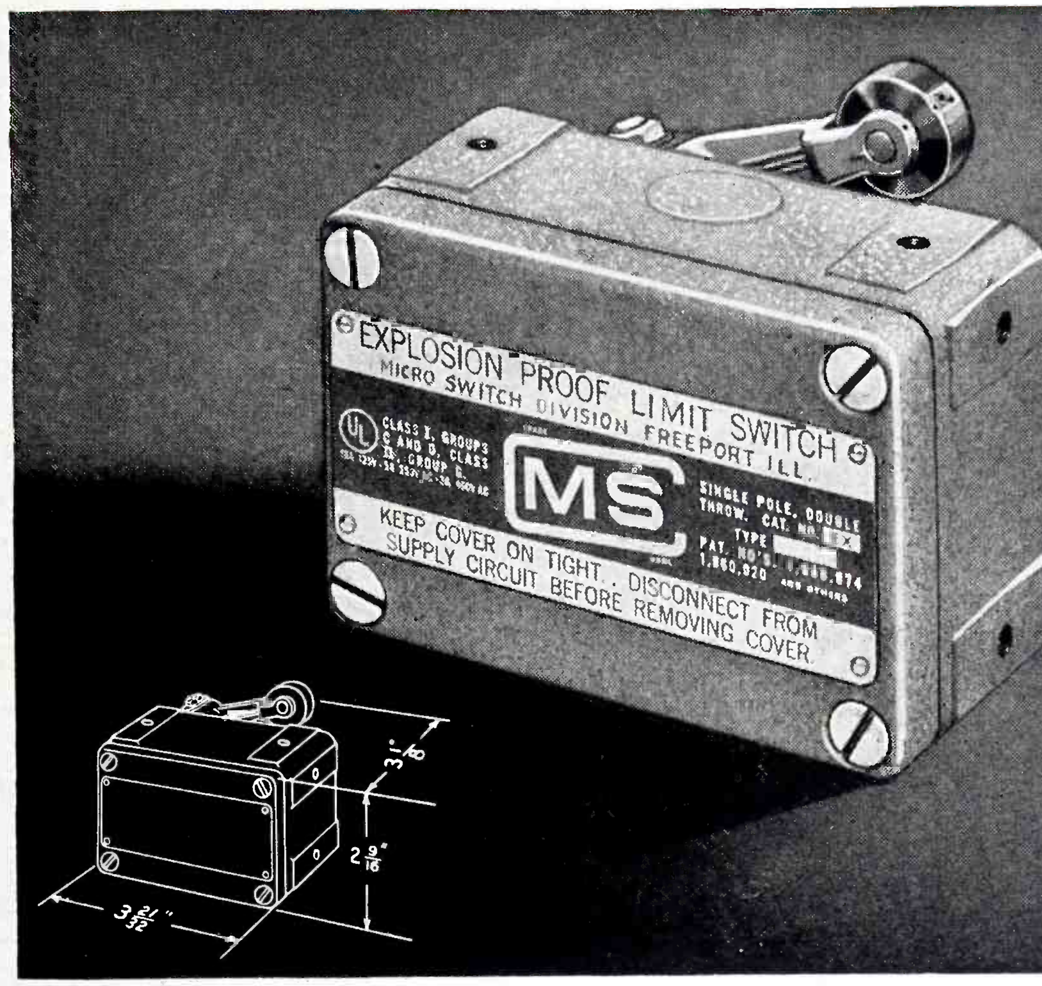
Finds a definite place on equipment n hazardous locations

Equipment going into chemical plants, paint or starch actories, flour mills, oil refineries, grain elevators, or gas plants can use the Explosion-Proof Snap-Action Switch o advantage to meet the needs for precision electrical ontrol problems.

This switch can be used as a general limit switch, safety witch, door switch, or hook switch, as well as for other ises under conditions made hazardous by the presence of vapors, explosive gases, or grain dust.

This Explosion-Proof Switch is Underwriters' Laboraories listed for hazardous locations Class I, Groups C nd D, and Class II, Group G.

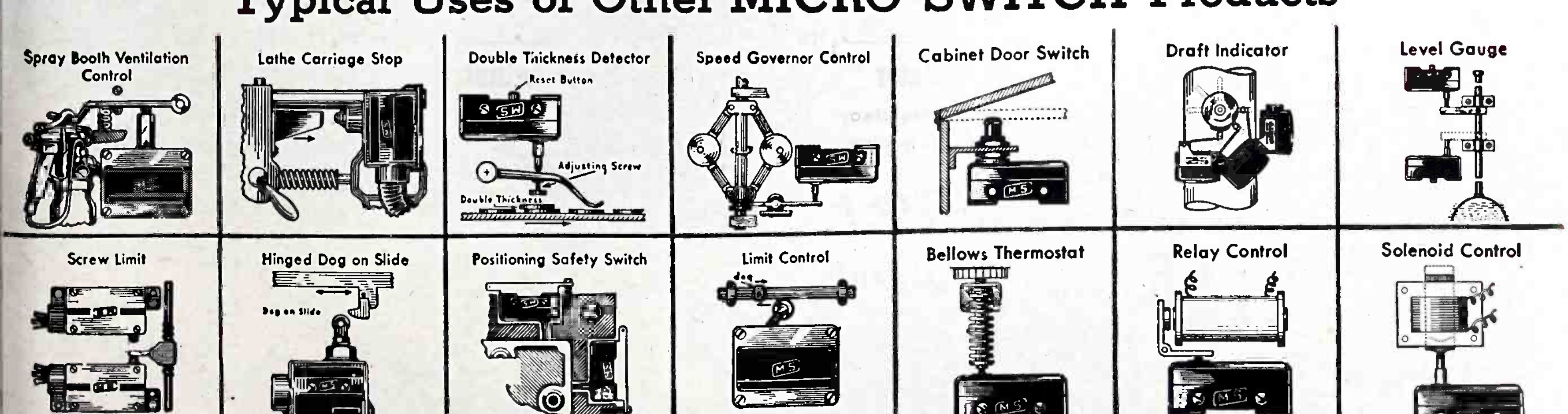
Actuators are either plunger or roller arm type. The plunger type actuator is of case-hardened steel and moves n a long zinc plated hexagonal bushing, while the roller rm actuator is adjustable through 360 degrees with a clockwise movement of the arm. The roller is of nonsparking material and is fitted with an oil impregnated bearing.



Locations Where Commonly Used

Equipment used in the following plants are now using Micro Switch Explosion-Proof Switches: Gasoline Plants . . . Power Plants . . . Flour Mills . . . Varnish Factories . . . Spray Booths . . . Distilleries . . . Gasoline Pumps . . . Grain Elevators . . . Paint Factories . . . Pyroxylin Factories . . . Hospitals . . . Printing Plants . . . and other industrial concerns where danger of explosion is present.

Typical Uses of Other MICRO SWITCH Products



itches Made by . . .

MICRO SWITCH (TRADE MARK)

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILLINOIS, U. S. A.

Sales Offices in Principal Cities

10,000,000,000 OHMS

for leakage resistance measurements at low potentials

WILL INDICATE:

Insulation Properties

Leakage Resistance

Conductivity of Insulating Materials

Leakage due to moisture absorption and surface moisture

★WESTON (MODEL 799)

INSULATION TESTER

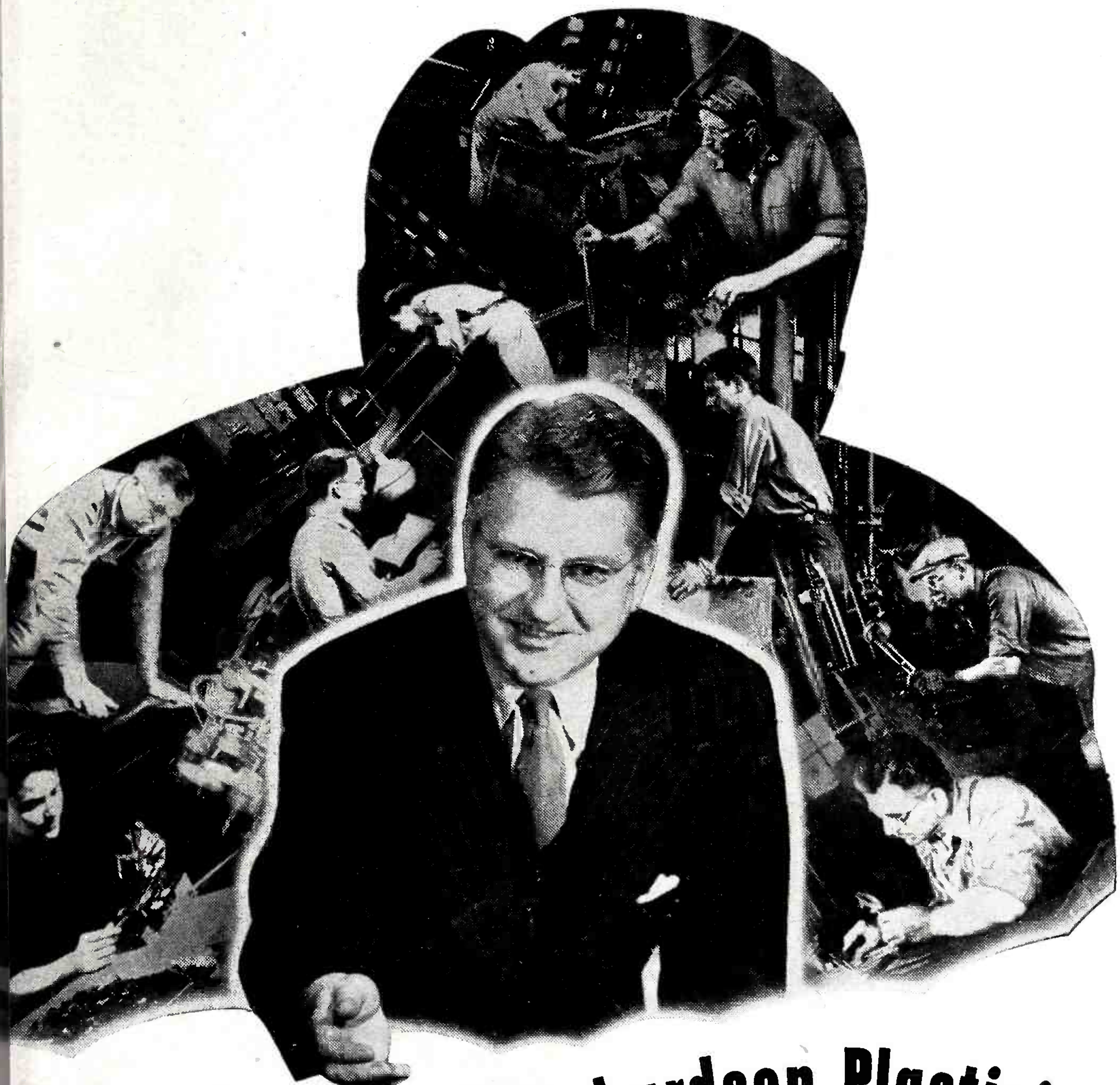
● A compact, one-hand operated Insulation tester . . . range .1 to 10,000 megohms . . . easily read scale . . . test potential less than 50 volts d-c. Ideal for testing electrical components, devices, materials, and new and existing Installations. Details from the WESTON representative near you, or write for bulletin.

Weston *Instruments*

Weston Electrical Instrument Corp., 618 Frelinghuysen Ave., Newark 5, New Jersey,

Albany · Atlanta · Boston · Buffalo · Chicago · Cincinnati · Cleveland · Dallas · Denver · Detroit · Jacksonville · Knoxville · Los Angeles · Meriden · Minneapolis · Newark · New Orleans · New York · Philadelphia · Phoenix · Pittsburgh · Rochester · San Francisco · Seattle · St. Louis · Syracuse · In Canada, Northern Electric Co., Ltd., Powerlite Devices, Ltd.

: RICHARDSON MEANS *Versatility* IN PLASTICS

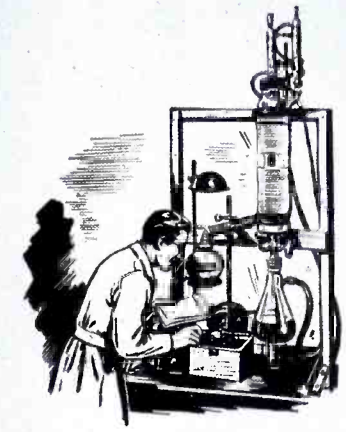


ake Hands with a Richardson Plastician!

He's one of many in the Richardson organization. They combine the best qualities of consultant . . . engineer . . . scientist . . . salesman . . . designer. If you have a problem in plastics, these men take the *problem* out of it . . . for you.

Richardson Plasticians form a flying squadron of skilled technicians. They are men whose varied educational backgrounds and practical industrial experiences equip them to utilize fully Richardson designing, molding, laminating, rubber-working and our own tooling facilities. It's a great team. No wonder our customers keep coming back for more.

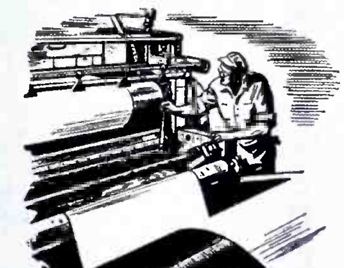
INSUROK *Precision Plastics*



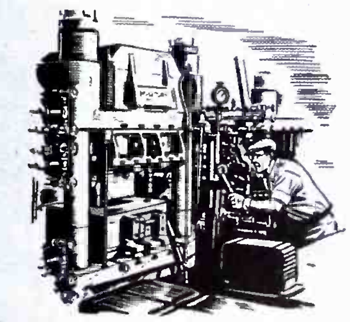
*RESEARCH
. . . a continuous transformation of possibilities into practical ideas in plastics.

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

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



*LAMINATING
. . . Sheets, rods, tubes. Standard NEMA grades; over 700 special grades.



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

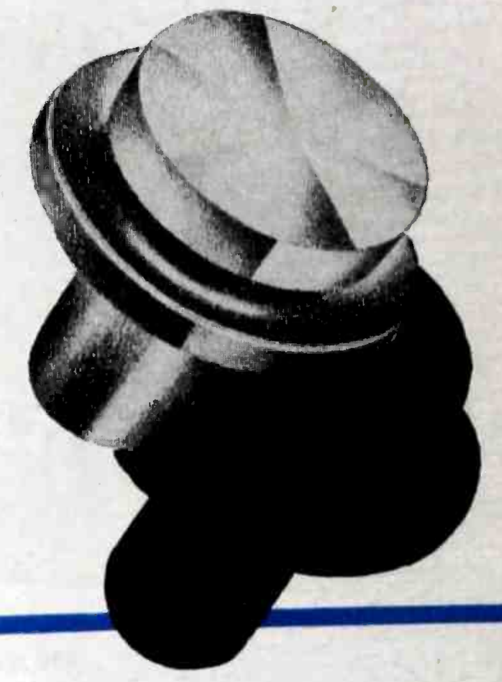
The RICHARDSON COMPANY

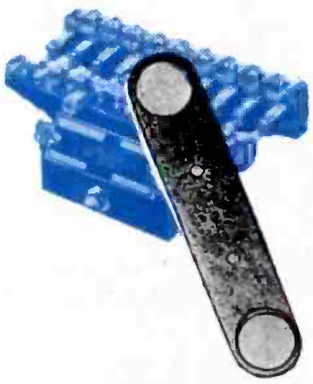
Sales Headquarters: MELROSE PARK, ILL. FOUNDED 1858 LOCKLAND, CINCINNATI 15, OHIO

ORK 6, 75 WEST STREET
ELPHIA 40, PA., 3728 NO. BROAD STREET
LAND 15, OHIO, 326-7 PLYMOUTH BLDG. • DETROIT 2, MICH., 6-252 G. M. BLDG. •
Sales Offices
ROCHESTER 4, N. Y., 1031 SIBLEY TOWERS BLDG.
MILWAUKEE 3, WIS., 743 NO. FOURTH STREET
ST. LOUIS 12, MO., 5579 PERSHING AVENUE

Factories: MELROSE PARK, ILL. • NEW BRUNSWICK, N. J. • INDIANAPOLIS, IND.

We didn't know you could do that with Callite Contacts



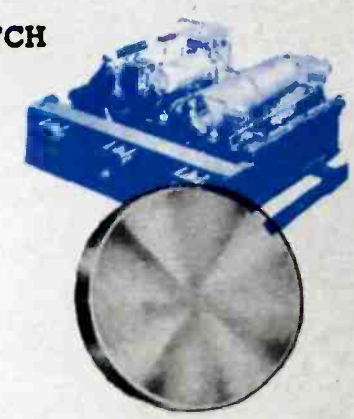


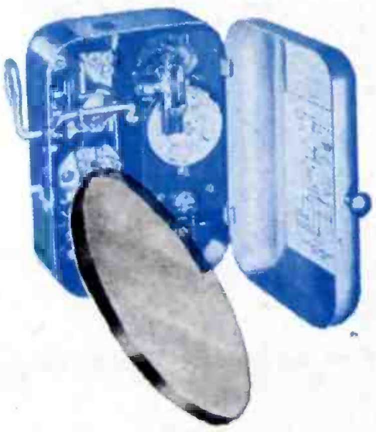
SIGNAL RELAY

Manufactured by Signal Engineering & Mfg. Co. with Callite Silver Contacts, this rugged signal relay withstands high impact shocks and vibration without impairing continuous operation or upsetting delicate relay adjustments.

AUTOTUNE TAP SWITCH

Collins' repositioning mechanism for transmitters and receivers changes frequencies with extreme precision at the touch of a button. This remarkable Autotune drives tap switches which employ Callite Silver Contacts.





FIRE PILOT CONTROL

Sampsel controls turn stokers on and off as needed, saving coal consumption and insuring efficient heating in homes and industries. Callite supplied Sampsel with special silver contacts that resist wear, burning, corrosion.

TRACTOR MAGNETO

Eisemann's heavy duty magneto for farm and industrial equipment is built to operate constantly under the most severe conditions of work and weather. Callite Tungsten Contacts play a vital part in the performance of its breakers and levers.

Perhaps none of the special Callite contacts illustrated here can be applied to your own product. But the same engineering ingenuity and flexibility of our organization can devise the exact contact design for your specific needs. In the 26 years of our leadership in the metallurgy of components, we have supplied standard and special shapes in every industry where contacts are used. If precision contacts are a question mark in your production, call on Callite first. Callite Tungsten Corp., 544 Thirty-ninth St., Union City, N. J. Branch Offices: Chicago, Cleveland.

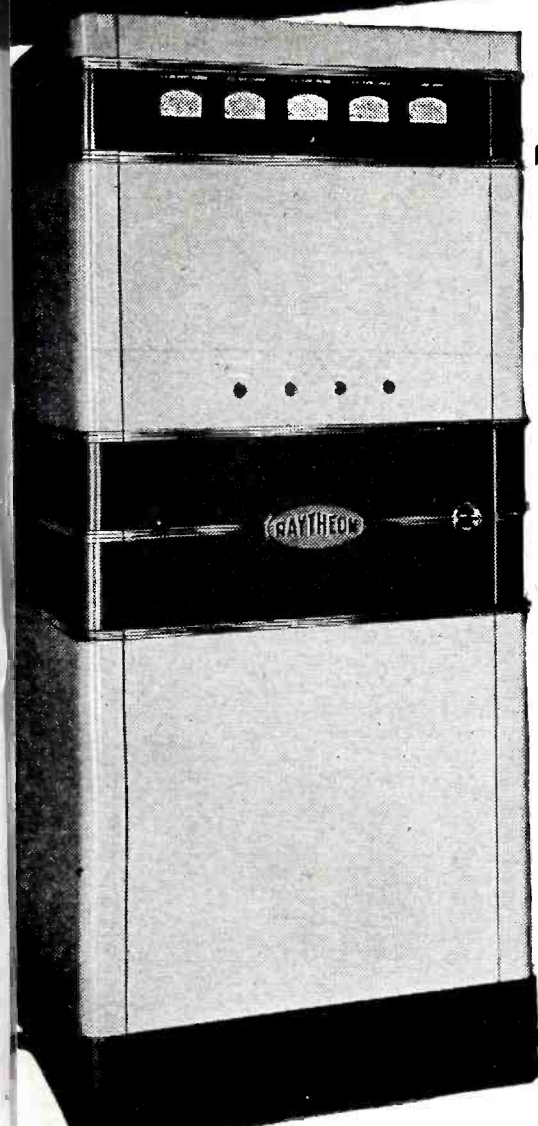
Callite CONTACTS — CALLITE TUNGSTEN CORPORATION CT

Standard and special shapes in tungsten, molybdenum, silver, platinum, palladium and alloys of these metals. Write for Catalog No. 152 which describes stock contacts and extraordinary designs used in individual applications.

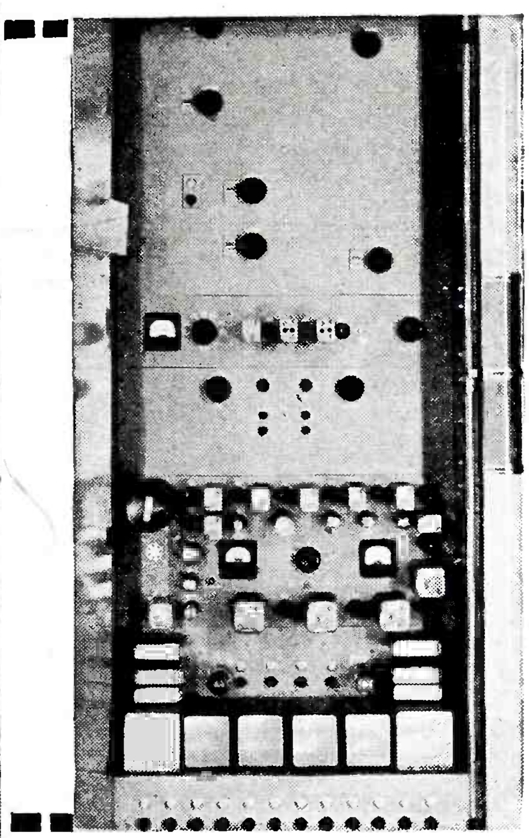
AYTHEON'S 250 WATT FM TRANSMITTER

ORPORATING THE NEW

Cascade PHASE SHIFT MODULATION



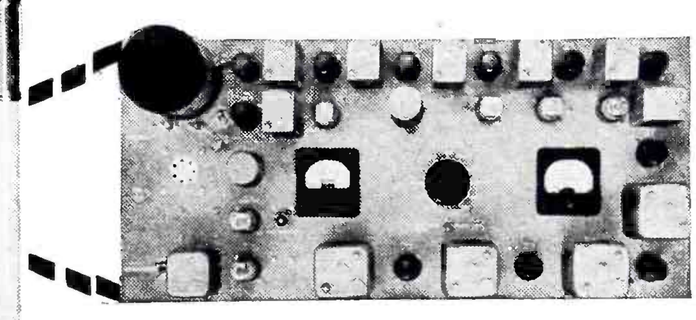
250 Watt FM Transmitter, also standard exciter unit for all higher power.



Thorough tests in actual competition with all other systems of modulation have proved the superiority of the Cascade Phase Shift Circuit—in signal quality, simplicity and dependability.

Raytheon's Cascade Phase Shift Modulation is a basically direct circuit which adds the phase shift of six simple stages to produce the required phase shift needed for high fidelity modulation—at an *inherently* lower noise level. This extremely simple circuit eliminates the major faults of other systems and brings important advantages never before possible (See features).

Carefully compare and you will buy Raytheon. *Place YOUR order now for Fall delivery.*



Above—Complete Cascade Phase Shift Modulator.
Left—Front control panel of Transmitter.

YOU WILL WANT EVERY ONE OF THESE TEN IMPORTANT FEATURES . . . ONLY RAYTHEON CAN GIVE THEM TO YOU

1. **Simplified circuit design** thru the *Cascade* system gives stability and efficiency to Raytheon FM.

2. **Direct Crystal Control,** independent of modulation, gives positive and automatic control of the mean carrier frequency. No complicated electronic or mechanical frequency stabilizers are used. A single high quality crystal does the job.

3. **An inherently lower noise level** is achieved by Cascade Phase Shift Modulation which adds the phase shift of six simple stages.

4. **Very low harmonic distortion**—less than 1.0% from 50 to 15,000 CPS with 100 KC frequency deviation.

5. **Conservatively operated circuits** prolong tube life—prevent program interruptions.

6. **No expensive special tubes.** The modulator unit uses only inexpensive receiver type tubes of proven reliability.

7. **Unit construction.** There is no obsolescence to Raytheon FM Transmitters. Add an amplifier later to give the desired increase in power. All units are perfectly matched in size, styling and colors.

8. **Simple, very fast tuning.** Circuit can be completely tuned up in two or three minutes without external measuring instruments.

9. **Lasting economy.** Low first cost—low power cost—advanced engineering design—plus modern styling, guarantee years of satisfaction.

10. **Easy to service.** Excellent mechanical layout, vertical type chassis and full height front and rear doors make servicing fast and easy.

THEON MANUFACTURING COMPANY

Broadcast Equipment Division

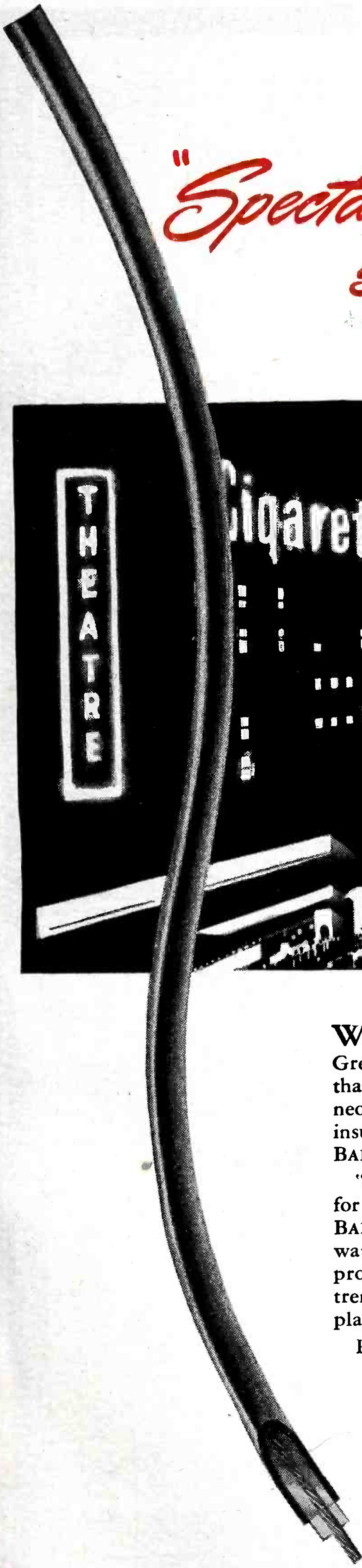
7517 No. Clark Street, Chicago 26, Illinois

RAYTHEON

Excellence in Electronics

OTED TO RESEARCH AND MANUFACTURE FOR THE BROADCASTING INDUSTRY

"Spectacular" wiring calls for spectacular insulation!



WIRING—miles of it—is what keeps the Great White Way aglow. And every mile of that wiring...particularly in the labyrinth of neon circuits...presents a tough problem in insulation. A problem made-to-order for BAKELITE Polyethylene!

"Spectacular" is none too strong a word for the job of insulation performed by BAKELITE Polyethylene! So light it floats on water, this plastic is so high in dielectric properties that wire and power cable of extremely *small cross-section* can be used to supplant older, bulkier, harder-to-handle types.

Polyethylene insulation has exceptional moisture and chemical resistance...an extremely low water-vapor transmission coefficient...it is inherently flexible and extensible...and possesses a wide temperature working range.

These are some of the reasons why BAKELITE Polyethylene insulation is winning its way into scores of new electrical applications...particularly where long service in exposed locations and small-diameter flexibility are all-important. Write to Department BJ-18 for complete information, technical data and, if you require them, experimental samples of BAKELITE Polyethylene.

BAKELITE

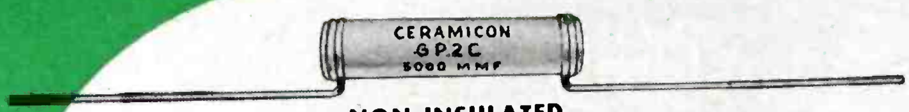
TRADE-MARKS

POLYETHYLENE

BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

ERIE "GP" CERAMICONS*

The Complete, Long-Established Line of General Purpose Ceramic Condensers

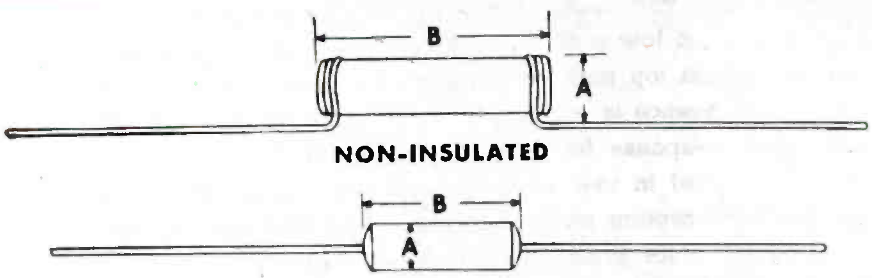


NON-INSULATED

INSULATED

THIS chart gives a complete selection of dependable, compact Erie general-purpose Ceramicons. Specially priced, these time-proven units are made for such applications as coupling and by-passing where temperature coefficient is not important—in other words for all receiver applications except in frequency determining circuits. For the latter type of applications the regular line of temperature-compensating Ceramicons is available.

Ceramics have been proven to be the best dielectrics—Erie Ceramicons have been proven to be the best in ceramic condensers. *Use them to your advantage.*



UNITS STAMPED WITH CAPACITY AND TOLERANCE		Max. Overall Dimensions	
		A	B
Insulated	GP1K, GP2K	.250″	.562″
	GP1L, GP2L	.250″	.812″
	GP1M, GP2M	.340″	1.328″
Non-Insulated	GP1A, GP2A	.200″	.400″
	GP1B, GP2B	.200″	.656″
	GP2C	.265″	1.125″
	GP2D	.360″	1.110″
	GP2E	.360″	1.560″
	GP2S	.230″	.860″

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

CAPACITY MMF	ERIE STYLE	TYPE* I=Insulated N=Non-Insulated	WORKING VOLTAGE	MAX. POWER FACTOR 1MC
10	GP1K	I	500	0.17%
	GP1A	N	500	0.17%
12	GP1K	I	500	0.16%
	GP1A	N	500	0.16%
15	GP1K	I	500	0.15%
	GP1A	N	500	0.15%
18	GP1K	I	500	0.14%
	GP1A	N	500	0.14%
20	GP1K	I	500	0.13%
	GP1A	N	500	0.13%
22	GP1K	I	500	0.12%
	GP1A	N	500	0.12%
24	GP1K	I	500	0.12%
	GP1A	N	500	0.12%
25	GP1K	I	500	0.12%
	GP1A	N	500	0.12%
27	GP1K	I	500	0.11%
	GP1A	N	500	0.11%
30	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
33	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
39	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
47	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
50	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
51	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
68	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
75	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
100	GP1K	I	500	0.1%
	GP1A	N	500	0.1%
	GP1L	I	500	0.1%
120	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
150	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
	GP1L	I	500	0.1%
	GP1B	N	500	0.1%
180	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
200	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
220	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
240	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
250	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
270	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
300	GP2K	I	500	3.0%
	GP2A	N	500	3.0%
330	GP2K	I	350	3.0%
	GP2A	N	350	3.0%
390	GP2K	I	350	3.0%
	GP2A	N	350	3.0%
470	GP2K	I	350	3.0%
	GP2A	N	350	3.0%
500	GP1M	I	500	0.1%
	GP2K	I	350	3.0%
	GP2A	N	350	3.0%
510	GP1M	I	500	0.1%
	GP2K	I	350	3.0%
	GP2A	N	350	3.0%
680	GP1M	I	500	0.1%
	GP2K	I	350	3.0%
	GP2A	N	350	3.0%
750	GP2L	I	350	3.0%
	GP2B	N	350	3.0%
1000	GP2L	I	350	3.0%
	GP2B	N	350	3.0%
1200	GP2L	I	350	3.0%
	GP2B	N	350	3.0%
1500	GP2L	I	350	3.0%
	GP2B	N	350	3.0%
1800	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
2000	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
2200	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
2400	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
2500	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
2700	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
3000	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
3300	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
4000	GP2M	I	350	3.0%
	GP2S	N	350	3.0%
4700	GP2M	I	350	3.0%
	GP2C	N	350	3.0%
5000	GP2M	I	350	3.0%
	GP2C	N	350	3.0%
5100	GP2M	I	350	3.0%
	GP2C	N	350	3.0%
6000	GP2D	N	350	3.0%
6800	GP2D	N	350	3.0%
7500	GP2E	N	350	3.0%
10000	GP2E	N	350	3.0%

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

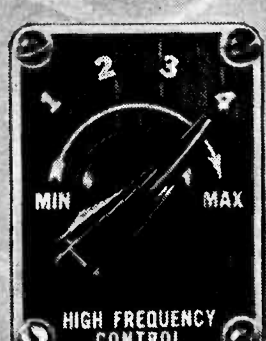
LONDON, ENGLAND • • TORONTO, CANADA

Listen ...it's a Jensen SPEAKER!

RA-151 REPRODUCER

RD-151 REPRODUCER

...WITH HIGH-FREQUENCY RANGE CONTROL



Jensen High Frequency Control gives you the kind of reproduction you want when you want it . . . all the way from two-way system high fidelity to conventional single speaker performance. Now you can adjust for best results on every program, every record, every type of service.

Now you can hear ALL program material at its best with the new JENSEN Coaxial Reproducers

- ★ Two articulated, coaxially mounted speakers
- ★ JENSEN *Bass Reflex** Cabinets for full low register
- ★ High-Frequency Range Control for all-purpose flexibility
- ★ Beautifully styled walnut and utility cabinets
- ★ Built-in Frequency-dividing Network

*Trade Mark Registered

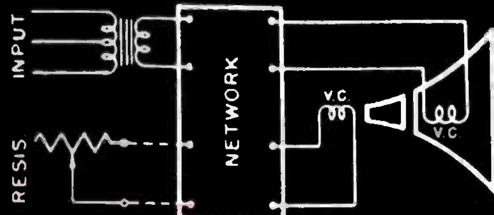
Never before have you been able to buy such performance . . . such versatility . . . at so low a cost. JENSEN now brings you the ultimate in reproducers with top performance so fine, so nearly ideal acoustically that obsolescence is eliminated for years to come. Yet you can instantly adjust response for most pleasing results with every type of program material in use today. Ideal for professional and home use for FM-AM reception and monitoring, transcriptions, commercial phono records . . . for practically every moderate-level high-quality application.

JENSEN MANUFACTURING CO., 6607 S. Laramie Ave., Chicago, U.S.A.

In Canada: J. R. Longstaffe, Ltd., 11 King St., Toronto

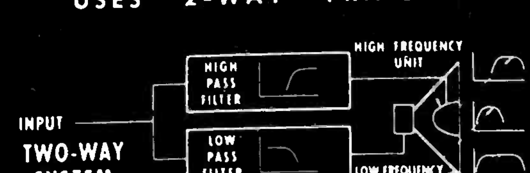
Jensen SPEAKERS WITH ALNICO 5

Designers and Manufacturers of Fine Acoustic Equipment



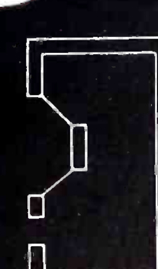
Separate coaxially-mounted speakers for low and high frequencies, with integral two-channel network. (Range control not shown.)

USES "2-WAY" PRINCIPLE

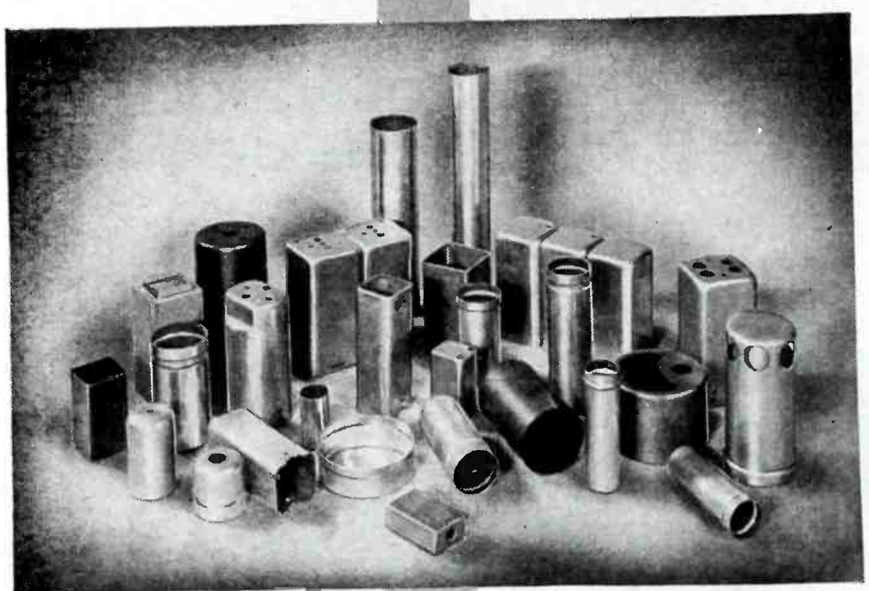


JENSEN BASS REFLEX

Acoustically-correct Bass Reflex Cabinet gives smoothly extended low register. Better than an "infinite" baffle . . . efficiently uses back radiation too.



HOW TO ADD A *Parts Division* TO YOUR PLANT WITH A CAPITAL INVESTMENT OF $0,000.00

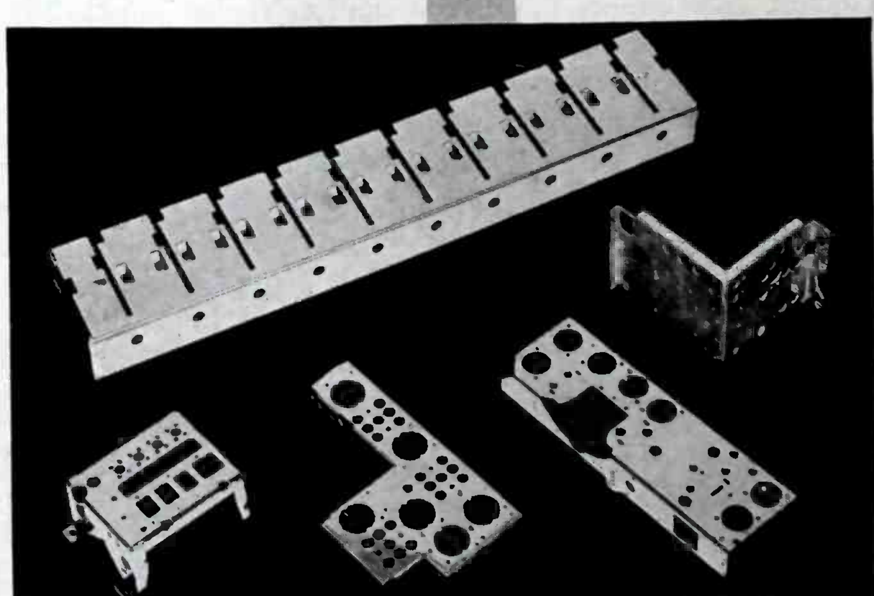


Paul and Beekman Division manufactures all types of drawn cans and housings from aluminum, steel, copper, stainless steel, etc.

Paul and Beekman Division specializes in economical, large-volume production of radio and electronic parts. We have the skilled personnel and the machines necessary to produce all types of standard parts, or items tailored to individual specifications.

When you make Paul and Beekman your parts division the initial investment is zero . . . and the long-run costs are as low as large-quantity production and good organization can make them. You get parts of highest quality . . . and you get them when you want them.

Paul and Beekman engineers are available for consultation, without obligation. Write us concerning your requirements.



Paul and Beekman Division manufactures all types and sizes of chassis and sub-assemblies, in large quantities.

PAUL and BEEKMAN *Division* 1810 COURTLAND ST., PHILADELPHIA 40, P

PORTABLE PRODUCTS CORPORATION

MANUFACTURERS OF: LAWN MOWERS • ELECTRICAL APPLIANCES • PRECISION STAMPINGS
INDUSTRIAL INSTRUMENTS • RADIOS • SAFETY EQUIPMENT

MITCHELL-RAND has VARNISHED TUBINGS

of fiberglas and staple fiber cotton yarn for every electrical insulation requirement.

M-R FIBERGLAS (INORGANIC) VARNISHED TUBINGS ARE MADE IN FOUR GRADES — STANDARD, DOUBLE SATURATED, TRIPLE STRENGTH AND IMPREGNATED.

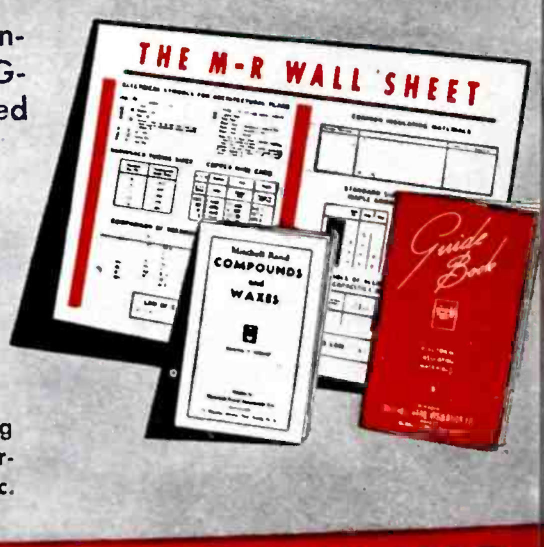
STANDARD GRADE has maximum flexibility, is treated with a minimum of varnish and recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

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

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

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



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

HEADQUARTERS
THE ELECTRICAL INSULATION
MR
FOR 57 YEARS

MITCHELL-RAND INSULATION COMPANY, INC.

51 MURRAY STREET **COrtlandt 7-9264** **NEW YORK 7, N.Y.**

A PARTIAL LIST OF M-R PRODUCTS

Fiberglas Varnished Tape and Cloth
Insulating Papers and Twines
Cable Filling and Pothead Compounds
Friction Tape and Splice
Transformer Compounds
Fiberglas Saturated Sleeving, Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth, Tubing
Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevi
Impregnated Varnish Tubing
Insulating Varnishes of all types
Extruded Plastic Tubing

hallicrafters PRESENTS THE

SX·42

Another first! Greatest continuous frequency coverage of any communications receiver—from 540 kc to 110 Mc

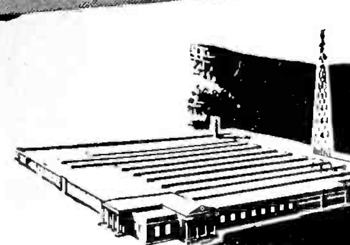
This is the long-awaited Hallicrafters SX-42, a truly great communications receiver. The tremendous frequency range of the SX-42, *greater than ever before available in a receiver of this type*, is made possible by the development of a new "split-stator" tuning system and the use of dual intermediate frequency transformers. Packed with advance features that every ham and every other radio enthusiast desires, the SX-42 clearly lives up to the Hallicrafters ideal of "the radio man's radio."

From now on watch Hallicrafters—the name that's remembered by the veteran, preferred by the radio amateur. See your distributor for demonstration of the SX-42 and for colorful literature describing this great set in complete technical detail.

Because of the precise and thorough engineering that must be done on the SX-42 and because the parts supply has not been continuous, top production peaks have not yet been reached. In the immediate future deliveries will necessarily run behind the demand, but the SX-42 is definitely worth waiting for.

$250.00
Amateur Net

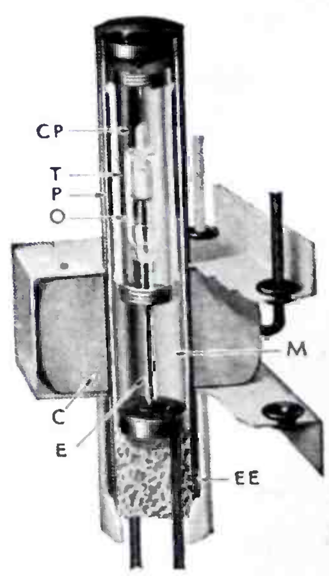
Adjustable Base for "eye-angle" tuning No. B-42
$7.50 APPROXIMATE



hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.
Sole Hallicrafters Representatives in Canada: Rogers Majestic Limited, Toronto-Montreal

BUILDERS OF *Skyfone* AVIATION RADIOTELEPHONE



CP
T
P
O
M
C
E
EE

Another Great -*hp*- Instrument

NEW -*hp*- Model 610A UHF SIGNAL GENERATOR

500 to 1350 Mc!

Here it is—a compact, highly-practical UHF signal generator for general laboratory use.

The -*hp*- model 610A Signal Generator is an outstanding addition to the -*hp*- family. It is designed to provide an extremely stable laboratory standard for tests and measurements between 500 Mc and 1350 Mc. Throughout these frequencies it supplies accurately known voltages ranging from 0.1 microvolt to 0.1 volt. R-f output may be continuous, amplitude modulated, pulsed, or square-wave modulated. Pulse length can be controlled between 2 and 50 microseconds, and pulse rate is variable from 60 to 3000 times per second.

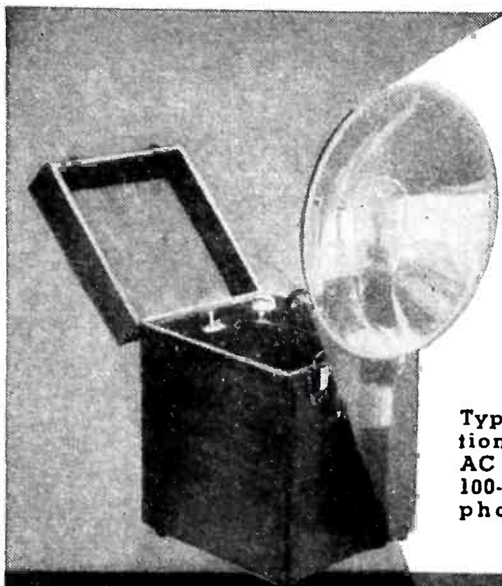
The -*hp*- model 610A is particularly valuable in the UHF field when determining gain or alignment, antenna data or standing wave ratios. It is admirably suited to measurement of single-stage or conversion gain, signal-to-noise ratio, circuit "Q," and transmission line characteristics.

This war-born instrument, complete with post-war refinements and easy-to-operate controls, is now ready for delivery. Write today for more details of this important new -*hp*- instrument!

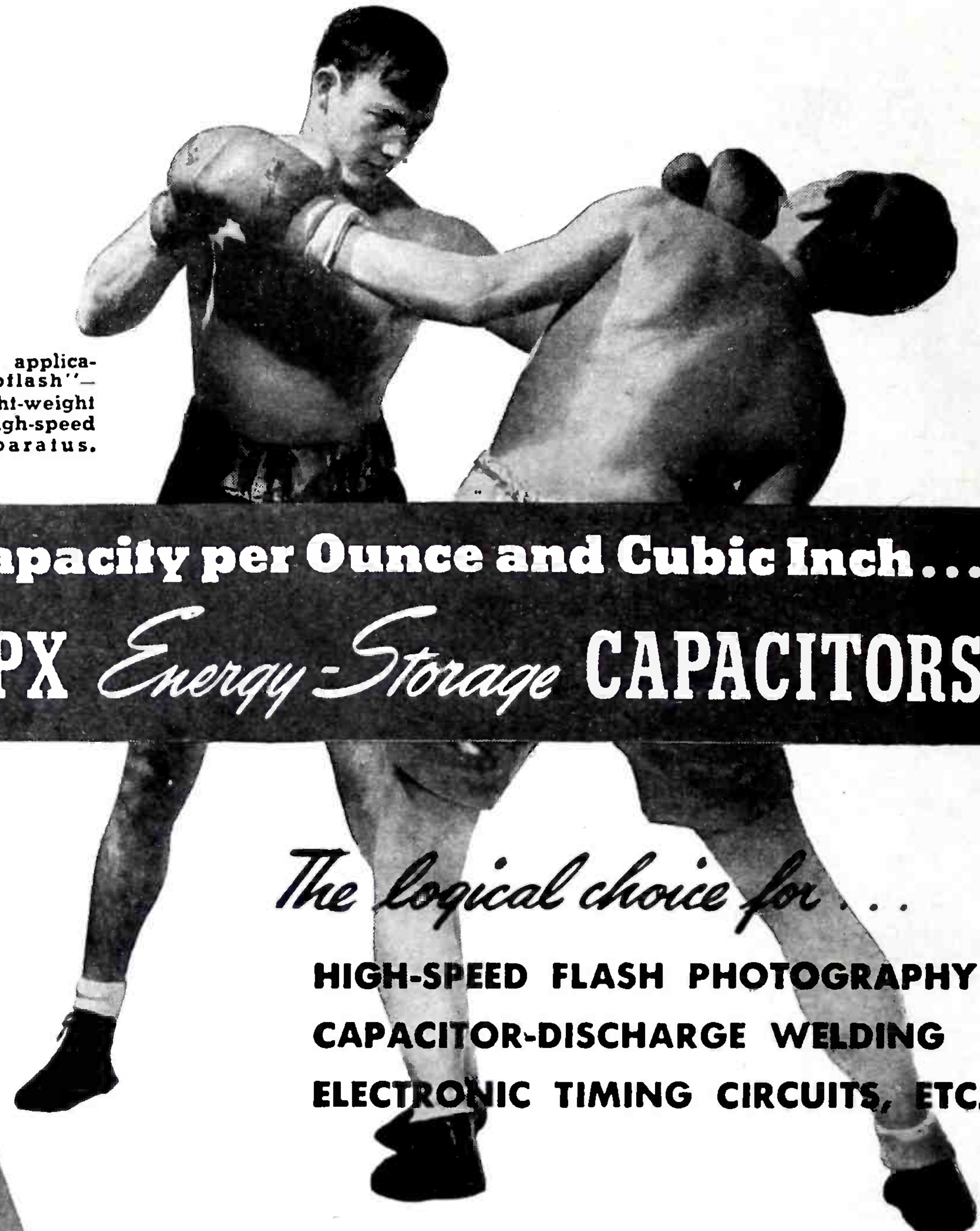
HEWLETT-PACKARD COMPANY
1324A PAGE MILL ROAD, PALO ALTO, CALIFORNIA

LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

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

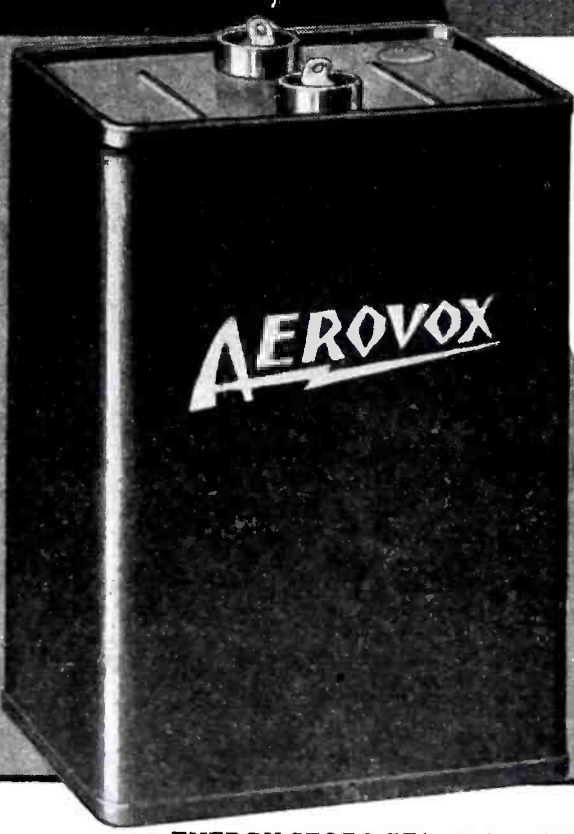


Typical discharge application—the "Syncroflash"—AC operated light-weight 100-watt-second high-speed photo-flash apparatus.



Maximum Storage Capacity per Ounce and Cubic Inch...

AEROVOX SERIES PX *Energy-Storage* CAPACITORS



12.5 mfd. 4000 volt DC peak Hyvol Energy-Storage Capacitor.

The logical choice for...

HIGH-SPEED FLASH PHOTOGRAPHY
CAPACITOR-DISCHARGE WELDING
ELECTRONIC TIMING CIRCUITS, ETC.

ENERGY STORAGE* CAPACITORS
PREFERRED RATINGS

WATTS—SECONDS	VOLTS—E	TYPE NO.	DIMENSIONS HT.	WT. LBS.
22.5	1.5 KVDC peak	PX10F1	2½ x 3¾ x 4⅝	2¾
50	1.8 " "	PX13D1	4-9/16 x 3¾ x 4⅝	4⅜
50	2.0 " "	PX14D2	4-9/16 x 3¾ x 4⅝	4⅜
100	2.5 " "	PX15D1	4-9/16 x 3¾ x 6½	6⅛
75	3.0 " "	PX18D1	4-9/16 x 3¾ x 4⅝	4⅜
550	3.0 " "	PX22F1	5⅛ x 13½ x 13	App. 64
100	4.0 " "	PX20D1	4-9/16 x 3¾ x 4⅝	4⅜
500	4.0 " "	PX32F1	5⅛ x 13½ x 13	63

Stored Energy = ½ CE^2 Watts-Seconds (C in farads)

● Interested in storing a large amount of energy in a small space—and at low cost, first and last?

If so, Aerovox Series PX Energy-Storage Capacitors are your logical choice. Here's why:

Light. Fast discharge. Easily installed. Exceptionally rugged mechanically and electrically. Time-proven Hyvol impregnant and fill for the generously-proportioned paper-and-foil sections, insures dependable service and longest life. Positively the maximum energy-storage with minimum bulk and weight.

Preferred ratings available for prompt delivery, are listed at left. Other ratings can be designed and made to order for exceptional requirements.

● Our engineers will gladly discuss the advantages of Aerovox Energy-Storage Capacitors as applied to your specific problems or needs.

AEROVOX capacitors

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

AEROVOX CORPORATION, NEW BEDFORD, MASS., U.S.A.

SALES OFFICES IN ALL PRINCIPAL CITIES • Export: 13 E. 40th ST., NEW YORK 16, N. Y.

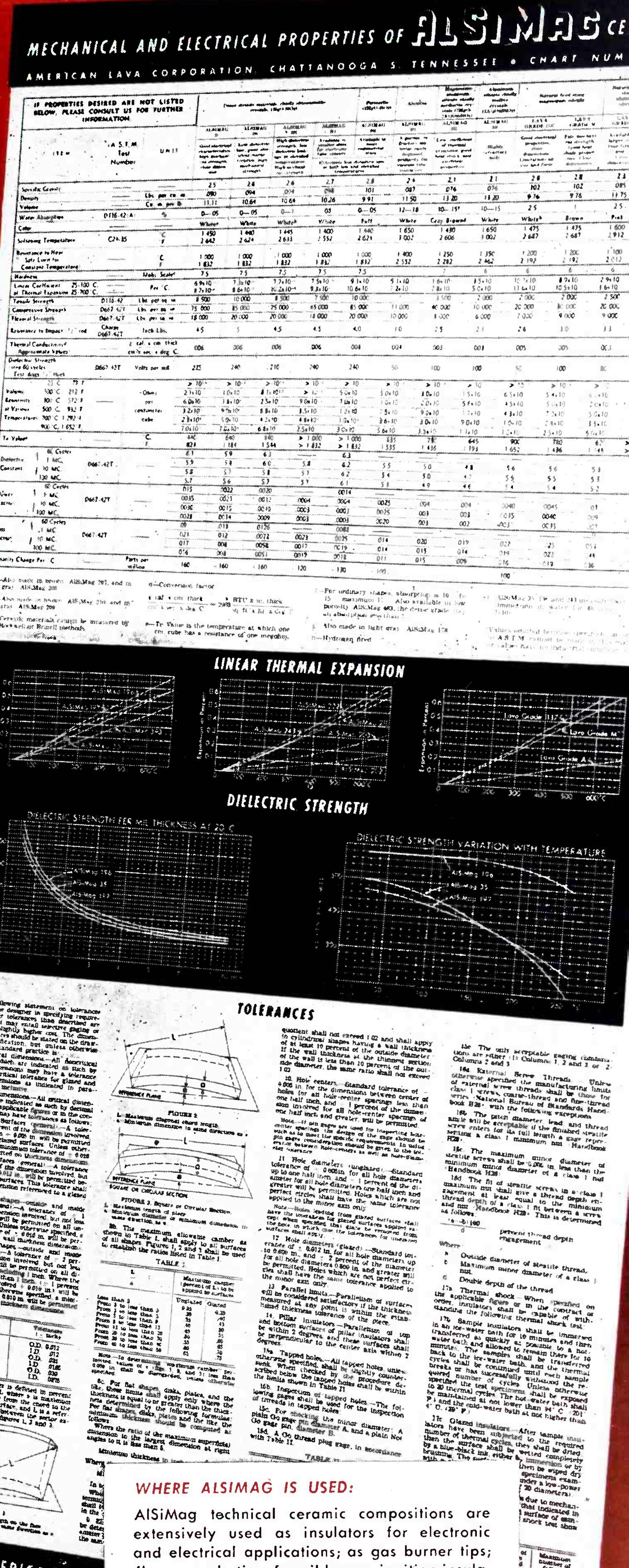
Cable: 'ARLAB' • In Canada: 'AEROVOX CANADA LTD., HAMILTON, ONT.

New Property Chart of ALSIMAG

TRADE MARK REGISTERED U.S. PATENT OFFICE

echnical ceramic compositions

SENT FREE ON REQUEST



WHAT ALSIMAG IS:

AlSiMag is the trade name of a large family of echnical ceramic compositions. These compo-itions have different physical, electrical, me-chanical and chemical characteristics. AlSiMag parts are custom made to specifications.

WHAT THE CHART TELLS:

The properties of the more frequently used AlSiMag compositions have been accurately determined and reproduced in chart form for quick reference.

ALSIMAG COMPOSITIONS NOT ON CHART:

Many special AlSiMag compositions have been developed to meet specific conditions. These are too numerous to chart. If chart indicates gen-eral characteristics of value, modifications to suit your special application may be available.

WHO NEEDS THE CHART:

Any designing engineer, production technician or purchasing agent will find chart helpful in his search for materials for unusual applications.

HOW TO GET THE CHART:

The AlSiMag Property Chart is sent free on re-quest. Request as many copies as you need to cover your organization. Write to:

AMERICAN LAVA CORPORATION

44TH YEAR OF CERAMIC LEADERSHIP

CHATTANOOGA 5, TENNESSEE

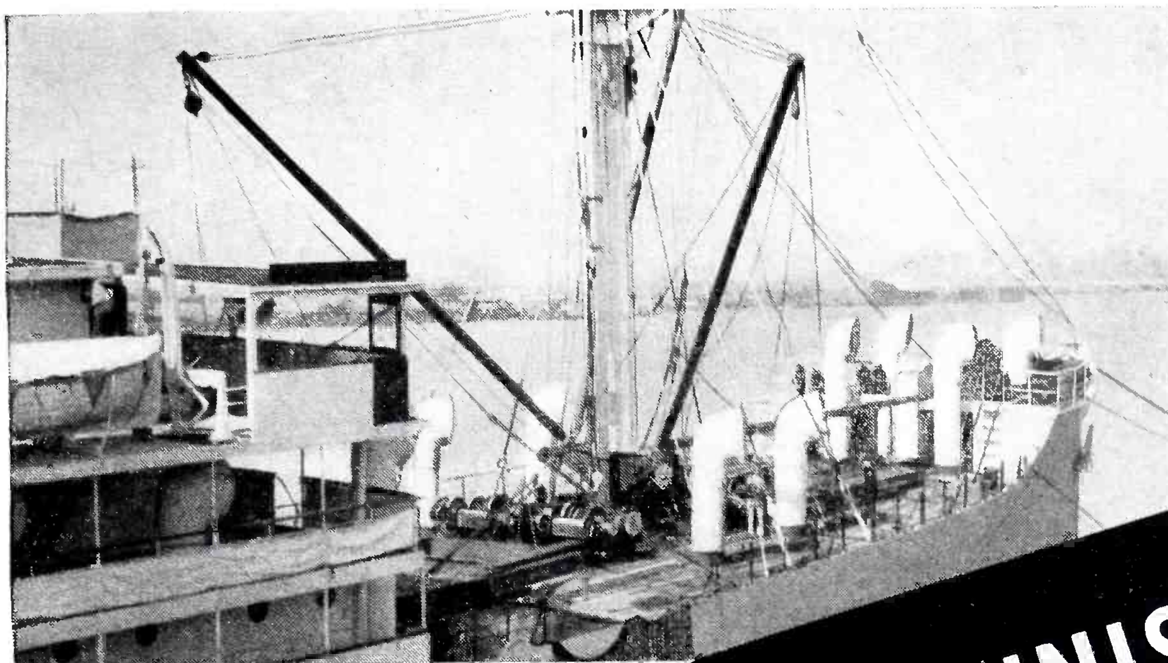
ENGINEERING SERVICE OFFICES: ST. LOUIS, Mo., 1123 Washington Ave., Tel: Garfield 4959 • NEWARK, N. J., 671 Broad St., Tel: Mitchell 2-8159 • CAMBRIDGE, Mass., 38-B Brattle St., Tel: Kirkland 4498 • CHICAGO, 9 S. Clinton St., Tel: Central 1721 SAN FRANCISCO, 163 Second Street, Tel: Douglas 2464 LOS ANGELES, 324 N. San Pedro St., Tel: Mutual 9076

Printed one side only, folded to file size. For use under desk glass or as a wall chart or in standard file.

WHERE ALSIMAG IS USED:

AlSiMag technical ceramic compositions are extensively used as insulators for electronic and electrical applications; as gas burner tips; flame nozzle tips; for oil burner ignition insulators; spray nozzles; as thread guides for abrasive yarns; as extrusion or spinnerette heads in certain fibre or chemical processes; as cores and inserts for precision castings; in work holders for electronic heating devices—in short wherever electricity, heat, chemical or certain abrasive or friction conditions must be controlled.

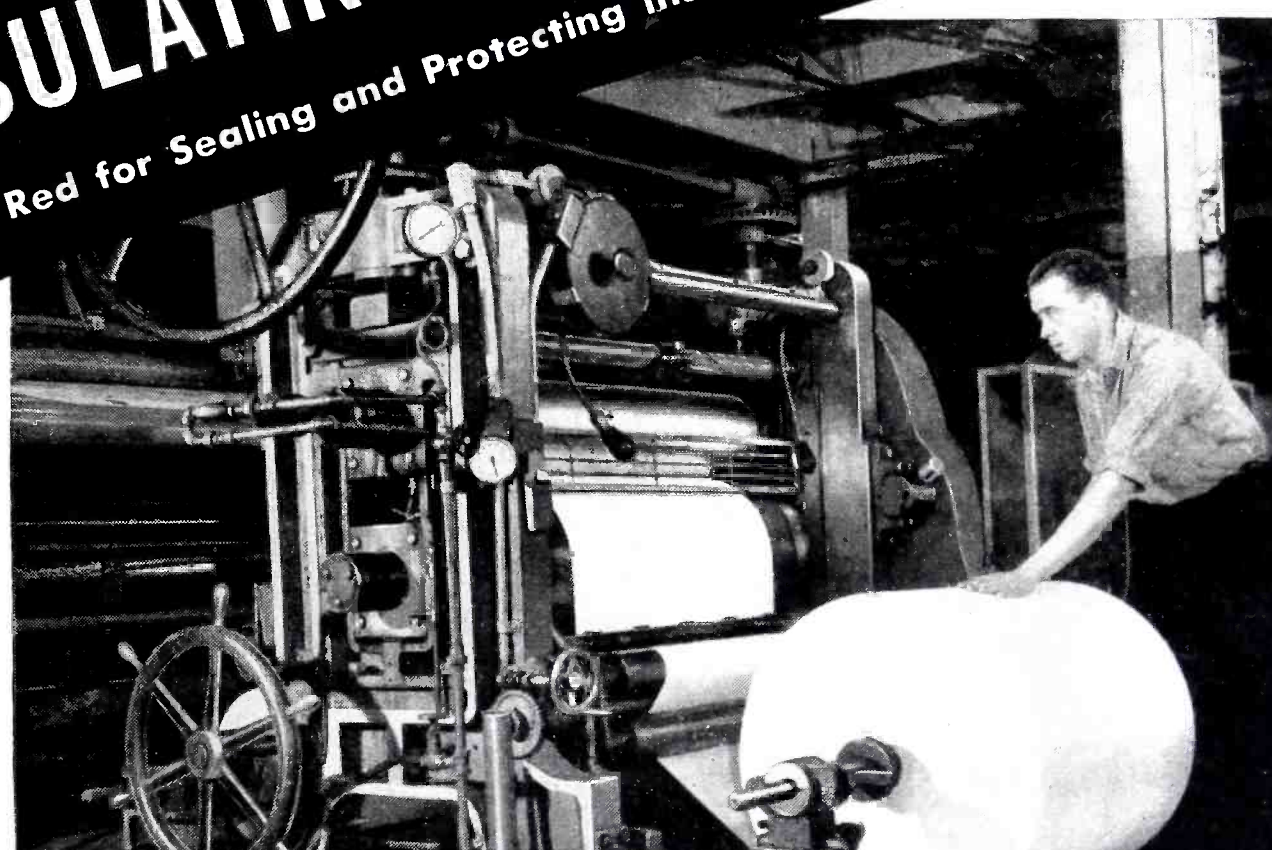
No electrical equipment can be any better than its insulation



This insulating finish was used on cargo vessels during the war to protect the efficiency of vital deck motors

G-E INSULATING FINISH 1201

Glyptal Red for Sealing and Protecting Insulated Surfaces



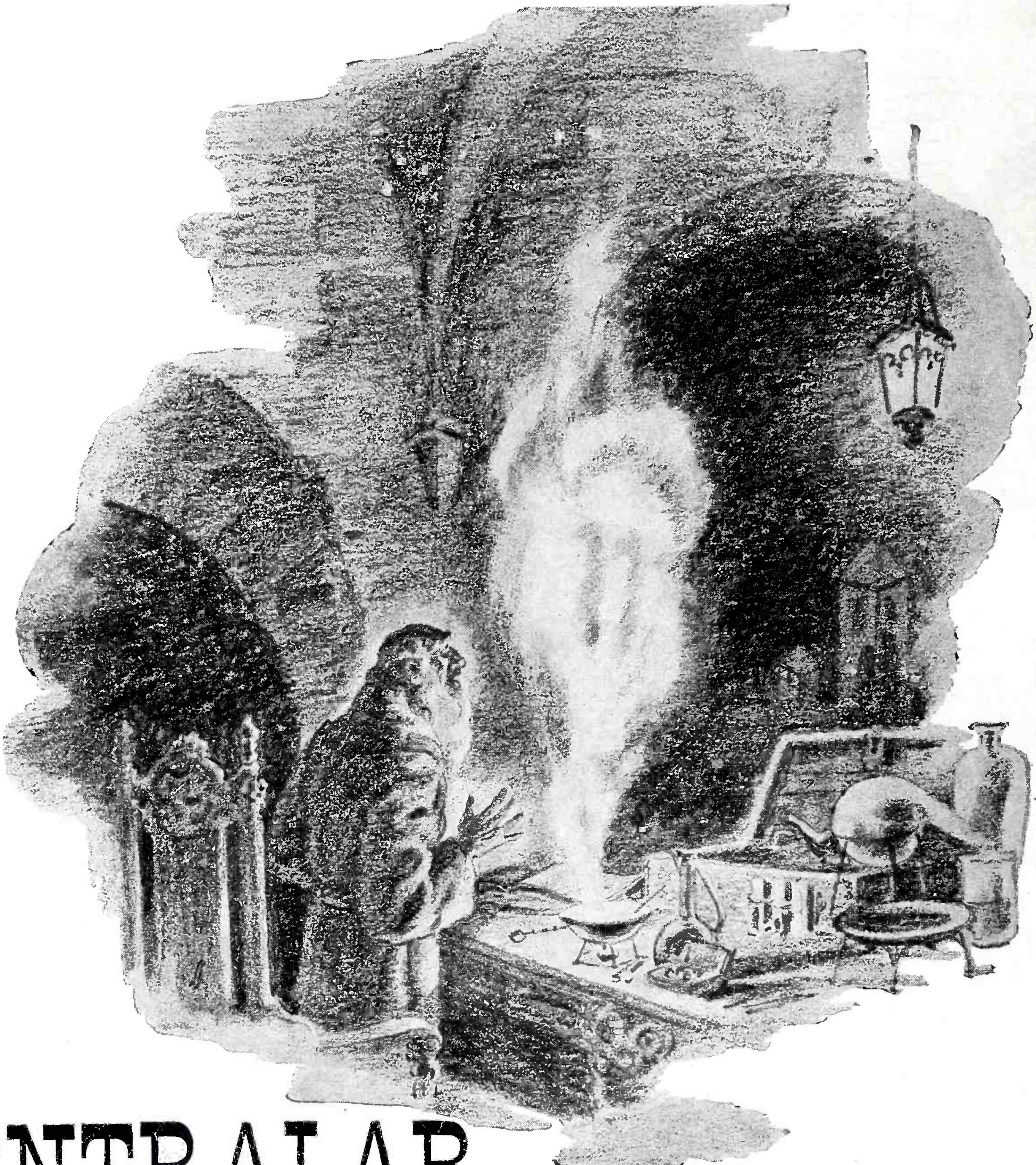
. . . and the same Glyptal Red is now in wide use to finish off induction motors in paper mills and other industrial plants.

GENERAL ELECTRIC has long been a leader in the field of scientific insulation. Better insulation had to come before each forward step of the electrical industry. When you specify G-E Insulating Varnishes, you invest in 45 years of experience . . . uniformity assured by G-E Quality Control . . . expert advice on any kind of application. For details consult your local G-E Merchandise Distributor. Or write direct to Section RIMA-12614, Resin and Insulation Materials Division, Chemical Department, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

CD46-17

G. E. OFFERS A COMPLETE LINE OF INSULATING MATERIALS



CENTRALAB

takes the "Mystery" out of CERAMICS

CENTRALAB controls porosity in ceramics. • Centralab controls heat-shock characteristics. Centralab controls physical strength. • Centralab holds tolerances of $\pm$ .001″ where grinding is feasible. Centralab is prepared to supply you with ceramics harder than the hardest quartz (7½ on Moh Scale). If you need a versatile ceramic for specialized or standard applications, invoke the magic name of Centralab.

Send for Bulletin No. 720

Centralab CRL

Division of GLOBE-UNION INC., Milwaukee

PRODUCERS OF

Silver Mica Capacitors
Bulletin 630

Ceramics
Bulletin 720

Ceramic Trimmers
Bulletin 630

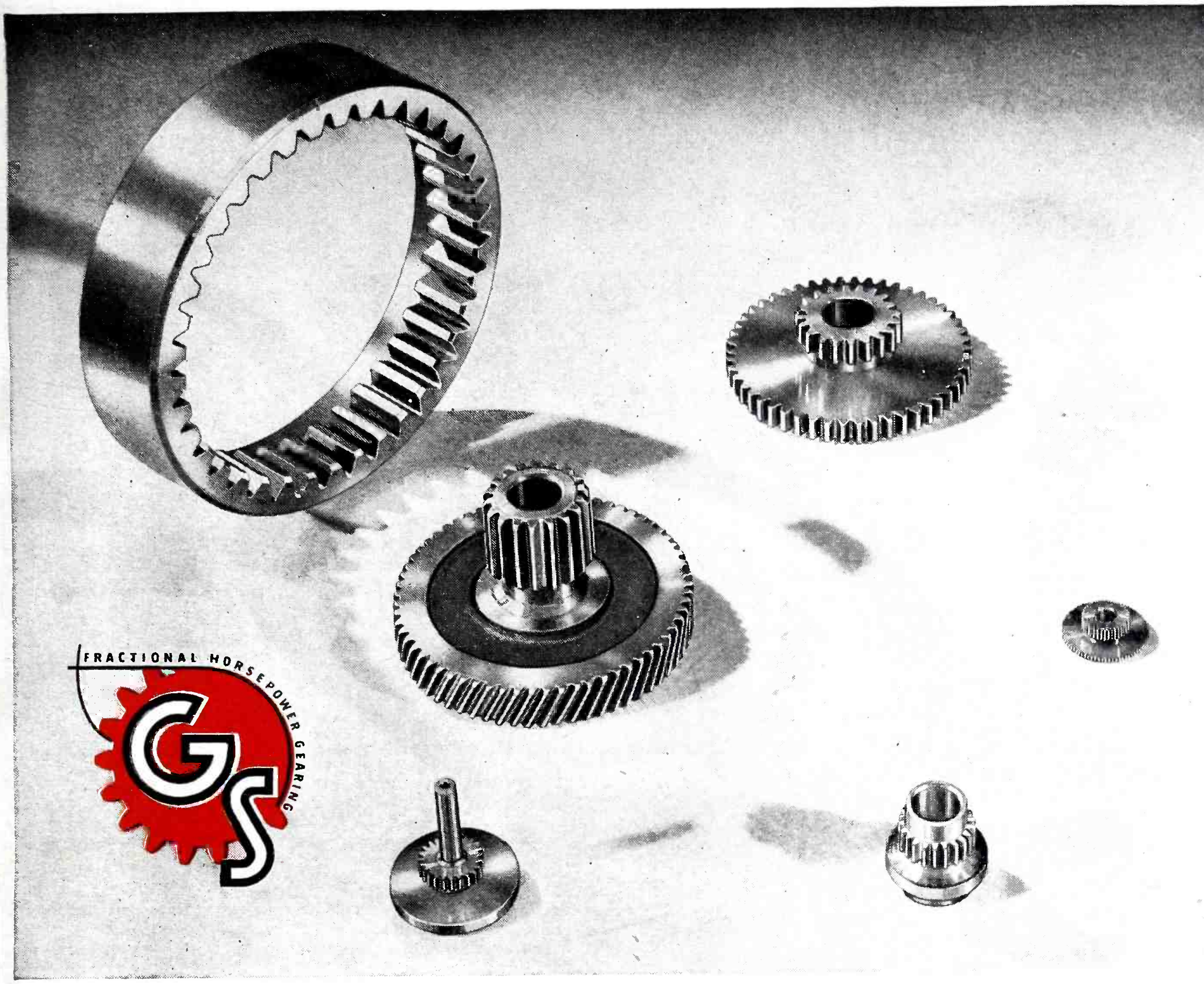
Ceramic High Voltage Capacitors
Bulletin 630

Radiohms
Bulletin 697

Tubular Ceramic Capacitors
Bulletin 630

Ceramic Plate Capacitors
Bulletin 630

Selector Switches
Bulletin 722



GO TO A *Specialist* WHEN YOU WANT THE BEST

That's usually good advice whether you want gherkins, or guns or . . Gears! Here at G.S. we've been specializing for more than a quarter century on making Fractional Horsepower Gears *exclusively*. Methods, and manpower, and machinery . . all have been raised to the highest possible efficiency . . all concentrate upon producing gears in quantity to a degree of *uniform* excellence unapproached, we believe, in the history of Small Gear Manufacture. For your own best interests, submit your fractional horsepower gear problems to our competent staff. Write today for the new G.S. catalog bulletin.

GEAR Specialties

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

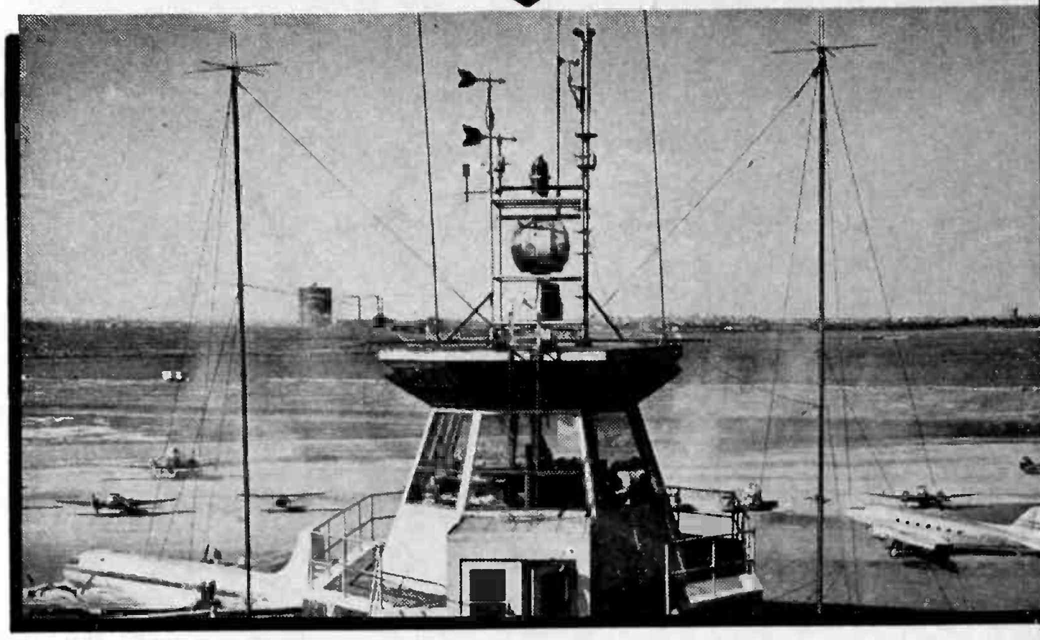
2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

Radio Receptor equipment has given the LaGuardia control tower dependable communications with more than 2,000,000 flights.

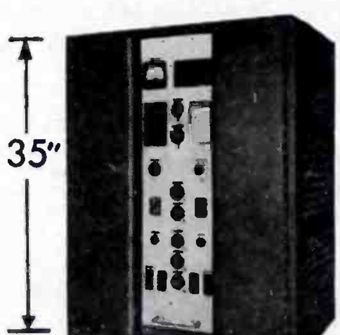
Radio Receptor equipment controls traffic 24 hours a day at New York's LaGuardia Field.

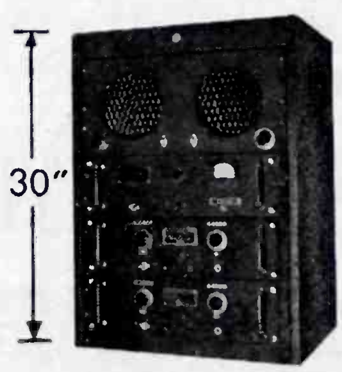


RADIO RECEPTOR EQUIPMENT

handles over 2,000,000 flights AT LAGUARDIA

With a military communications background so successful that no Radio Receptor equipment has been declared surplus, we are now working closely with the government agencies to provide the new commercial equipment so sorely needed by airports and airlines today.





(Right) Receiver unit consisting of 2 fixed frequency crystal controlled VHF or LF airport receivers, microphone, speaker panels and remote control. *(Left)* VHF or LF Transmitter unit.

CONTINUOUS operation at LaGuardia Field gives daily proof of the reliability of Radio Receptor communications equipment. Radio Receptor low-frequency equipment shown above has helped handle an average of 640 flights per day ever since its installation when the tower was built.

Also at LaGuardia, Radio Receptor VHF equipment was chosen to serve American Overseas Airlines after thorough testing at distances up to 225 miles. Like the low-frequency equipment in the field's control tower, this VHF gear handles Flagship flights with day-in-day-out dependability.

DEPENDABLE, LOW-COST RADIO FOR THE *SMALL* AIRLINE AND AIRPORT, TOO

Now, Radio Receptor's "packaged radio station" RSV-1 offers dependable ground-air communications to the small airport and airline at a price well within the small operating budget. The RSV-1 is a *complete* VHF communications system . . . yet it costs less than a light plane. In two compact cabinets the RSV-1 contains a 50-watt transmitter, two receivers, two speakers, and remote control unit . . . antennas and microphone are also included. The RSV-1 is easily installed . . . it requires no alterations in existing field facilities. It's easily maintained . . . all chassis assemblies roll out of cabinets for during-operation checks. It's easy to operate . . . one of your present staff can learn to use the RSV-1 quickly.

Standard Radio Receptor equipment also includes "packaged low-frequency radio station" RSL-1, 25 to 3000 watt transmitters and receivers for all ground-air communications bands. Special Radio Receptor equipment covers all phases of ground-air radio communications and navigational aids. Mail coupon today for details.

2115

Please send me the bulletins checked: C-13

- ☐ "Packaged Radio Station RSV-1" (VHF)
- ☐ "Packaged Radio Station RSL-1" (low frequency)
- ☐ LF Transmitter (Bulletin No. 5009)
- ☐ HF Receiver (Bulletin No. 5008)
- ☐ VHF Receiver (Bulletin No. 5007A)
- ☐ VHF Transmitter (Bulletin No. 5006)
- ☐ "Highways of the Air" (the story of airway radio)

Name ____________________

Position ____________________

Company ____________________

Address ____________________

City ____________ State ____________

Communications Division

RADIO RECEPTOR COMPANY, INC.

Since 1922 in Radio and Electronics

251 West 19th Street
New York 11, N. Y.

Export Representatives: RCA International Division, New York

Constant Voltage

Let's face the fact . .

CONSTANT VOLTAGE IS YOUR PROBLEM

When wide and violent voltage disturbances strike your equipment, do you realize what happens—

—*to costly filaments and tubes?*

—*to precision parts?*

—*to sensitive, balanced circuits?*

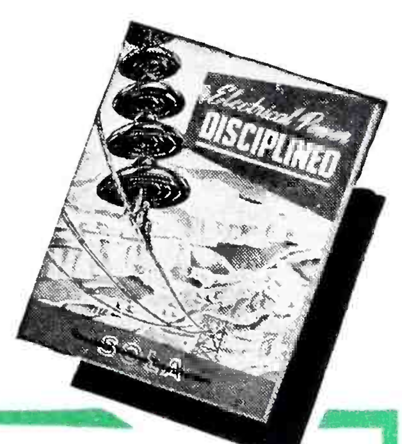
—*to over-all efficiency?*

—*to customer good-will?*

Constant Voltage is *your* problem. You specify on your label the voltage at which your equipment will perform at peak efficiency and without damage. But, unless *you* provide that voltage as a "built-in" component it will never be consistently available.

A SOLA Constant Voltage Transformer can be "built-in" without saddling your equipment with prohibitive costs. In fact, there are many instances where it has been accomplished at an actual saving over original design estimates, through the elimination of other costly components and drastic reductions in anticipated service calls during the guarantee period.

There are 31 standard types of SOLA Constant Voltage Transformers available in capacities ranging from 10VA to 15KVA. If none of these prove suited to your requirements, special units can be custom-designed to your exact specifications.



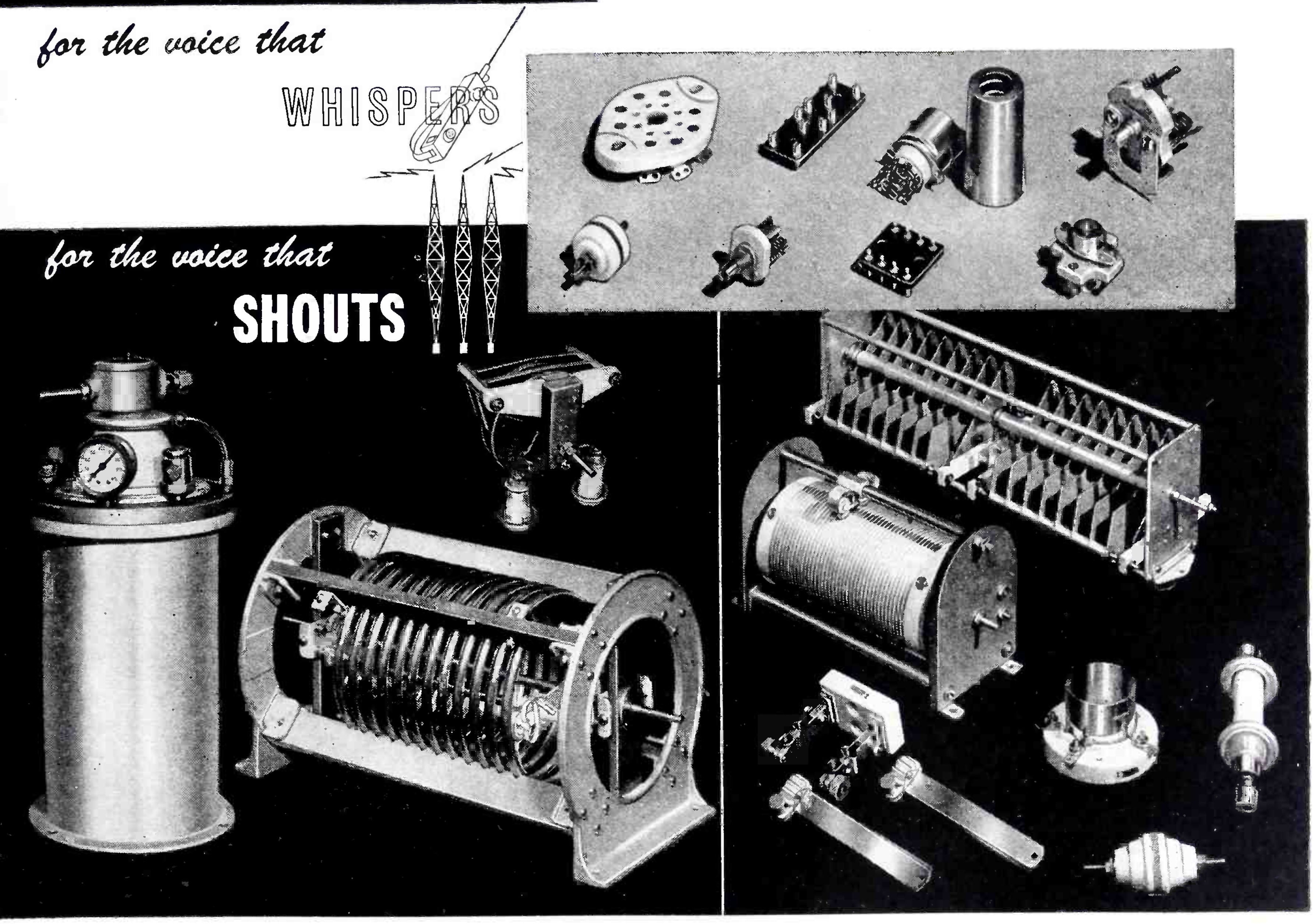
Write for Bulletin DCV-102
Here you'll find the answer to a problem that confronts every manufacturer and user of electrical or electronic equipment.

SOLA *Constant Voltage* **TRANSFORMERS**

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. **SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois**

Manufactured in Canada under license by FERRANTI ELECTRIC LIMITED, Toronto

JOHNSON COMPONENTS



If you design or build electronic equipment no smaller than a handy-talkie, no larger than a 50 KW transmitter there are JOHNSON components "your size." Many of the small parts above find application in circuits operating at battery voltages. The miniature socket for instance is a modification of a predecessor that floated down over Europe in a handy-talkie with the paratroopers. They're catalog items with the exception of the terminal boards which typify JOHNSON ability to manufacture special assemblies quickly, easily and economically. The miniature condenser is an inch and half overall, has .015" spacing, 12 mmf. maximum and 3 mmf. minimum capacity. On the large side of the condenser family are the pressurized nitrogen-dielectric condensers offering RMS voltage ratings to 30,000 V capacities to 10,000 mmf., and highest capacity to mounting space ratios. Similar comparisons might be made with the other JOHNSON components.

Between the large and small above there's a big JOHNSON line from which to choose. Check the list below for parts you need. You'll find them carefully designed, skillfully manufactured. For more information write department D today.

Johnson Products Include

Condensers • R. F. Chokes • Connectors • Pilot and Dial Lights
Directional Antenna Equipment • Inductors • Q Antennas • Plugs & Jacks
Broadcast Components • Tube Sockets • Insulators • Hardware

JOHNSON
a famous name in Radio

. F. JOHNSON CO., WASECA, MINNESOTA

RATINGS

Filament voltage	6.3 v
Filament current	250 amp
Grid-plate transconductance	12,000 mhos
Interelectrode capacitances:	
Grid-filament	28.5 mmfd
Grid-plate	20 mmfd
Plate-filament	0.55 mmfd
Frequency at max ratings	110 mc
Type of cooling	forced air
Plate ratings per tube, Class C power amplifier, grounded-grid circuit (key-down conditions without modulation):	
Max voltage	7,500 v
Max current	2 amp
Max input	12 kw
Max dissipation	4 kw
USEFUL POWER OUTPUT, typical operation (at 6,000 v and 1.3 amp)	6.4 kw

- **High power output—see ratings!—yet forced-air cooled for convenience of installation.**
- **Frequency up to 110 mc at max plate input.**
- **Ultra-modern in design and electrical characteristics.**
- **G-E Ring-Seal construction gives large terminal-contact areas.**
- **COMPACT and sturdy. Built to "take it" in hard station service.**

BROADCAST stations that prefer forced-air cooling, and builders of transmitters for this type service, both will welcome General Electric's Type GL-5518 triode—a NEW v-h-f tube with plenty of power, modern in every way, able to meet the exacting demands of FM with plus-marks for its performance.

A pair of GL-5518's, operating conservatively in a grounded-grid amplifier, will put out more than 12½ kw of power. *Usually the GL-5518 needs no neutralization in grounded-grid circuits;* but when required, a small amount of fixed neutralization suffices over a wide frequency band.

To these features should be added:

1. Extremely low lead inductance.
2. Minimum r-f losses due to silver-plating all external metal parts.
3. Topnotch electrical efficiency from generous ring-seal terminal-contact areas.

Let G-E tube engineers work with you to apply the GL-5518 to new equipment for the big FM broadcast market that favors air-cooling. Phone your nearby G-E office, or write *Electronics Department, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

161-F15-8850

FIRST AND GREATEST NAME IN ELECTRONICS

INSTANT ACTION

- when you want it
- where you want it . . . . . with

alliance MOTORS

The New Model A shaded pole induction type motor. 1/30th horsepower, size 2¾ inches x 4⅝ inches, for voltages up to 220 and frequencies of 50 or 60 cycles. Suitable for driving fans, and for continuous or intermittent duty.

Alliance Powr-Pakt Motors are manufactured in shaded pole induction, and split phase resistor type. Ratings range from less than 1/400th up to 1/20th horsepower.

New uses for the Powr-Pakt line! Heating and ventilating controls, opening and closing valves, rotating fans, electronic and electric controls, signals, automatic dispensers, turntable drives, automatic tuning devices, radio controls.

Modern design calls for "tailored power"

Alliance motors are rated as low as 1/400th h.p. on up to 1/20th h.p. They are small, compact and some weigh less than one pound. They furnish economical driving energy to meet the special demands of small loads. Some are uni-directional—others are reversible—some are for continuous duty—others for intermittent operation.

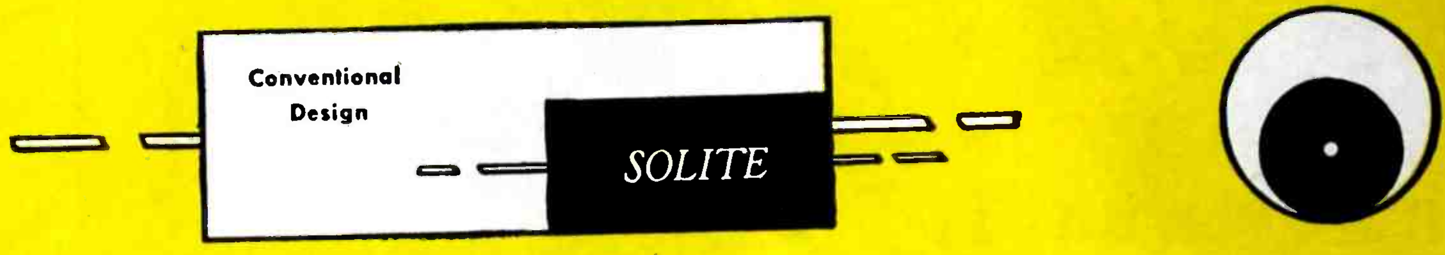
Alliance Powr-Pakt motors are mass produced, precision made and low in cost. They can help you get *instant action*—when you want it—and where you want it! Write today.

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

SOLITE* CAPACITORS

new! startlingly smaller!



ACTUAL SIZE 1 MF, 200 WVDC

TODAY'S trend to ultra-compact electronic designs strides forward with this remarkable, new Solar development in truly tiny paper capacitors.

*SOLITE** Capacitors, utilizing a unique, revolutionary self-healing metallized paper construction, occupy approximately one-third to one-fourth the volume of equivalent conventional multi-paper capacitors. There is a similar saving in weight.

A comparison of typical ratings in tubular types tells its own story:

Dimensions in Inches							
Capacitance	WVDC	SOLITE		Conv. Design		Weight in Ounces	
(mf)		Length	Diam.	Length	Diam.	SOLITE	Conv. Design†
0.1	200	5/8	3/8	1 5/8	1/2	0.08	0.32
0.5	200	1 1/8	15/32	2	11/16	0.13	0.75
1.0	200	1 1/8	17/32	2 1/2	13/16	0.26	1.15
1.0	400	2 1/8	11/16	2 1/2	1	0.69	1.75

† Based on aluminum foil construction. Lead foil capacitors will be still heavier.

*SOLITE** Capacitors are available in both non-metallic and metallic housings in standard d-c voltage ratings up to 400 volts. *SOLITE** Capacitors are also supplied for alternating current applications.

Pilot quantities of *SOLITE** Capacitors may be had immediately. Solar is prepared to discuss delivery schedules of production quantities for your use in those specific applications where you can take best advantage of this important new advance in the capacitor art.

Full details of *SOLITE** Capacitors may be obtained on letterhead request from: Solar Manufacturing Corporation, 285 Madison Avenue, New York 17, N. Y.

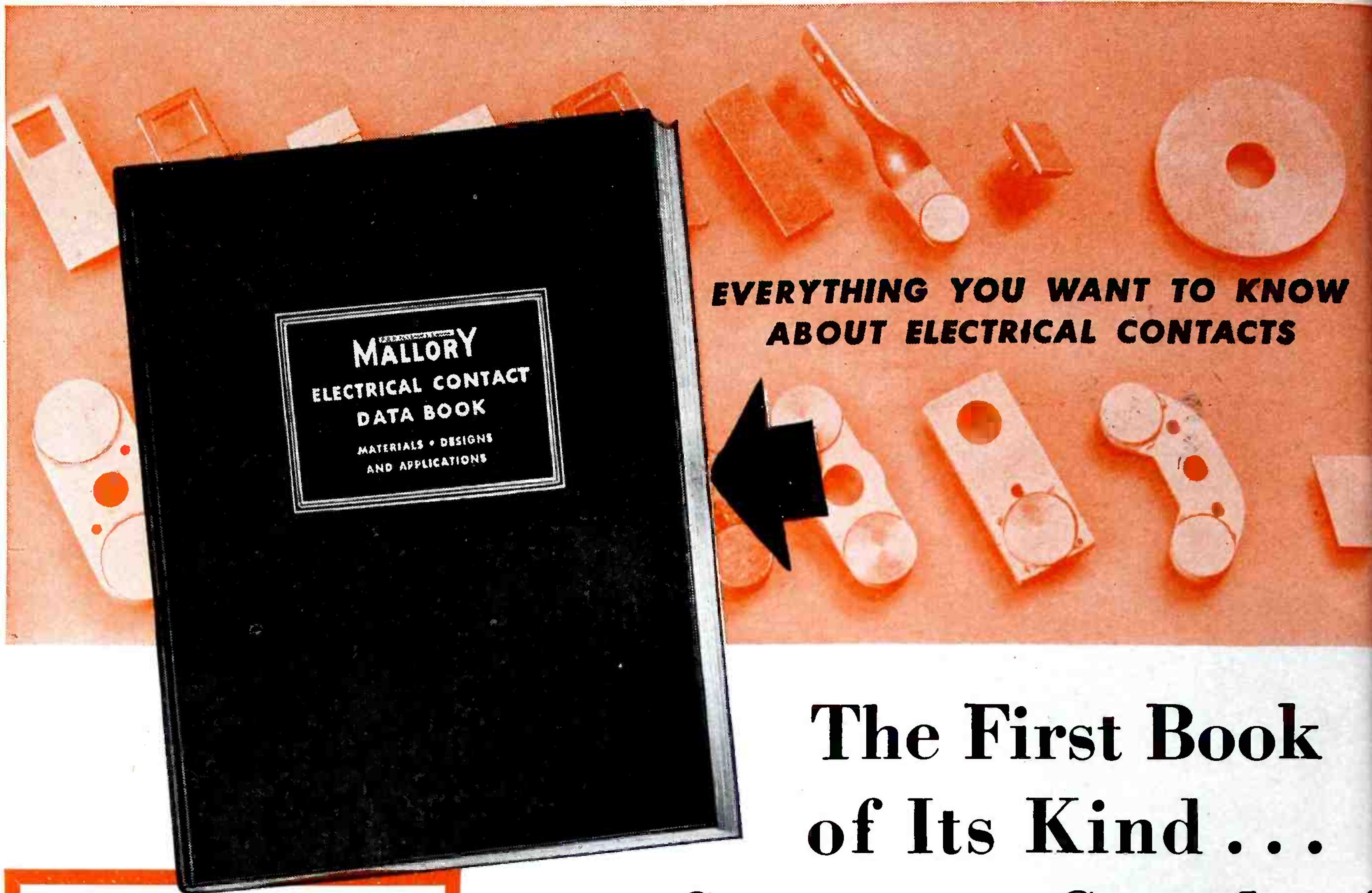
"WHEN SPACE IS TIGHT, USE *SOLITE*"

* Trade Mark

SOLAR

SOLAR CAPACITORS

"Quality Above All"



The First Book of Its Kind . . .

Competent, Complete!

A Summary of Contents

- Fundamentals of Electrical Contacts
- Selection of Contact Materials
- Contact Design, Assembly Methods and Maintenance
- The Automotive Battery Ignition Systems
- Contacts for Low Voltage Type Voltage and Current Regulators
- Contact Materials in Circuit Breakers
- Sliding Contacts
- Fundamentals of Electricity for Contact Applications
- Miscellaneous Tables — Engineering Data

Until recently there was very little published information on electrical contacts. What information existed was scattered in magazine articles and in two obscure books published abroad.

Now comes the first "encyclopedia" on the subject — a volume so comprehensive that it includes the latest there is to know about contact design, construction, application and materials . . . so completely up-to-date that it includes theories that have yet to be established, opinions that have yet to be proved. This is because the subject, even at this late date, has many controversial aspects.

Five years in the writing, the Mallory Contact Data Book belongs in every engineering library. Its combination of scientific facts, observations, first-hand experiences cannot be duplicated anywhere else. To recognized engineers writing on company letterhead, the book is free. To others, it is available at our printing cost — $2.50. *The Contact Data Book is still another example of Mallory's desire to provide helpful material for those who have a professional interest in the fields we serve.*

P. R. MALLORY & CO. Inc.
MALLORY ELECTRICAL CONTACTS & CONTACT ASSEMBLIES

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

CROSS TALK

▸**DEFINITION** . . . At the National Electronics Conference, Dr. E. U. Condon, Director of the Bureau of Standards, proposed a new definition of electronics: "the science, art and industry concerned with electrical phenomena involving charged atomic particles outside of solid and liquid bodies." In so doing Dr. Condon welcomes to the confraternity of particles, once limited to electrons and ions, several brothers and sisters, the positron, proton, alpha particle, deuteron and meson. Only the chargeless neutron and neutrino are excluded. There was a time when a respectable science could be built on just one particle, but that time has passed. There seems to be no fundamental conflict between Dr. Condon's proposition and the hallowed definition of the AIEE, "That branch of science and technology which relates to the conduction of electricity through gases and in vacuo." But the family of conductors has grown with the years.

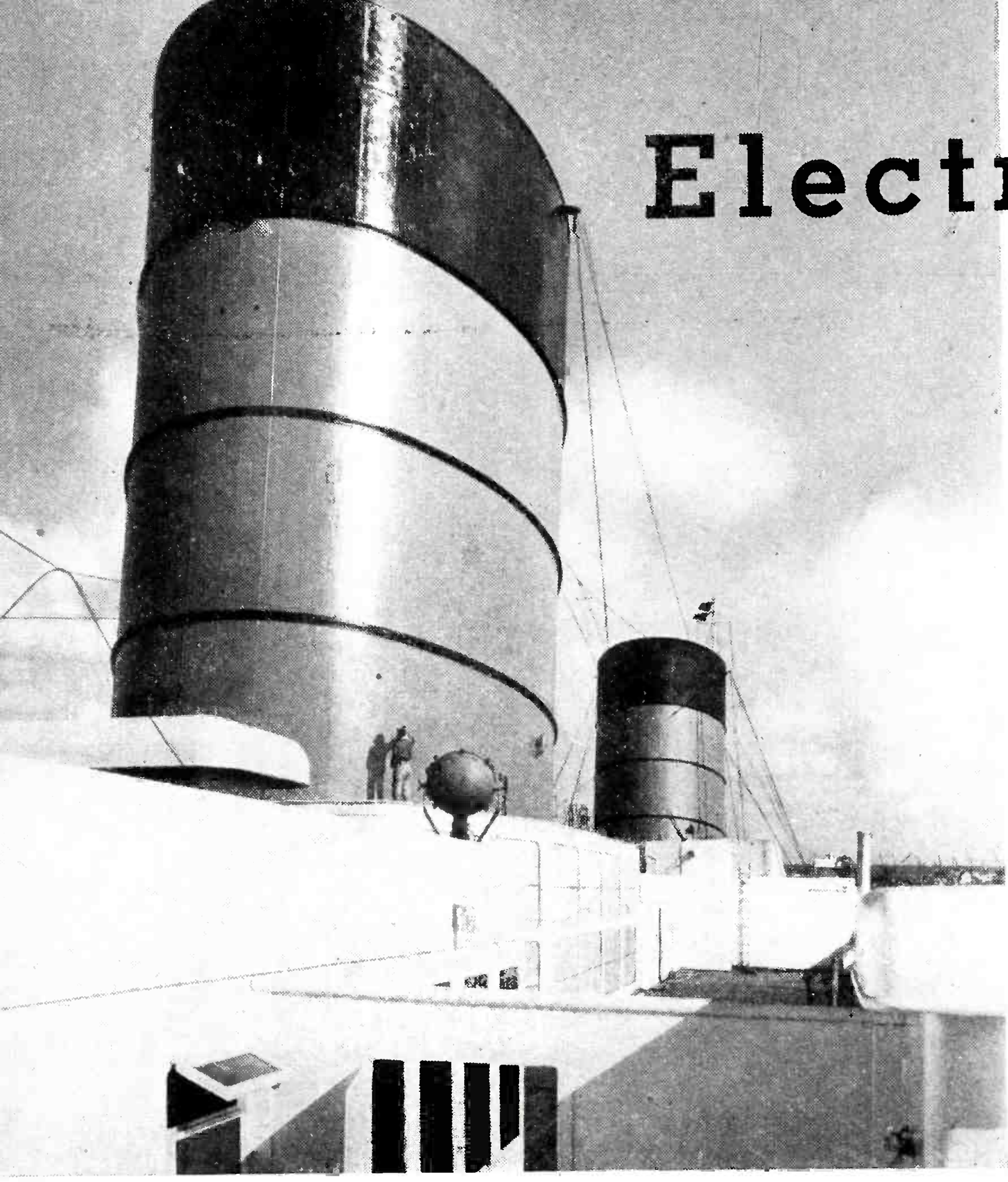
Speaking of definitions, we find the radio engineer defined by the Canadian Council of the I.R.E. as one who combines in himself some proportion of the electrical engineer, the business man and the physicist. Like many a true word, this definition is likely to be resented by all parties mentioned!

▸**SKYWAVES** . . . Radio and astronomy seem to be crossing paths regularly these days. First were the Signal Corps radar echoes from the moon. Then M. W. Baldwin of Bell Labs reported the existence of mysterious echoes from regions in the atmosphere about two kilometers high. These objects or regions are invisible to optical telescopes, but are regularly observed on 10-cm and 3-cm radars, moving about 30 miles an hour, sometimes with the wind, sometimes against it. Source unknown. More recently, the meteor showers in October were thoroughly watched by radio and radar. Individual meteors were tracked by radar at White Sands, New Mexico, using equipment set up to track the V-2 rockets. J. A. Pierce and his group at Harvard recorded meteor whistles (Doppler beats caused by reflection from the meteor of a steady c-w carrier) during the showers. Pierce also successfully recorded the "artificial" E-layer induced by a meteor shower, and has traced the ionization from the aurora borealis in a cathode-ray picture which bears a striking resemblance to the visible aurora. After years of effort aimed ultimately at destruction, these new fields of activity have all the freshness of a spring breeze.

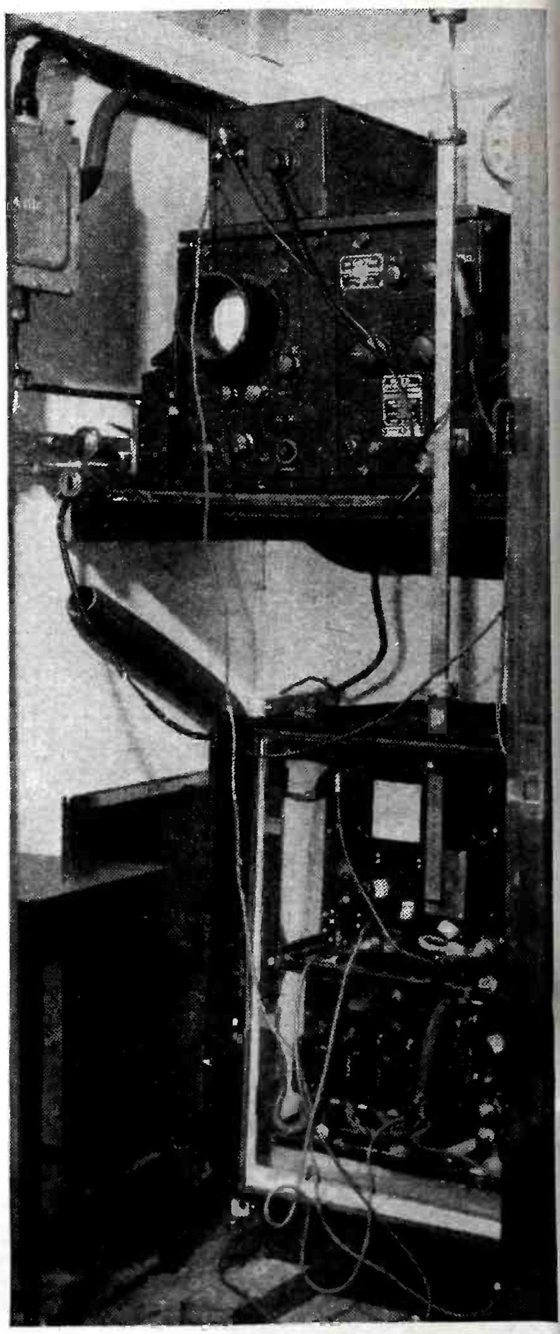
▸**BASIC** . . . Viewers with alarm of the heavy financial support by Army, Navy and Air Force in the research programs of the colleges may take heart from the fact (recently confirmed by two large eastern institutions) that the military are taking, and liking, basic research under their collegiate contracts. Many were the fears that the immediate problems of military science would displace the traditional untrammeled atmosphere of scientific endeavor. Nor were the fears entirely unfounded. Many "here's the breadboard, please make it work" problems have been taken to the colleges from NRL, Watson Lab, Belmar, and Wright Field. But all such have been turned down as interfering with more vital basic research. Moreover, the contracts are so written that the turn-downs stick.

How long government money will continue to be available for this purpose is anyone's guess. But so long as the people and the Congress remain convinced that research is the beginning of defense, and so long as the contract admininstrators insist that the research be basic, not superficial, much good will come from it, not only as a protection against war but for positive use in peace.

Electronics on



Radio antennas on the Queen Elizabeth, held at minimum to preserve graceful lines of ship, are supported largely by these two huge decorative funnels



Loran equipment on shelf, with radar transmitter below. Waveguide goes to spinner on roof of bridge

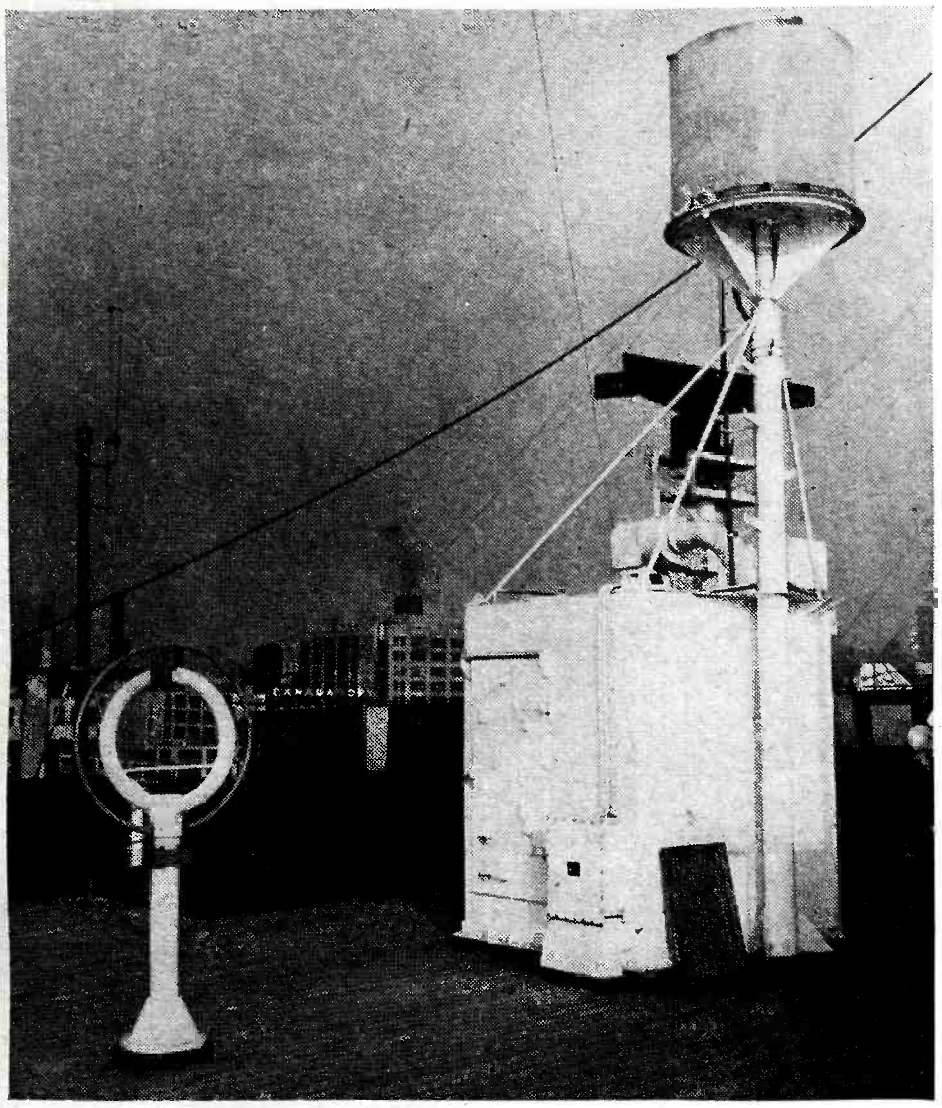
Main radio control room of Queen Elizabeth, showing operating positions and master control desk. The entire marine radio installation was made by International Marine Radio Co. Limited, an I. T. & T. affiliate. Speech secrecy racks fill another wall

PICTURES taken after the maiden commercial run of the 83,673-ton superliner Queen Elizabeth reveal that the military electronic equipment which helped her to dodge enemy aircraft and submarines during the war is now contributing to the safety and speed of peacetime trips as a luxury liner. On the bridge 90 feet above the water, British and American equipment operates side by side when bad visibility renders visual observation impossible, permitting full speed even in iceberg zones or in heavily travelled shipping lanes.

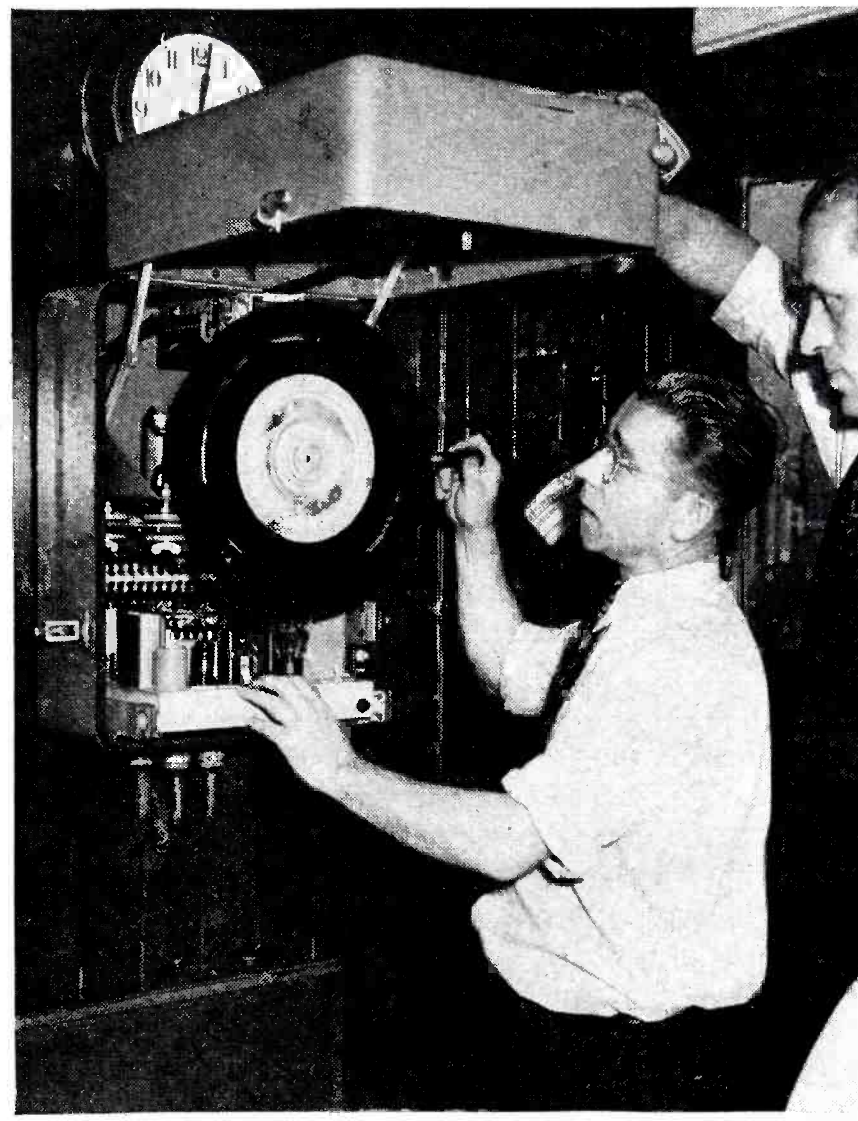
Loran equipment for navigation

World's Largest Liner

Radar, loran, depth sounding, and radio installations of the Queen Elizabeth played major roles in successful evasion of submarine packs and enemy aircraft during the war, now contribute to safety of all-weather navigation on trans-Atlantic passenger runs



Radar and radio d-f antennas on roof of bridge, with radio direction-finding loop at left. Another d-f loop is directly above the main radio room



Service technicians E. K. Fricke (left) and F. Eklund of Bludworth Marine making routine maintenance adjustments of echo depth-sounding indicator in wheelhouse

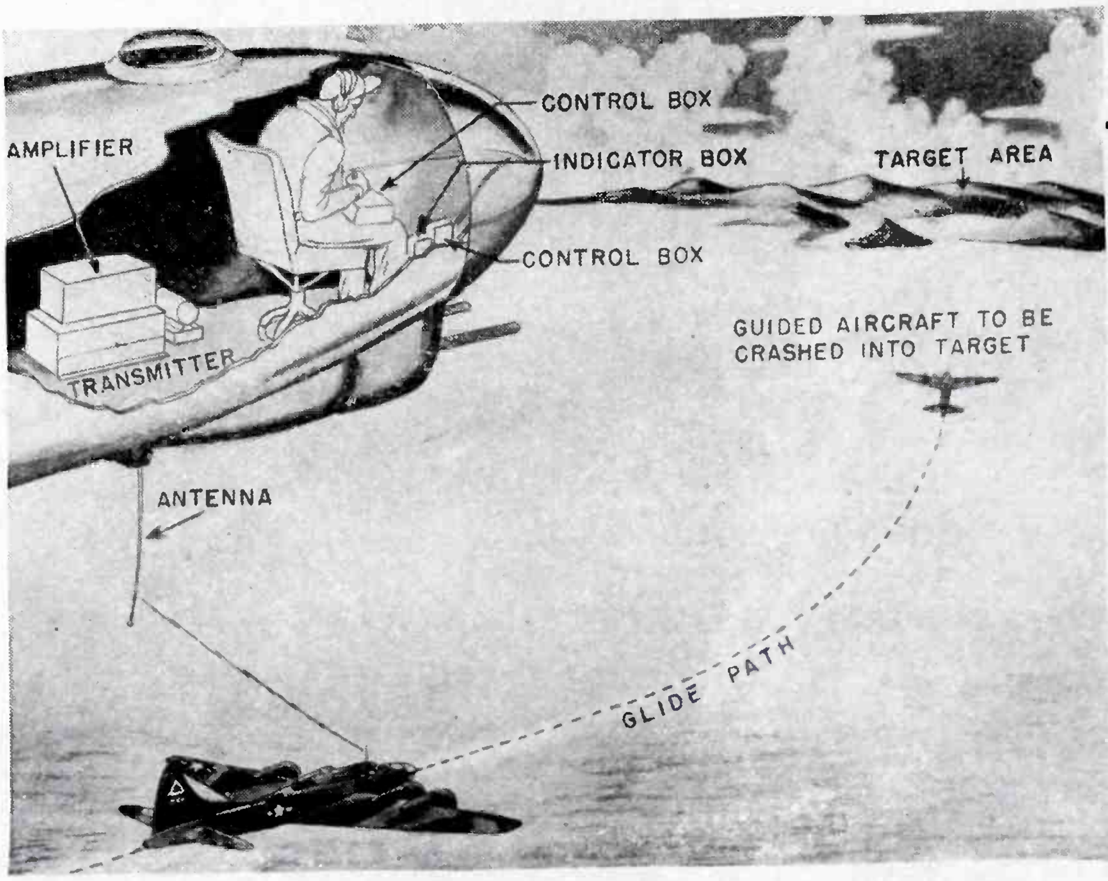
is located in a small room directly behind the wheelhouse. This is standard U. S. military design, model DAS-2 made for the U. S. Navy by General Electric Co. It employs marker scales on the scope screen for determination of loran line numbers, as described in ELECTRONICS, Dec. 1945, p 110. Supplementing loran for precise position determination at short ranges is British Gee equipment, also a pulse-timing system.

Radar equipment is all British. Transmitters are in the loran room directly under the radar spinners, and the indicators are in a midget darkroom located in a corner of the wheelhouse. Ranges of the two Cossor search radars are 10 and 50 miles respectively. Aircraft search radar used during the war was not evident when the ship docked at pier 90, New York City on her maiden passenger run.

In shoal waters echo depth-sounding equipment is turned on. This provides, on an indicator alongside the helmsman, an exact reading of depth in large neon-illuminated numerals, and simultaneously produces a continuous and permanent record of ocean-bottom profile in the chart room as a supplementary guide for navigators.

The radio installation consists of four remotely located main transmitters, a main radio room with four operating positions, message secrecy units (speech scramblers) to insure privacy of personal radiotelephone calls to shore, a complete emergency radio station that is independent of the ship's power supply, and a low-power radio set in the wheelhouse which enables the Captain, navigating officers, and pilot to converse directly with personnel on tugs or the quayside when docking. Two of the 26 motor lifeboats carry transmitters.

RADIO CONTROL



Tactical use of a Weary Willy, as sketched by William Bass to show how operator in Mother aircraft at upper left controls direction and flight functions of explosive-filled bomber on last flight, using ARW-18 remote control equipment

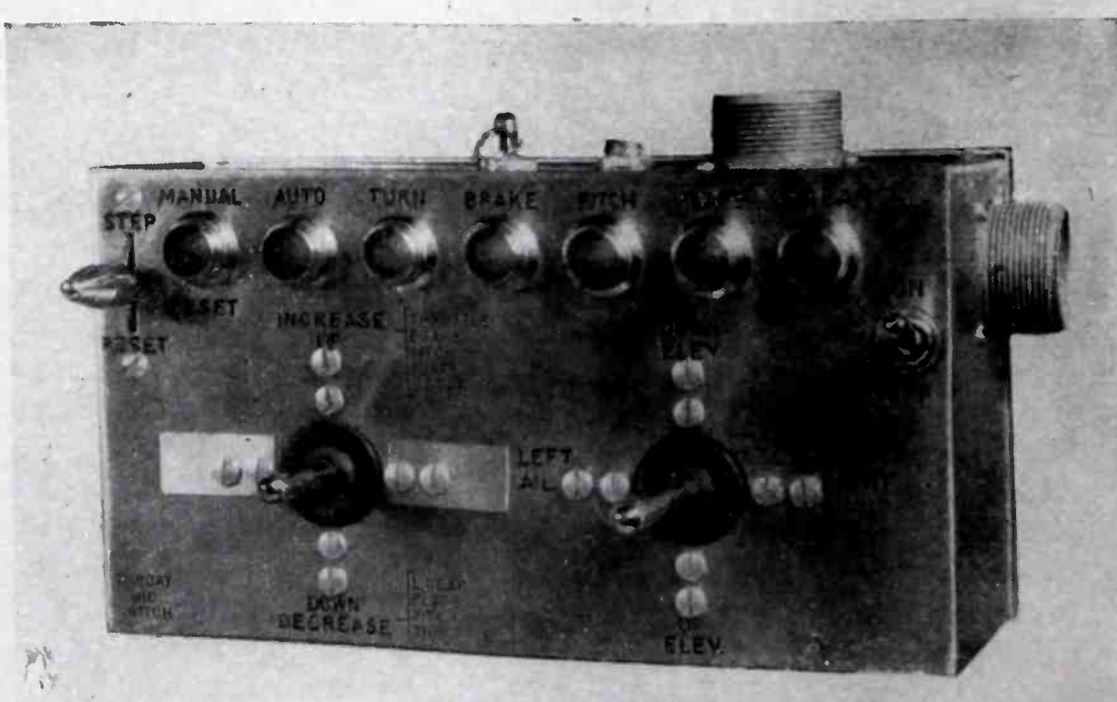
During the early stages of World War II, while the Army Air Forces were undertaking the destruction of Germany with the help of newly developed techniques for high-altitude radar precision bombing, American scientists were perfecting an even more practical and accurate bombing method. Their scientific collaboration resulted in a series of remotely-controlled experimental missiles. One of these, the Roc, could hit a circle 100 feet in diameter from an altitude of 15,000 feet, without ground visibility. Another, the GB-4 glide bomb, was less accurate but was capable of being released and guided to the target by an aircraft some 20 miles from the target and outside the flak zone. Still another, the Razon VB-3 free-falling bomb, when released from altitudes of 15,000 feet, would under conditions of good visibility strike within 20 feet of the target area.

The conception of pilotless aircraft dates back to experiments performed in 1918, when a young officer, Capt. Henry H. Arnold, collaborated with a young scientist, Charles F. Kettering, and worked out some basic principles. Since then, the captain has become a five-star General, recently retired; the scientist is the vice-president of General Motors Corporation; and the dream of pilotless flight has become a reality.

The story of the development of offensive guided missiles realistically begins in 1939. The Army Air Forces at the Air Materiel Command, Wright Field, Dayton, Ohio, successfully developed, in conjunction with a commercial manufacturer, a radio method for the remote control of pilotless target aircraft, to be used during antiaircraft gunnery practice.

This first system consisted of lightweight aircraft equipped with small radio receiving sets capable of responding to transmitted signals. These signals, in turn, were converted in the receiver to the voltages necessary to control the rudder and elevator of the target plane, thereby directing it in flight. The transmitting equipment, on the ground, sent out to the target a radio-frequency signal coded by impulses to select the flight functions to be performed.

From this beginning, Wright Field laboratory personnel developed and constructed, in the same year, vastly improved radio equipment employing audio tones to select flight functions, with the receiving equipment in the target aircraft using tuned filter circuits. This basic audio tone technique served throughout World War II for the control of the many versions



Control box for ten-channel ARW-18 f-m transmitter used by operator in Mother plane to maneuver a PQ-14 pilotless aircraft

SYSTEMS for Guided Missiles

Descriptions of the more important guided missiles and pilotless aircraft developed by the Army Air Forces during the war, with circuits of representative radio control systems, techniques of tactical usage, control problems, and intimations of future trends

By Captain SAM L. ACKERMAN and GEORGE RAPPAPORT

Electronic Subdivision, Engineering Division
Air Materiel Command, Wright Field, Dayton, Ohio

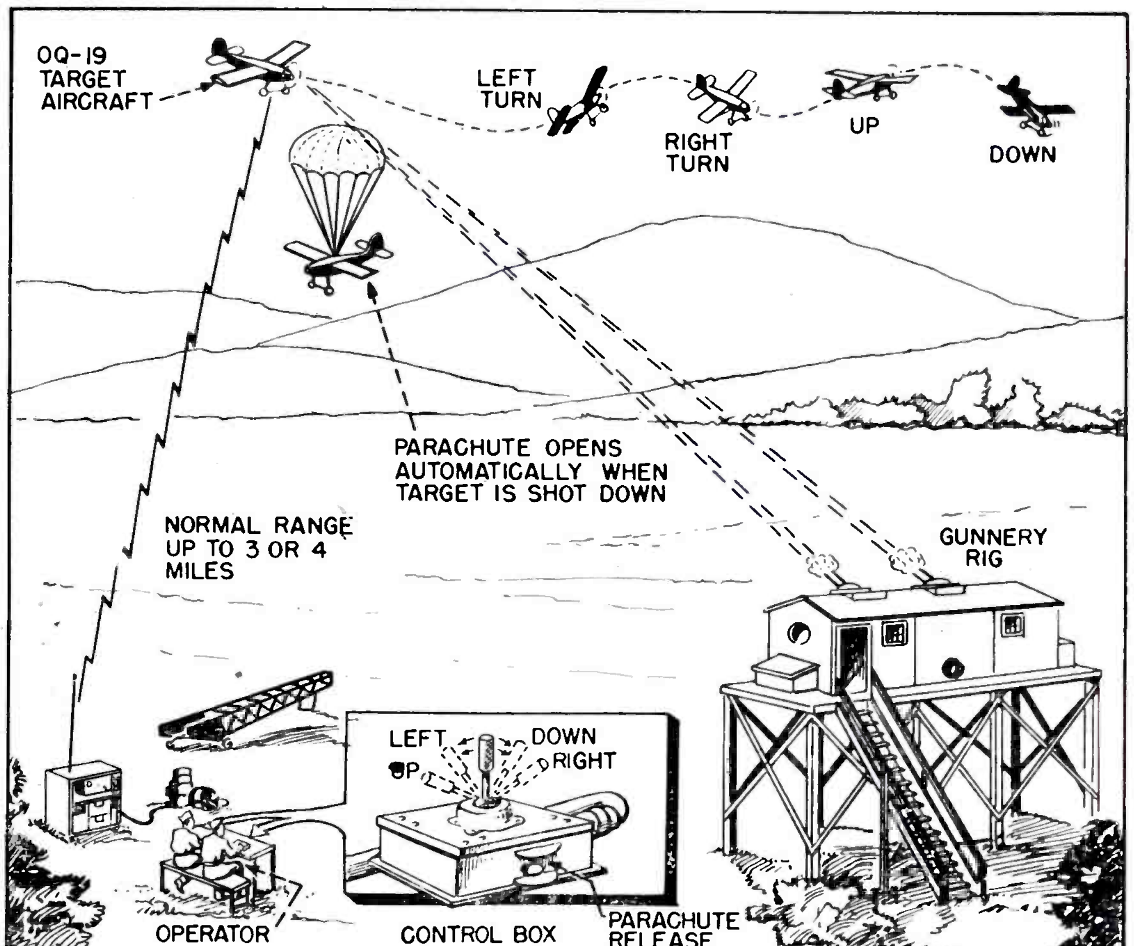
of target aircraft, guided missiles, and free-falling bombs developed by the U. S. Army Air Forces. Other techniques, which came into play in the late stages of the war, invaded such new fields as radar target seekers and radar pulse control techniques. This article will briefly describe the various types of pilotless aircraft, insofar as present security regulations permit.

Target Aircraft

Small pilotless aircraft are controlled remotely by radio, usually launched by catapult and landed by parachute, and used as targets for antiaircraft gunnery crews. Models include the OQ and the almost full-size PQ series of pilotless aircraft and the RC-56, RC-57, RC-64, RC-65, ARW-1 and ARW-18 electronic target-control equipment.

The RC-56 a-m transmitter for remote control of target aircraft may be located as a permanent ground installation, jeep-mounted for portability, or located in a Mother (controlling) flying aircraft. The transmitter may be set to any of four fixed frequencies and may be tone-modulated by any of five audio signals, as called for by the positions of the miniature joy stick and switches that are manipulated by the operator.

The RC-57 superregenerative receiver used in target aircraft contains frequency-selective filter circuits (the decoder) which differentiate between the various tone-modulated signals received, and a relay unit that furnishes control voltages to the servomechanism or other devices operating the rudder and elevator of the aircraft. This receiver could also be installed on trucks, tanks, and watercraft to permit bombing and strafing practice of an evasive target by gunners in aircraft.



Ground installation of model RC-56 a-m transmitter for training gunners firing from gun turrets simulating those used in B-29 and B-32 bombers, with model RC-57 superregenerative receiver in OQ-19 pilotless aircraft serving as evasive target

The PQ-14 target aircraft is a low-wing monoplane powered by a six-cylinder 155-hp Franklin engine. It has a ceiling of 17,000 feet and can operate for 3 hours at a speed of 160 miles per hour. This plane may be maneuvered to simulate strafing of gunnery batteries or high-altitude bombing missions. Its automatic pilot, brakes, retractable landing gear, and flaps are all controllable from the remote control station by means of the ARW-1 10-channel f-m radio receiver and ARW-18 f-m transmitter, which together give 18 controllable functions. Control is accomplished from a modified Beechcraft C-45 Mother plane trailing a safe distance behind the target, with the pilot of the target aircraft sitting in the copilot's seat and manipulating a miniature joy stick and switches. Indicator lights check his selection of flight functions.

War-weary B-17 bombers no longer fit for combat service, loaded with 20,000 pounds of explosives and crashed into the target by remote control from another plane, were known as Weary Willies. Human pilots were generally used during takeoff, and bailed out while still in friendly territory. Television cameras and transmitters sometimes scanned the instrument board of the Weary Willy or the area in front of it, and relayed the picture back to the Mother plane, which followed at a safe distance of about 20 miles.

Guided Bombs

Azon is a free-falling vertical bomb having controlled surfaces to permit control of its trajectory in azimuth only, for accurate bombing of line targets such as bridges, roads, and railways. The Azon assembly was attached to an ordinary 1,000 or 2,000-pound free-falling bomb. Two fins are controlled by gyros under the influence of a CRW-2 remote control system mounted in the tail assembly. The RC-186 transmitting equipment in the Mother aircraft provided a choice of 47 channels for transmission of the control signal. Two audio control channels gave right and left control for the bomb. In a typical run over the target, the Norden bombsight was used to drop the bomb; seconds later a million-candlepower flare attached to the tail lit automatically, so the bombardier could follow the flight of the bomb visually and make corrections. One serious drawback of Azon is the necessity for making a long run after actually dropping the bomb, during which the plane is a vulnerable target for flak in heavily fortified areas.

Razon is a free-falling bomb controlled in both range and azimuth. It uses a CRW-7 four-channel audio system. A Crab sight attached to the Norden bombsight in the form of a half mirror projects the image of the bomb flare on the target, enabling the Norden sight to show the true height of the bomb as required for range corrections. The same hazardous bombing run as for Azon must be performed.

Spazon is a free-falling bomb which is allowed to spin normally during the first part of its fall to obtain accuracy, and corrections are made by radio as the missile approaches the target. The technique was not altogether successful, and was dropped in favor of other projects.

Glomb is a remotely controlled glide bomb developed to extend the range of the missile from the Mother aircraft and eliminate the dangerous follow-through techniques of Azon and Razon. A wing with a span of 12 feet was attached to a standard bomb, along with a twin boom and a set of tail surfaces that were gyroscopically stabilized and radio controlled. The type GB-4 contained also a complete television transmitter to relay to the bombardier a complete flight picture. Two of these missiles were carried under the wing of a B-17 bomber and released one at a time from an altitude of 15,000 feet and at a distance of 17 miles from the target. The Mother aircraft then made a 180-degree turn while the missile continued on its way to the target. The bombardier, watching his television receiver, directed the bomb to the impact point. The second bomb could then be released and dropped in a similar manner.

Jet bombs constitute a group of guided missiles which for the most part is still classified because of its remote control equipment or because of the aerodynamic characteristics of the bomb. Entirely new techniques are being used for control, the most significant being use of radar stations at the controlling point.

Roc is a glide bomb developed near the end of the war, having unusual aerodynamic control surfaces incorporated in a wing structure that surrounds the belly of the bomb. Controls are operated remotely by two electric motors, in response to signals from the Mother aircraft. The circular fin at the tail of a bomb acts as a drag, slowing the descent sufficiently to

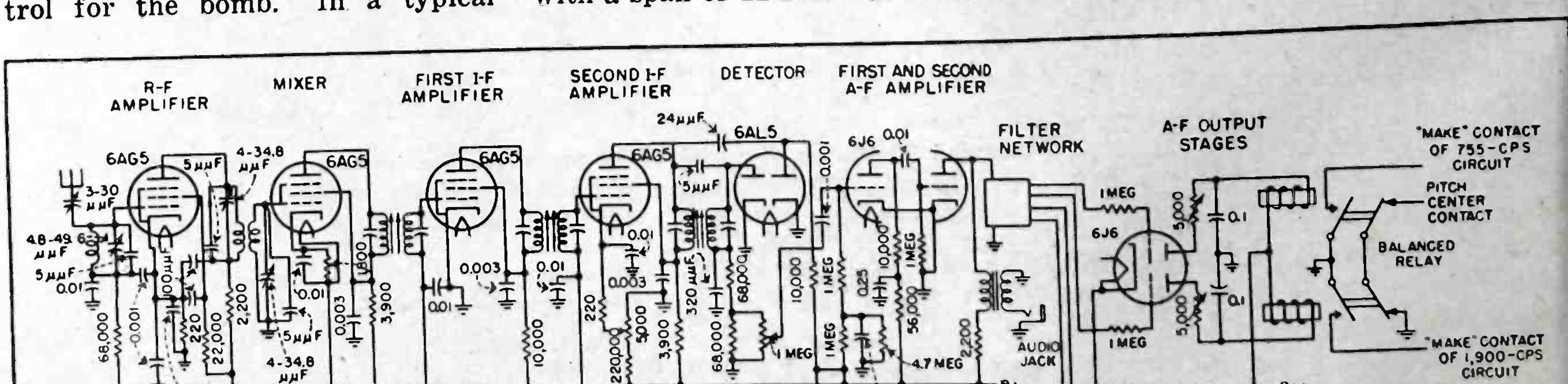


FIG. 1—Circuit of four-channel CRW-7 superheterodyne receiver used for azimuth and elevation control of Razon bombs, with overall selectivity curves for each channel

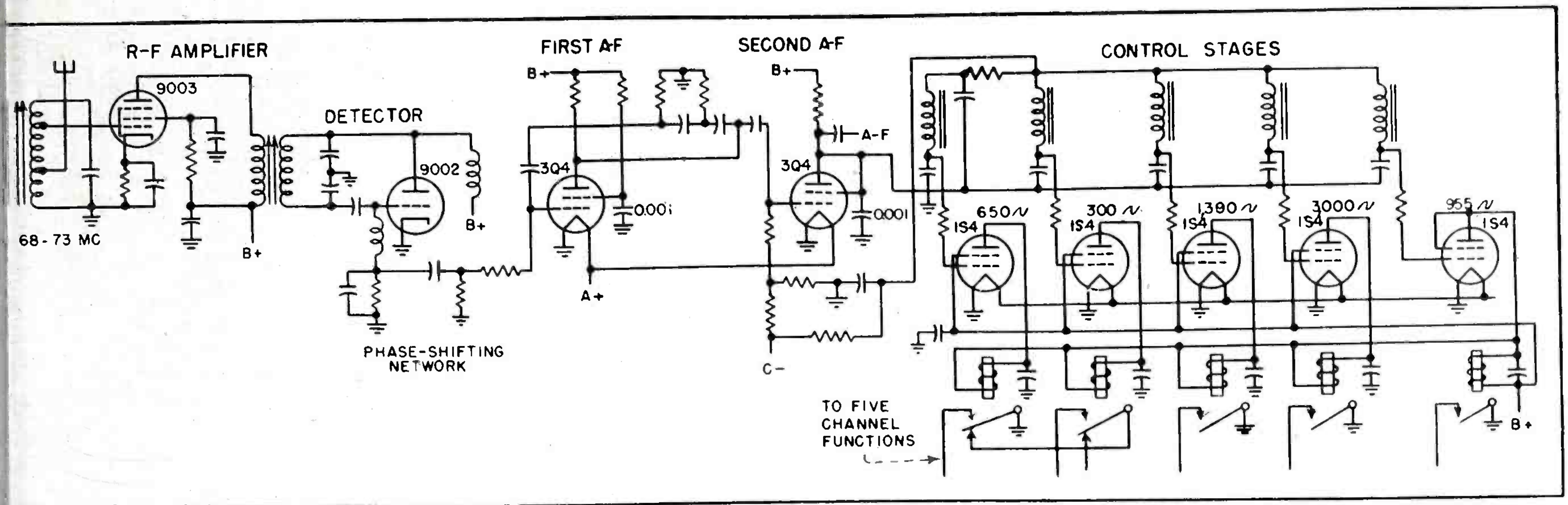


FIG. 2—Circuit of five-channel RC-57 superregenerative receiver used in pilotless aircraft serving as targets for gunnery practice

provide three times the maneuverability of the Razon. The Roc can be adapted for television and radio control and for target seeking.

Another technique of target destruction involved automatic release of all bombs in a squadron simultaneously, the planes being positioned in a formation giving a saturation pattern for the target of the day. The bombardier, in the lead plane, opened the bomb bay doors of all planes in the squadron by radio remote control and then pressed a button that automatically released all bombs. The transmitter in the lead plane was the ARW-9 (RC-186 modified), while the receiving equipment in all other aircraft in the squadron was the ARW-10, a modified version of the CRW-2.

Receiving Equipment

Tone-modulated remote-control receiving equipment generally consists of three separate units: the r-f receiver proper, the audio filter selectors, and the control relays. The circuit of one such equipment will be discussed in detail, and other equipments will be analyzed only insofar as they differ fundamentally.

The circuit of the model CRW-7 four-channel superheterodyne receiver is given in Fig. 1. This crystal-controlled receiver is capable of operating at any one of 47 predetermined frequencies, and was used primarily for Razon control during the war.

In operation, the tone-modulated r-f signal received by the antenna is amplified by the r-f amplifier circuit and then fed to the control grid of the mixer stage. The oscillator section employs a modified Pierce oscillator with an untuned grid circuit and with the plate circuit tuned to the third harmonic of the crystal frequency, followed by a tripler amplifier stage that applies the ninth harmonic of the crystal frequency to the mixer tube inductively by cathode injection. The mixer filament is connected in such a manner that it is at the same r-f potential as the cathode, eliminating the loading effect of the filament-cathode capacitance. The mixer plate circuit is tuned to the 15-mc i-f value. The gain of the first i-f stage is controlled by avc, while that of the second i-f stage is controlled by three factors—avc, a fixed bias tapped from a bleeder resistance, and the bias voltage developed across the cathode resistor.

One section of the duodiode is used for audio detection, and the other provides avc voltage for the r-f stage, the i-f stages, and the first audio stage. The output of the second i-f amplifier stage is also coupled through a capacitor to the plate of the avc section of the duodiode, making possible the desired avc voltage for the audio tube. Two stages of audio amplification follow the detector, with the output feeding a selective filter network. The four secondaries of this tuned audio transformer network respond to the audio frequencies of 475, 755, 1,900, and 3,000 cycles per second. Each filter output voltage is applied to the grid of a triode that is biased beyond cutoff and has in its plate circuit a relay which closes an electrical circuit to a mechanical actuator. A series resistor in the grid circuit prevents strong signals from causing excessive grid current. High grid current would load the filters, reducing the circuit Q and thus reducing filter selectivity on strong signals.

Rheostats in the plate circuits of the triodes permit adjusting channel sensitivity. Balanced relays are used, one for each twin triode. As long as no signal is applied, the relays will remain in a balanced condition. When a signal is received on a grid, the relay in that circuit will be unbalanced in one direction. If a signal appears on the other control grid of the same tube, the relay will be unbalanced in the opposite direction. In the balanced condition, relay contacts are set so that the mechanism controlled by the relay will return to a centered position. If the relay is unbalanced in one direction, the mechanism will be maneuvered off center position in a predetermined direction, and vice versa.

The model RC-57 superregenerative receiver employed in control of target aircraft for gunnery training purposes operates on any of four fixed carrier frequencies in the range from 68 to 73 mc, using the circuit shown in Fig. 2. The r-f amplifier stage is conventional, with slug tuning for the r-f coil connected to the nonresonant antenna. A self-quenching superregenerative detector similar to a Colpitts oscillator is used for detection.

Since the detector grid current is proportional to the incoming signal, the voltage developed is likewise proportional to the incoming signal. This voltage constitutes the audio output. As a result of grid blocking in the detector tube, a high level of quench voltage is developed, which and manipulating a miniature joy stick and switches. Indicator lights check his selection of flight functions.

War-weary B-17 bombers no longer fit for combat service, loaded with 20,000 pounds of explosives and crashed into the target by remote control from another plane, were known as Weary Willies. Human pilots were generally used during takeoff, and bailed out while still in friendly territory. Television cameras and transmitters sometimes scanned the instrument board of the Weary Willy or the area in front of it, and relayed the picture back to the Mother plane, which followed at a safe distance of about 20 miles.

Guided Bombs

Azon is a free-falling vertical bomb having controlled surfaces to permit control of its trajectory in azimuth only, for accurate bombing of line targets such as bridges, roads, and railways. The Azon assembly was attached to an ordinary 1,000 or 2,000-pound free-falling bomb. Two fins are controlled by gyros under the influence of a CRW-2 remote control system mounted in the tail assembly. The RC-186 transmitting equipment in the Mother aircraft provided a choice of 47 channels for transmission of the control signal. Two audio control channels gave right and left control for the bomb. In a typical run over the target, the Norden bombsight was used to drop the bomb; seconds later a million-candlepower flare attached to the tail lit automatically, so the bombardier could follow the flight of the bomb visually and make corrections. One serious drawback of Azon is the necessity for making a long run after actually dropping the bomb, during which the plane is a vulnerable target for flak in heavily fortified areas.

Razon is a free-falling bomb controlled in both range and azimuth. It uses a CRW-7 four-channel audio system. A Crab sight attached to the Norden bombsight in the form of a half mirror projects the image of the bomb flare on the target, enabling the Norden sight to show the true height of the bomb as required for range corrections. The same hazardous bombing run as for Azon must be performed.

Spazon is a free-falling bomb which is allowed to spin normally during the first part of its fall to obtain accuracy, and corrections are made by radio as the missile approaches the target. The technique was not altogether successful, and was dropped in favor of other projects.

Glomb is a remotely controlled glide bomb developed to extend the range of the missile from the Mother aircraft and eliminate the dangerous follow-through techniques of Azon and Razon. A wing with a span of 12 feet was attached to a standard bomb, along with a twin boom and a set of tail surfaces that were gyroscopically stabilized and radio controlled. The type GB-4 contained also a complete television transmitter to relay to the bombardier a complete flight picture. Two of these missiles were carried under the wing of a B-17 bomber and released one at a time from an altitude of 15,000 feet and at a distance of 17 miles from the target. The Mother aircraft then made a 180-degree turn while the missile continued on its way to the target. The bombardier, watching his television receiver, directed the bomb to the impact point. The second bomb could then be released and dropped in a similar manner.

Jet bombs constitute a group of guided missiles which for the most part is still classified because of its remote control equipment or because of the aerodynamic characteristics of the bomb. Entirely new techniques are being used for control, the most significant being use of radar stations at the controlling point.

Roc is a glide bomb developed near the end of the war, having unusual aerodynamic control surfaces incorporated in a wing structure that surrounds the belly of the bomb. Controls are operated remotely by two electric motors, in response to signals from the Mother aircraft. The circular fin at the tail of a bomb acts as a drag, slowing the descent sufficiently to

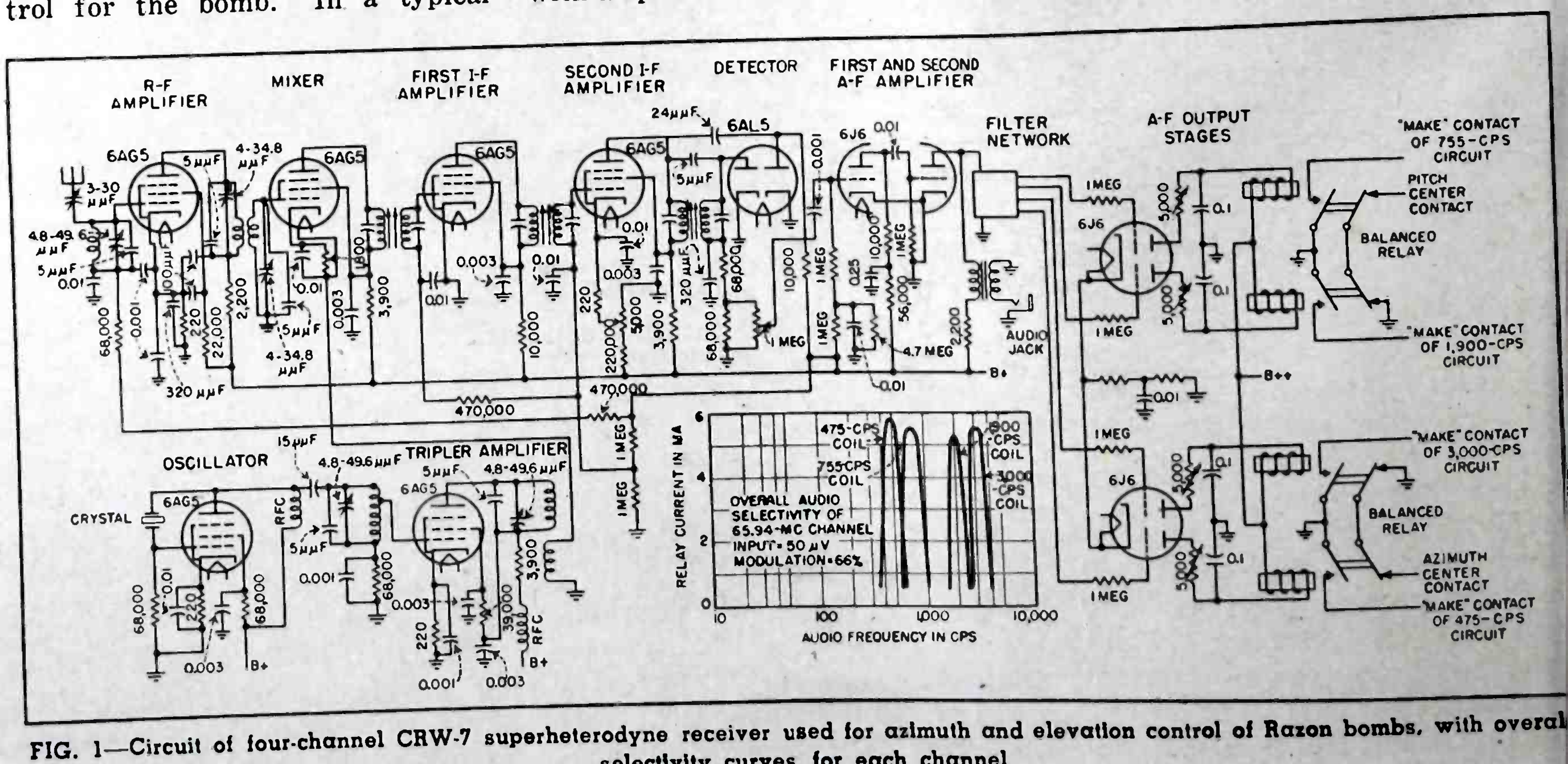


FIG. 1—Circuit of four-channel CRW-7 superheterodyne receiver used for azimuth and elevation control of Razon bombs, with overall selectivity curves for each channel

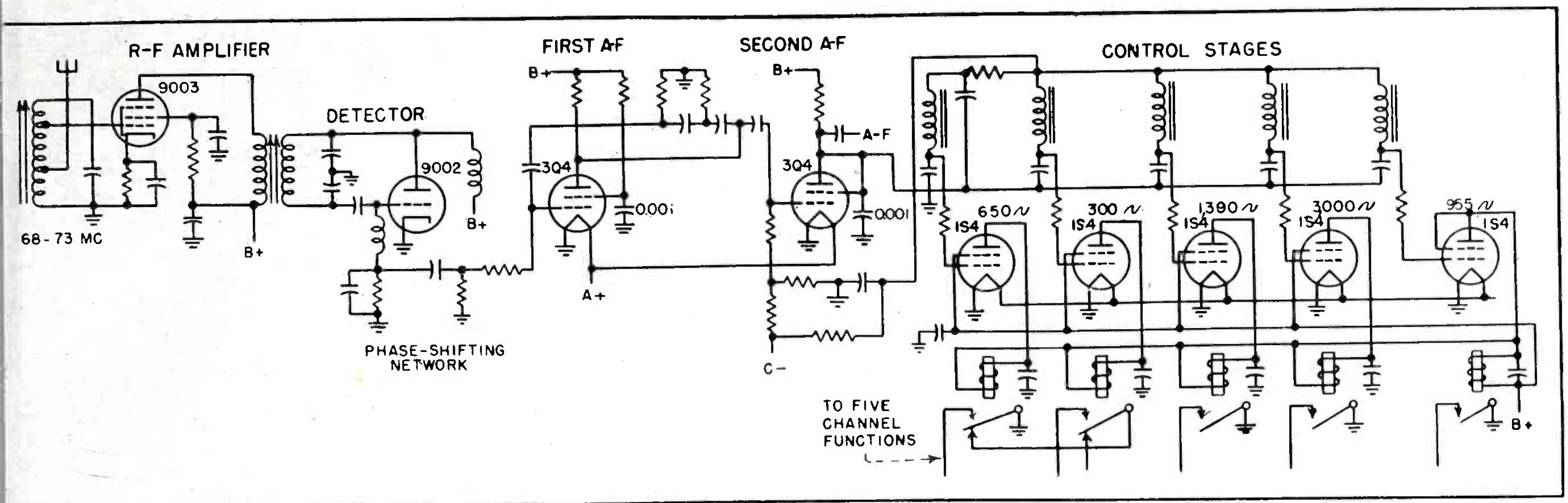


FIG. 2—Circuit of five-channel RC-57 superregenerative receiver used in pilotless aircraft serving as targets for gunnery practice

provide three times the maneuverability of the Razon. The Roc can be adapted for television and radio control and for target seeking.

Another technique of target destruction involved automatic release of all bombs in a squadron simultaneously, the planes being positioned in a formation giving a saturation pattern for the target of the day. The bombardier, in the lead plane, opened the bomb bay doors of all planes in the squadron by radio remote control and then pressed a button that automatically released all bombs. The transmitter in the lead plane was the ARW-9 (RC-186 modified), while the receiving equipment in all other aircraft in the squadron was the ARW-10, a modified version of the CRW-2.

Receiving Equipment

Tone-modulated remote-control receiving equipment generally consists of three separate units: the r-f receiver proper, the audio filter selectors, and the control relays. The circuit of one such equipment will be discussed in detail, and other equipments will be analyzed only insofar as they differ fundamentally.

The circuit of the model CRW-7 four-channel superheterodyne receiver is given in Fig. 1. This crystal-controlled receiver is capable of operating at any one of 47 predetermined frequencies, and was used primarily for Razon control during the war.

In operation, the tone-modulated r-f signal received by the antenna is amplified by the r-f amplifier circuit and then fed to the control grid of the mixer stage. The oscillator section employs a modified Pierce oscillator with an untuned grid circuit and with the plate circuit tuned to the third harmonic of the crystal frequency, followed by a tripler amplifier stage that applies the ninth harmonic of the crystal frequency to the mixer tube inductively by cathode injection. The mixer filament is connected in such a manner that it is at the same r-f potential as the cathode, eliminating the loading effect of the filament-cathode capacitance. The mixer plate circuit is tuned to the 15-mc i-f value. The gain of the first i-f stage is controlled by avc, while that of the second i-f stage is controlled by three factors—avc, a fixed bias tapped from a bleeder resistance, and the bias voltage developed across the cathode resistor.

One section of the duodiode is used for audio detection, and the other provides avc voltage for the r-f stage, the i-f stages, and the first audio stage. The output of the second i-f amplifier stage is also coupled through a capacitor to the plate of the avc section of the duodiode, making possible the desired avc voltage for the audio tube. Two stages of audio amplification follow the detector, with the output feeding a selective filter network. The four secondaries of this tuned audio transformer network respond to the audio frequencies of 475, 755, 1,900, and 3,000 cycles per second. Each filter output voltage is applied to the grid of a triode that is biased beyond cutoff and has in its plate circuit a relay which closes an electrical circuit to a mechanical actuator. A series resistor in the grid circuit prevents strong signals from causing excessive grid current. High grid current would load the filters, reducing the circuit Q and thus reducing filter selectivity on strong signals.

Rheostats in the plate circuits of the triodes permit adjusting channel sensitivity. Balanced relays are used, one for each twin triode. As long as no signal is applied, the relays will remain in a balanced condition. When a signal is received on a grid, the relay in that circuit will be unbalanced in one direction. If a signal appears on the other control grid of the same tube, the relay will be unbalanced in the opposite direction. In the balanced condition, relay contacts are set so that the mechanism controlled by the relay will return to a centered position. If the relay is unbalanced in one direction, the mechanism will be maneuvered off center position in a predetermined direction, and vice versa.

The model RC-57 superregenerative receiver employed in control of target aircraft for gunnery training purposes operates on any of four fixed carrier frequencies in the range from 68 to 73 mc, using the circuit shown in Fig. 2. The r-f amplifier stage is conventional, with slug tuning for the r-f coil connected to the nonresonant antenna. A self-quenching superregenerative detector similar to a Colpitts oscillator is used for detection.

Since the detector grid current is proportional to the incoming signal, the voltage developed is likewise proportional to the incoming signal. This voltage constitutes the audio output. As a result of grid blocking in the detector tube, a high level of quench voltage is developed, which

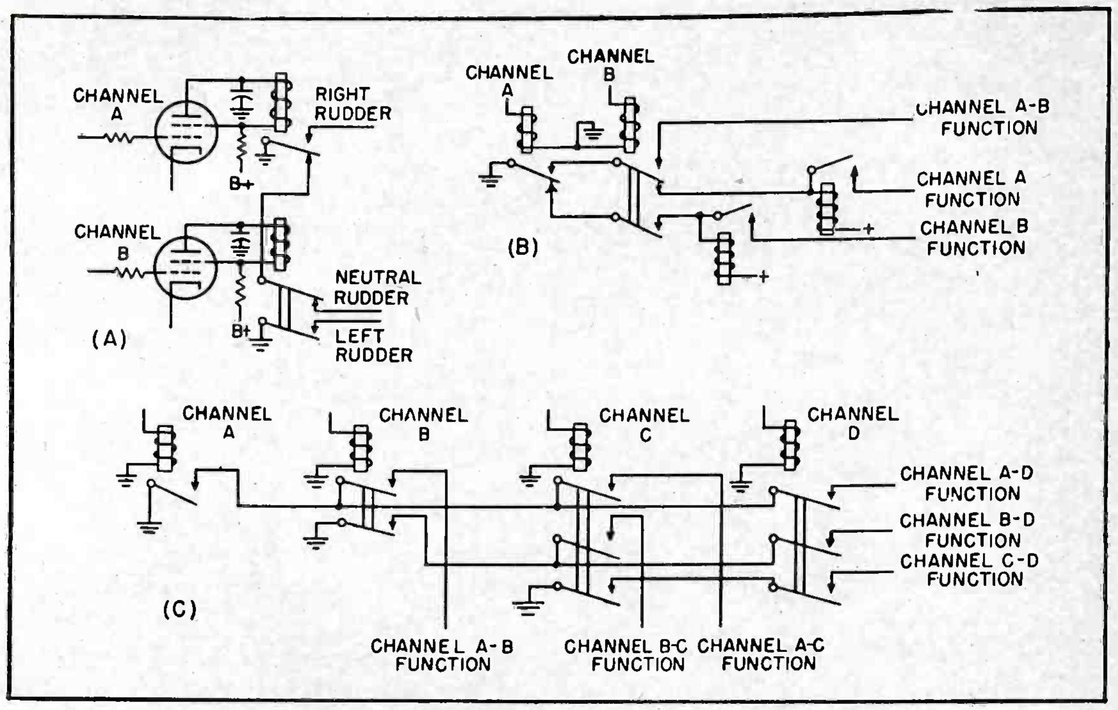


FIG. 3—Three basic types of relay arrangements for increasing the number of controllable functions obtained with a given receiver system

would normally accompany the detector signal output. This quench voltage is removed by a phase-shifting network to prevent overloading associated amplifiers and filter circuits. The a-f amplifier is essentially conventional, with regeneration in the first a-f stage making the gain at 3,000 cycles approximately twice that at 300 cycles. To equalize the response, a 0.001-microfarad capacitor is employed as a high-frequency bypass from plate to ground in the second a-f stage.

Five separate series-resonant *LC* circuits in parallel with the output of the second audio amplifier, each tuned to a different frequency, act as audio-frequency filters. Four of these tuned circuits are similar and have the signal fed through the tuning capacitor to the control grid of the particular relay-control tube. The fifth, for 650 cycles, is inverted so that the audio signal feeds through the inductance first, then through the capacitance to ground. This change reverses the selectivity characteristic and makes the 650-cycle filter less likely to respond to the next higher frequency.

When responding to its frequency, each filter builds up, through resonant action, a voltage sufficient to overcome the grid bias on its particular relay-control tube, enabling the tube to pass plate current and actuate the corresponding relay.

The model RC-64 f-m superheterodyne receiver used in guiding small target aircraft for gunnery training purposes operates in the 35 to 40-mc band, normally on one fixed frequency. The fourth harmonic of the crystal oscillator is combined with the incoming signal in the mixer to produce an intermediate frequency of 3 mc. The third i-f transformer feeds into the grid of the limiter tube, which acts to reduce any amplitude modulation due to static or noise impulses. The voltage developed by the limiter grid current is used for automatic volume control for the i-f and r-f stages. A conventional twin diode discriminator changes the frequency variations of the incoming signal to an audio frequency by means of a conventional discriminator network.

The discriminator output feeds into a two-stage audio amplifier that operates a carrier relay. The audio amplifier also feeds a paralleled group of ten relay triodes through *RC* filter networks that change the audio fidelity to offset the preemphasis introduced in the transmitter, with audio filters in each relay circuit responding only to the assigned frequency for that relay.

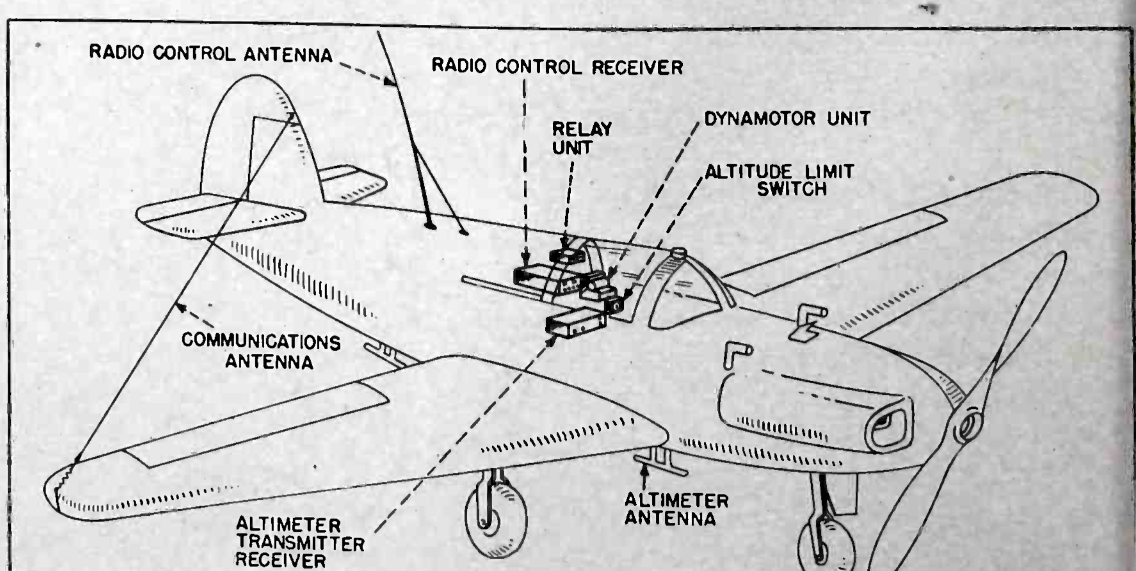
Superregenerative receiver CRW-2, designed for Azon bombs and automatic bomb release operations, is capable of receiving carrier frequencies between 50 and 100 mc. This range is covered by five sets of plug-in units. It is quite similar to RC-57 in operation and theory, but has only two audio channels.

Audio-Tone Control Systems

Various methods are available for increasing the number of controllable functions provided by an elementary receiver system. These may be divided into the following four categories: (1) single tone; (2) single tone and simultaneous dual tones; (3) dual tones; (4) single auxiliary step tones and single primary tone.

In the single-tone relay system a separate tone channel and actuating relay are required for each function performed. The output of the audio selector filter network channel is fed directly into a pentode which in turn actuates a relay that feeds a voltage directly to control surface mechanisms or to a gyro or servo for further interpretation.

By arranging relay circuits as in Fig. 3A, two channels can be made to perform three functions. Here a neutral position for the rudder (or any other such device) is provided when channels *A* and *B* are not operating. No neutral position is pro-



Low-wing PQ-14 target aircraft using f-m radio control receiver ARW-1. With a speed of 160 miles an hour, this plane can be maneuvered to simulate strafing

vided for the elevators of the OQ targets, however, inasmuch as a change in the plane's center of gravity due to normal fuel consumption will make the plane rise or dive of its own accord and therefore require constant correction.

Removal of the carrier frequency makes possible an additional function if desired. This is actually employed with one variety of target aircraft, where the parachute is automatically released when the carrier is removed.

In the single tone and simultaneous dual tone system single tones and single relays accomplish one function each, and simultaneous combination of two tones accomplishes still another function which is not related to either of the functions produced by the single tones. The basic circuit is given in Fig. 3B.

The relays in series with the outputs of the *A* and *B* channels are safety devices that act as time-delay relays (about 5 milliseconds) to allow for any minute differences between the start of the two tones at the transmitter. If this precautionary measure were omitted and either of the two channels should operate separately when a dual-channel function is implied, the single tone action would be performed and in some cases (supposing it were the detonate channel) there would be disastrous results.

The dual-tone system always requires simultaneous transmission of two tones to perform a single function. While the four-channel circuit shown in Fig. 3C gives six functions, a five-channel system would provide 10 functions and a six-channel system would make possible the control of 15 different aircraft functions. Safety time-delay relays are not needed.

In the system employing single auxiliary step tones and single primary tones a single auxiliary tone is used to position a stepping relay which selects the desired function, and another primary tone is used for actually accomplishing the movement. A reset channel tone releases a cam on the selector switch, allowing the selector to swing back to its starting position.

The third portion of the system consists of four primary tones which are only used to control the control surfaces (right or left rudder, elevators up or down). It would be undesirable to refer these basic flight functions to a selector switch of this type.

Pulse Control Techniques

Methods other than tone control have been utilized to transmit intelligence to guided missiles. One of these methods is pulse control by the use of radar. The radar transmitters are usually keyed at an audio rate. If, however, provisions are incorporated in the design of the transmitter to provide a variable audio rate of pulsing, then a receiver with suitable audio filters can select these audio transmissions and convert these impulses into desirable control functions through relay boxes.

Pulse control development has been conducted using primarily uhf transmitters, which necessarily limit the range at which control can be effected to line-of-sight distances. This system could be applied as well to lower-frequency transmitters where space and weight considerations for both transmitter and receiver are not primary factors.

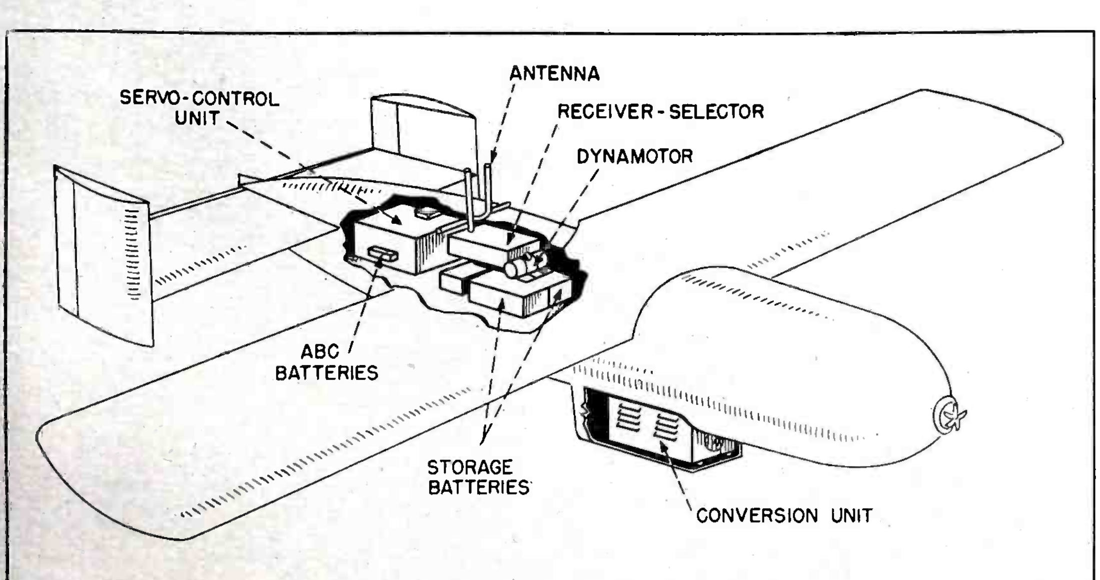
The security of a single pulse control system is not adequate for modern warfare, since an aggressive enemy through active monitoring can easily determine not only the system which is in operation but also the type of intelligence that is being transmitted over the system. A coded pulsing system will materially add to the security of the system; however, such a system with single or coded pulses is susceptible to jamming, becoming more and more unreliable as the receiver in the missile approaches enemy territory.

Work is continuing on an expanded guided missiles program, involving detailed consideration of means for automatically accomplishing the takeoff, control, navigation, and final trajectory on a basis similar to that employed by bomber aircraft on missions.

Future Guided Missiles

It is still too early to describe in detail the technical aspects of this program. There is, however, a basic philosophy for the guidance of missiles which will be pursued on a long-range basis, namely, assurance of positive control throughout the life of the missile together with means for availability of missile progress data at the remote launching point. This second phase is perhaps the most difficult as it involves the transmission of video-type signals over distances beyond radio line-of-sight without the benefit of airborne relay stations. This problem may be met through various concessions in the solution of special military problems.

This article has presented most of the more important guided missiles developed by the Army Air Forces during the past war, and indicates certain aspects of future development trends. Limitations which are being considered and eliminated are range, speed complexity, traffic-handling capacity, and vulnerability to countermeasures.



Radio-controlled glide bomb known as Glomb, controllable from Mother aircraft at distance up to 17 miles from target

Dynamic Suppression of

By controlling the bandwidth of an audio amplifier automatically in accordance with the characteristics of the recorded music, suppression of high and low-frequency noise may be achieved without noticeable injury to the realism of reproduction

THE MOST OBVIOUS shortcoming of ordinary reproduction of music from phonograph records is the presence of the high-frequency background noise level caused by minute irregularities on the surface of the record. Although this noise is more or less random in character, the most annoying part of it is concentrated in the same frequency range as the upper musical harmonics. Any attempt to reduce it has heretofore been accompanied by a serious attenuation of these harmonics and often of some of the higher musical fundamentals also.

For years, it has been recognized that the most satisfactory simple means of controlling noise is by controlling bandwidth, using as sharp a cutoff as possible beyond the desired band and a minimum of attenuation within the band. The reproduction of phonograph records represents about the only phase in the field of electrical reproducing where this precept has been generally disregarded. There are several reasons for this. One is that the commonly used crystal pickup, when operated into a high-resistance load, provides conveniently a drooping frequency characteristic or high-frequency rolloff without the use of any additional parts. Another is that phonograph records have been made with various degrees of high-frequency preemphasis, and a single tone control adjusting the rate of rolloff can be used either to compensate for the recording characteristics or to reduce noise, the latter of course always at the expense of fidelity. The third and perhaps most important reason is that a sharp cutoff frequency sufficiently low to reduce the noise level appreciably makes such a deep excursion into the range of lower overtones and higher fundamentals of the music as to produce an extremely unnatural and mechanical quality at high volume levels.

To a secondary degree there are also present low-frequency noises or rumbles, which may be in either the record or the turntable, and which are noticeable during soft passages which do not contain many low frequencies. The present tendency to use large amounts of bass boost or automatic low-frequency compensation greatly exaggerates any rumble that may be present.

High-frequency and low-frequency noises are present at substantially constant level during the playing of a record. Hence they are most noticeable during soft passages and least noticed (often masked completely) during loud passages. The noise suppressor described in this paper is a device which controls the bandwidth of reproduction automatically and continuously as a function of the volume and frequency characteristics of the music, extending the band during the loud passages and contracting it during the low-level portions, the variation in bandwidth being independently controlled at both ends of the spectrum. Thus the noise is reduced when it would be most noticeable, and full bandwidth is used when it is most necessary, at high levels. This automatic contraction and extension

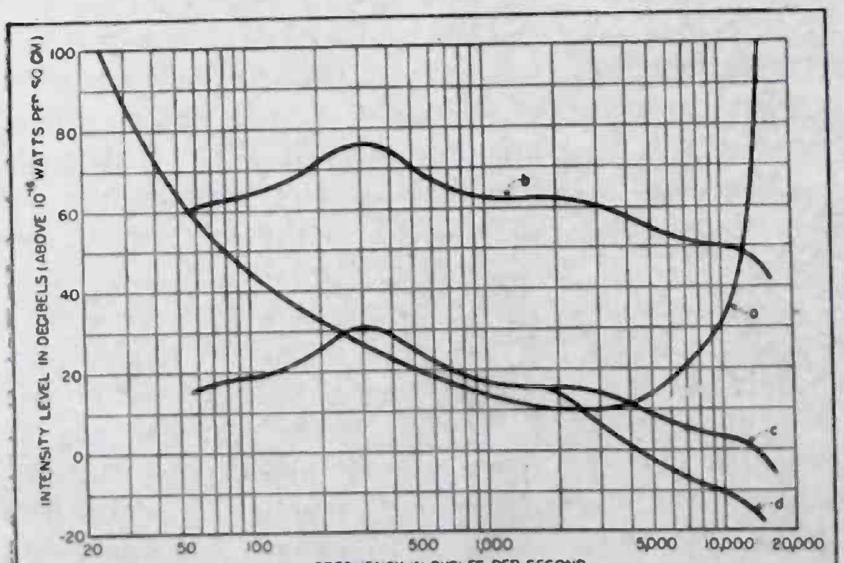


FIG. 1—Typical threshold of hearing (a) and most probable distribution of frequency components in music at high levels (b), with volume control turned down (c) and with orchestra playing softly (d)

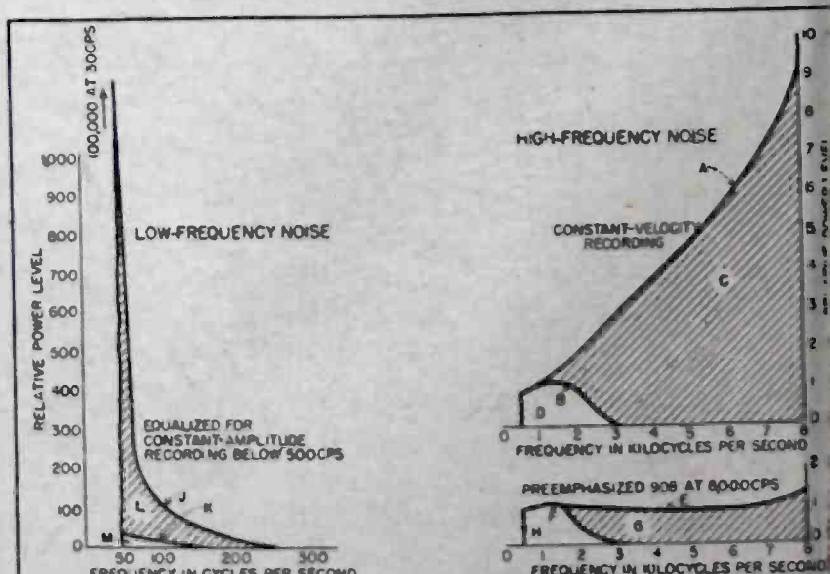
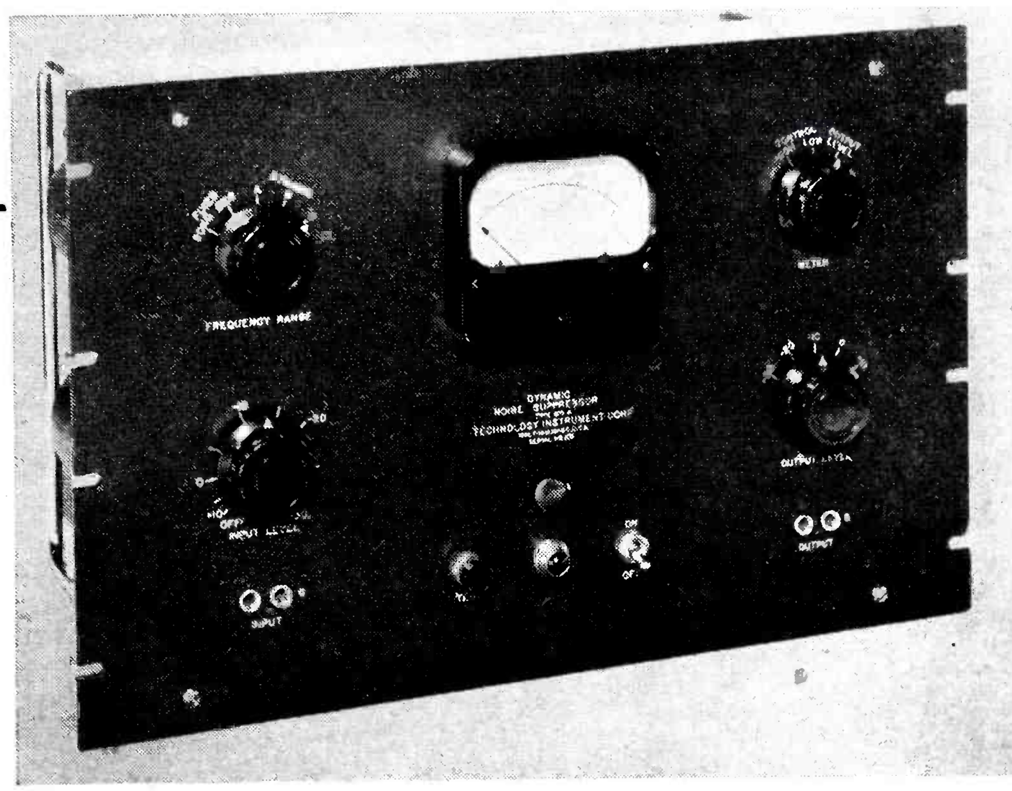


FIG. 2—Relative noise level per cycle bandwidth at high and low frequencies, when reproducing shellac records with and without dynamic noise suppressor. Shaded areas represent degree of noise reduction

Phonograph Record Noise

By H. H. SCOTT

Technology Instrument Corp.
Waltham, Mass.



Dynamic noise suppressor designed particularly for broadcast station use

of the bandwidth has but a negligible effect on the apparent realism of reproduction, because of the threshold characteristic of the ear and the distribution of energy in musical sounds as described below.

Music and Hearing

Curve *a* in Fig. 1 shows the threshold of hearing[1] for an average person, in terms of frequency. Sounds below this curve are inaudible. The distribution of the most probable amplitudes of the various frequency components involved in typical orchestral music[2] is shown by curve *b*. This may be moved up and down by varying the volume level of the reproduction as shown in curve *c*, but it will be noted that it always intersects curve *a* at definite points in both the low and high-frequency ranges. For any particular position of curve *c* and for the type of signal represented by curve *c*, all frequencies above and below these high and low-frequency limits, respectively, may be neglected so far as being of any importance to the listener is concerned, since he will not be able to hear them.

As a practical matter, if the reduction of volume is obtained by the musicians playing more softly, the shape of curve *c* will actually be altered to something more like curve *d*, showing still greater reduction in amplitude at the higher frequencies. This is the result of the well known fact that most musical instruments produce purer tones (less harmonics) when played softly than when played loudly. It will be noted that at low levels curve *d* may cross the threshold curve at a high-frequency limit as low as 2500 cycles.

Theoretically, then, when listening to low-level orchestral music of the type indicated, insertion of a 2500-cycle low-pass filter will produce little or no change which is obvious to the listener. This is actually borne out by listening tests. But the introduction of the filter results in a tremendous decrease in needle scratch. This is true because most of the scratch noise is high-frequency noise and its level is well above the threshold of hearing.

A similar situation exists at the low-frequency end of the range. Here again, reproduction of those components which fall below the threshold of hearing results in no worthwhile improvement in the quality of the signal but may cause rumble noise which is considerably louder than the desired signal components.

If, therefore, some system is devised which automatically cuts off sharply in response characteristics for the ranges including those components of a signal which are at too low a level to be heard, the apparent quality of reproduction will not suffer, and the signal-to-noise ratio will be improved to a worthwhile degree. The present state of the electronic art allows practical accomplishment of this objective in several different ways, with varying elaborateness of equipment.

Degree of Noise Reduction

The amount of audible noise reduction obtained with the system under discussion is difficult to express in simple terms, since it depends so much upon the high-frequency hearing of the individual, the effect of auditory masking of the small remaining noise by the music signal, and various psychological factors dealing with annoyance and personal preference.

A relatively simple system can be made to give more than 20-db attenuation to high-frequency and low-frequency noise, with substantially no attenuation within the pass band. A narrow band of noise is all that is left, and it is so situated (in shellac records) that it coincides with the point of minimum noise energy. It also lies within the musical spectrum, so that it is easily masked by even low-level music. In general terms, it may be said that the suppressor reduces the noise level from a point where it is distinctly annoying to a point where it is practically eliminated on the best records and prac-

Dynamic Suppression of

By controlling the bandwidth of an audio amplifier automatically in accordance with the characteristics of the recorded music, suppression of high and low-frequency noise may be achieved without noticeable injury to the realism of reproduction

THE MOST OBVIOUS shortcoming of ordinary reproduction of music from phonograph records is the presence of the high-frequency background noise level caused by minute irregularities on the surface of the record. Although this noise is more or less random in character, the most annoying part of it is concentrated in the same frequency range as the upper musical harmonics. Any attempt to reduce it has heretofore been accompanied by a serious attenuation of these harmonics and often of some of the higher musical fundamentals also.

For years, it has been recognized that the most satisfactory simple means of controlling noise is by controlling bandwidth, using as sharp a cutoff as possible beyond the desired band and a minimum of attenuation within the band. The reproduction of phonograph records represents about the only phase in the field of electrical reproducing where this precept has been generally disregarded. There are several reasons for this. One is that the commonly used crystal pickup, when operated into a high-resistance load, provides conveniently a drooping frequency characteristic or high-frequency rolloff without the use of any additional parts. Another is that phonograph records have been made with various degrees of high-frequency preemphasis, and a single tone control adjusting the rate of rolloff can be used either to compensate for the recording characteristics or to reduce noise, the latter of course always at the expense of fidelity. The third and perhaps most important reason is that a sharp cutoff frequency sufficiently low to reduce the noise level appreciably makes such a deep excursion into the range of lower overtones and higher fundamentals of the music as to produce an extremely unnatural and mechanical quality at high volume levels.

To a secondary degree there are also present low-frequency noises or rumbles, which may be in either the record or the turntable, and which are noticeable during soft passages which do not contain many low frequencies. The present tendency to use large amounts of bass boost or automatic low-frequency compensation greatly exaggerates any rumble that may be present.

High-frequency and low-frequency noises are present at substantially constant level during the playing of a record. Hence they are most noticeable during soft passages and least noticed (often masked completely) during loud passages. The noise suppressor described in this paper is a device which controls the bandwidth of reproduction automatically and continuously as a function of the volume and frequency characteristics of the music, extending the band during the loud passages and contracting it during the low-level portions, the variation in bandwidth being independently controlled at both ends of the spectrum. Thus the noise is reduced when it would be most noticeable, and full bandwidth is used when it is most necessary, at high levels. This automatic contraction and extension

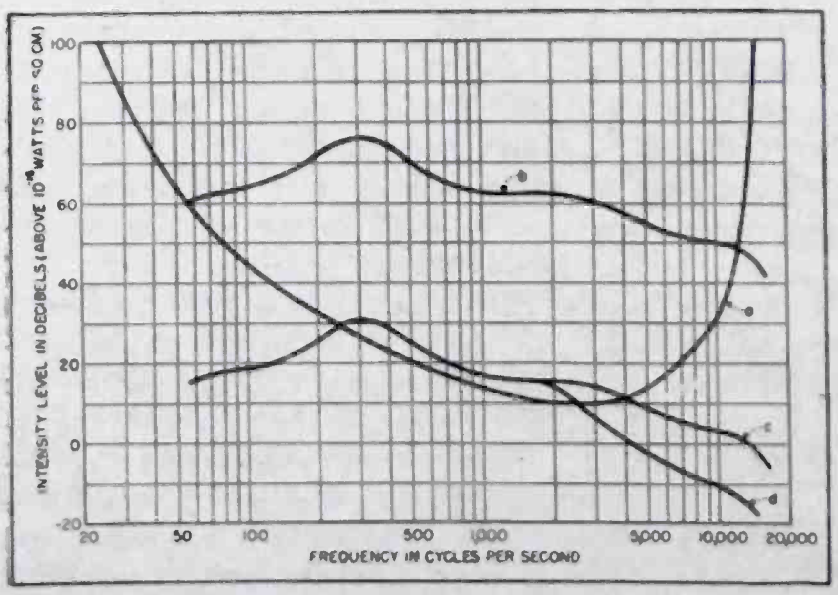


FIG. 1—Typical threshold of hearing (a) and most probable distribution of frequency components in music at high levels (b), with volume control turned down (c) and with orchestra playing softly (d)

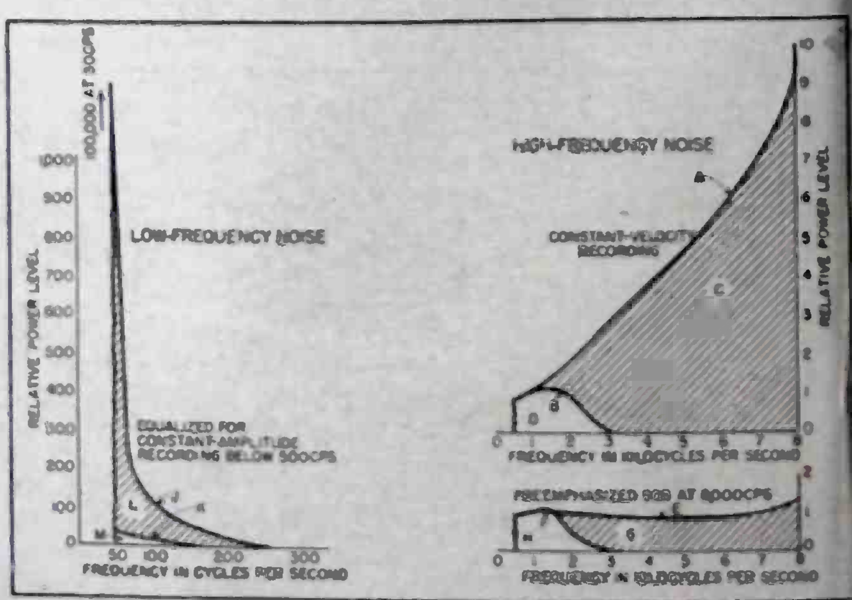
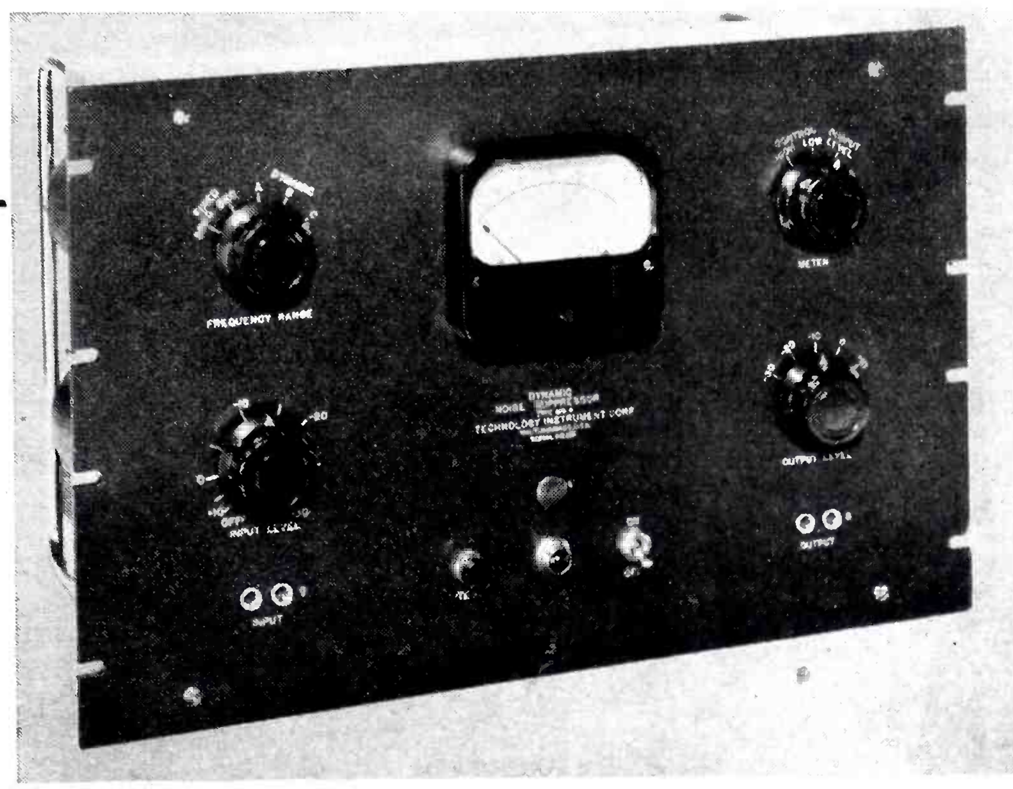


FIG. 2—Relative noise level per cycle bandwidth at high and low frequencies, when reproducing shellac records with and without dynamic noise suppressor. Shaded areas represent degree of noise reduction

Phonograph Record Noise

By H. H. SCOTT
Technology Instrument Corp.
Waltham, Mass.



Dynamic noise suppressor designed particularly for broadcast station use

of the bandwidth has but a negligible effect on the apparent realism of reproduction, because of the threshold characteristic of the ear and the distribution of energy in musical sounds as described below.

Music and Hearing

Curve *a* in Fig. 1 shows the threshold of hearing[1] for an average person, in terms of frequency. Sounds below this curve are inaudible. The distribution of the most probable amplitudes of the various frequency components involved in typical orchestral music[2] is shown by curve *b*. This may be moved up and down by varying the volume level of the reproduction as shown in curve *c*, but it will be noted that it always intersects curve *a* at definite points in both the low and high-frequency ranges. For any particular position of curve *c* and for the type of signal represented by curve *c*, all frequencies above and below these high and low-frequency limits, respectively, may be neglected so far as being of any importance to the listener is concerned, since he will not be able to hear them.

As a practical matter, if the reduction of volume is obtained by the musicians playing more softly, the shape of curve *c* will actually be altered to something more like curve *d*, showing still greater reduction in amplitude at the higher frequencies. This is the result of the well known fact that most musical instruments produce purer tones (less harmonics) when played softly than when played loudly. It will be noted that at low levels curve *d* may cross the threshold curve at a high-frequency limit as low as 2500 cycles.

Theoretically, then, when listening to low-level orchestral music of the type indicated, insertion of a 2500-cycle low-pass filter will produce little or no change which is obvious to the listener. This is actually borne out by listening tests. But the introduction of the filter results in a tremendous decrease in needle scratch. This is true because most of the scratch noise is high-frequency noise and its level is well above the threshold of hearing.

A similar situation exists at the low-frequency end of the range. Here again, reproduction of those components which fall below the threshold of hearing results in no worthwhile improvement in the quality of the signal but may cause rumble noise which is considerably louder than the desired signal components.

If, therefore, some system is devised which automatically cuts off sharply in response characteristics for the ranges including those components of a signal which are at too low a level to be heard, the apparent quality of reproduction will not suffer, and the signal-to-noise ratio will be improved to a worthwhile degree. The present state of the electronic art allows practical accomplishment of this objective in several different ways, with varying elaborateness of equipment.

Degree of Noise Reduction

The amount of audible noise reduction obtained with the system under discussion is difficult to express in simple terms, since it depends so much upon the high-frequency hearing of the individual, the effect of auditory masking of the small remaining noise by the music signal, and various psychological factors dealing with annoyance and personal preference.

A relatively simple system can be made to give more than 20-db attenuation to high-frequency and low-frequency noise, with substantially no attenuation within the pass band. A narrow band of noise is all that is left, and it is so situated (in shellac records) that it coincides with the point of minimum noise energy. It also lies within the musical spectrum, so that it is easily masked by even low-level music. In general terms, it may be said that the suppressor reduces the noise level from a point where it is distinctly annoying to a point where it is practically eliminated on the best records and prac-

Dynamic Suppression of

By controlling the bandwidth of an audio amplifier automatically in accordance with the characteristics of the recorded music, suppression of high and low-frequency noise may be achieved without noticeable injury to the realism of reproduction

THE MOST OBVIOUS shortcoming of ordinary reproduction of music from phonograph records is the presence of the high-frequency background noise level caused by minute irregularities on the surface of the record. Although this noise is more or less random in character, the most annoying part of it is concentrated in the same frequency range as the upper musical harmonics. Any attempt to reduce it has heretofore been accompanied by a serious attenuation of these harmonics and often of some of the higher musical fundamentals also.

For years, it has been recognized that the most satisfactory simple means of controlling noise is by controlling bandwidth, using as sharp a cutoff as possible beyond the desired band and a minimum of attenuation within the band. The reproduction of phonograph records represents about the only phase in the field of electrical reproducing where this precept has been generally disregarded. There are several reasons for this. One is that the commonly used crystal pickup, when operated into a high-resistance load, provides conveniently a drooping frequency characteristic or high-frequency rolloff without the use of any additional parts. Another is that phonograph records have been made with various degrees of high-frequency preemphasis, and a single tone control adjusting the rate of rolloff can be used either to compensate for the recording characteristics or to reduce noise, the latter of course always at the expense of fidelity. The third and perhaps most important reason is that a sharp cutoff frequency sufficiently low to reduce the noise level appreciably makes such a deep excursion into the range of lower overtones and higher fundamentals of the music as to produce an extremely unnatural and mechanical quality at high volume levels.

To a secondary degree there are also present low-frequency noises or rumbles, which may be in either the record or the turntable, and which are noticeable during soft passages which do not contain many low frequencies. The present tendency to use large amounts of bass boost or automatic low-frequency compensation greatly exaggerates any rumble that may be present.

High-frequency and low-frequency noises are present at substantially constant level during the playing of a record. Hence they are most noticeable during soft passages and least noticed (often masked completely) during loud passages. The noise suppressor described in this paper is a device which controls the bandwidth of reproduction automatically and continuously as a function of the volume and frequency characteristics of the music, extending the band during the loud passages and contracting it during the low-level portions, the variation in bandwidth being independently controlled at both ends of the spectrum. Thus the noise is reduced when it would be most noticeable, and full bandwidth is used when it is most necessary, at high levels. This automatic contraction and extension

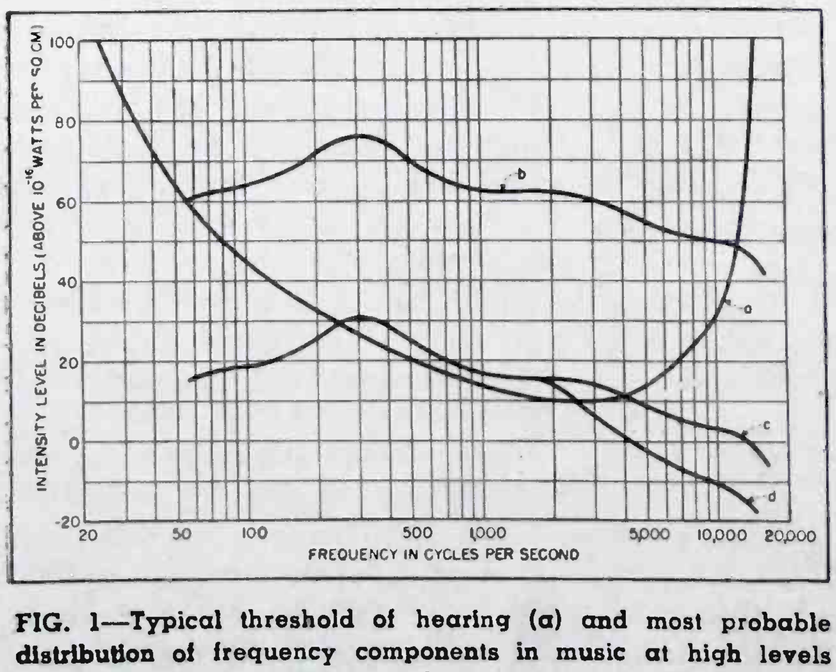


FIG. 1—Typical threshold of hearing (a) and most probable distribution of frequency components in music at high levels (b), with volume control turned down (c) and with orchestra playing softly (d)

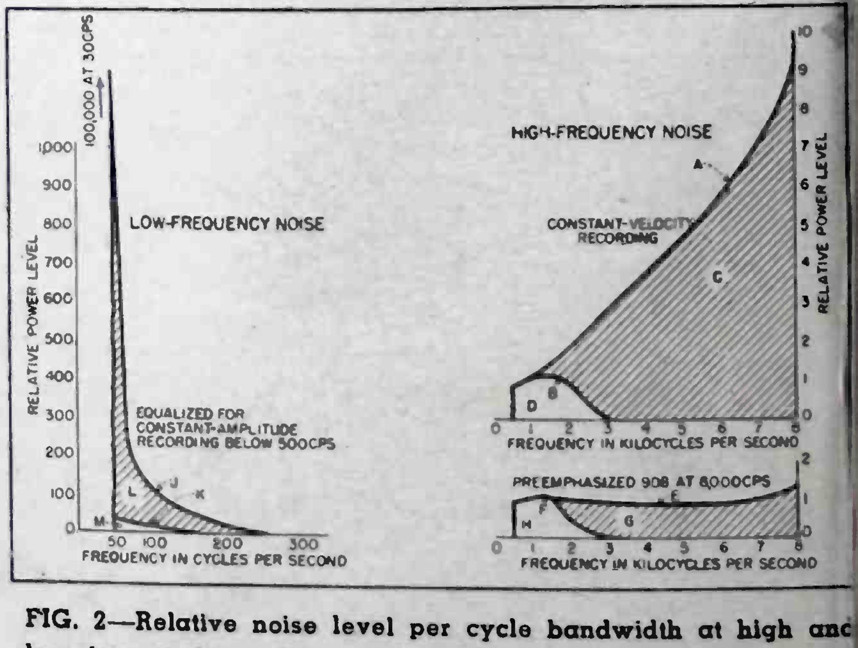
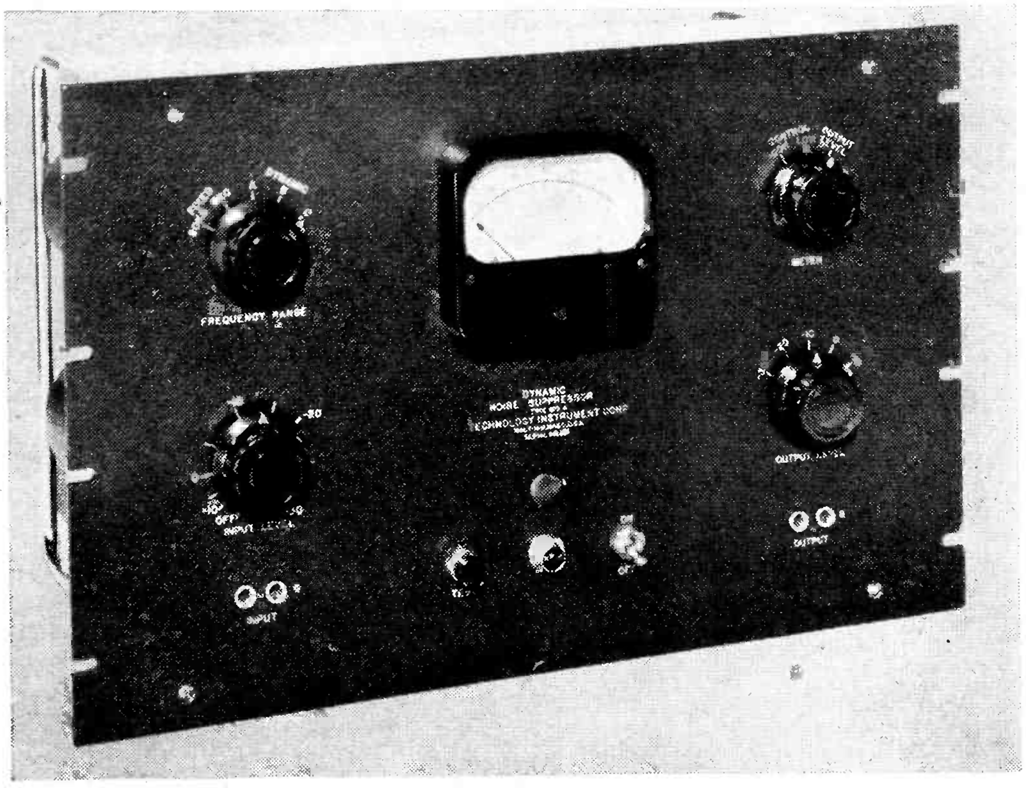


FIG. 2—Relative noise level per cycle bandwidth at high and low frequencies, when reproducing shellac records with and without dynamic noise suppressor. Shaded areas represent degree of noise reduction

Phonograph Record Noise

By H. H. SCOTT
Technology Instrument Corp.
Waltham, Mass.



Dynamic noise suppressor designed particularly for broadcast station use

of the bandwidth has but a negligible effect on the apparent realism of reproduction, because of the threshold characteristic of the ear and the distribution of energy in musical sounds as described below.

Music and Hearing

Curve *a* in Fig. 1 shows the threshold of hearing[1] for an average person, in terms of frequency. Sounds below this curve are inaudible. The distribution of the most probable amplitudes of the various frequency components involved in typical orchestral music[2] is shown by curve *b*. This may be moved up and down by varying the volume level of the reproduction as shown in curve *c*, but it will be noted that it always intersects curve *a* at definite points in both the low and high-frequency ranges. For any particular position of curve *c* and for the type of signal represented by curve *c*, all frequencies above and below these high and low-frequency limits, respectively, may be neglected so far as being of any importance to the listener is concerned, since he will not be able to hear them.

As a practical matter, if the reduction of volume is obtained by the musicians playing more softly, the shape of curve *c* will actually be altered to something more like curve *d*, showing still greater reduction in amplitude at the higher frequencies. This is the result of the well known fact that most musical instruments produce purer tones (less harmonics) when played softly than when played loudly. It will be noted that at low levels curve *d* may cross the threshold curve at a high-frequency limit as low as 2500 cycles.

Theoretically, then, when listening to low-level orchestral music of the type indicated, insertion of a 2500-cycle low-pass filter will produce little or no change which is obvious to the listener. This is actually borne out by listening tests. But the introduction of the filter results in a tremendous decrease in needle scratch. This is true because most of the scratch noise is high-frequency noise and its level is well above the threshold of hearing.

A similar situation exists at the low-frequency end of the range. Here again, reproduction of those components which fall below the threshold of hearing results in no worthwhile improvement in the quality of the signal but may cause rumble noise which is considerably louder than the desired signal components.

If, therefore, some system is devised which automatically cuts off sharply in response characteristics for the ranges including those components of a signal which are at too low a level to be heard, the apparent quality of reproduction will not suffer, and the signal-to-noise ratio will be improved to a worthwhile degree. The present state of the electronic art allows practical accomplishment of this objective in several different ways, with varying elaborateness of equipment.

Degree of Noise Reduction

The amount of audible noise reduction obtained with the system under discussion is difficult to express in simple terms, since it depends so much upon the high-frequency hearing of the individual, the effect of auditory masking of the small remaining noise by the music signal, and various psychological factors dealing with annoyance and personal preference.

A relatively simple system can be made to give more than 20-db attenuation to high-frequency and low-frequency noise, with substantially no attenuation within the pass band. A narrow band of noise is all that is left, and it is so situated (in shellac records) that it coincides with the point of minimum noise energy. It also lies within the musical spectrum, so that it is easily masked by even low-level music. In general terms, it may be said that the suppressor reduces the noise level from a point where it is distinctly annoying to a point where it is practically eliminated on the best records and prac-

tically unnoticeable on the worst records.

The only fair proof of the effectiveness and true value of the dynamic noise suppressor is in actual listening tests. Figure 2 has been prepared in an attempt to give a graphical portrayal of the amount of noise reduction. Curve *A* represents typical noise level per cycle bandwidth on a standard-grade shellac record.[3] The variation among records is very great, and while some high-quality records, particularly of the Vinylite type, may be noticeably quieter, many records, particularly if at all worn, produce far higher noise levels in the high-frequency range.

Curve *A* represents the relative noise level at various frequencies in terms of power level, as reproduced with a flat overall characteristic from a constant-velocity recording. The total area *C* plus *D* under curve *A* represents the total noise, since a linear frequency scale is used. Similarly, curve *B* represents the remaining noise spectrum when using the dynamic noise suppressor and the area *D* under this curve represents the remaining noise energy. Visual comparison of the area *D* with the total area *C* plus *D* gives some idea of the amount of noise reduction obtained on the physical basis of overall noise energy. It will be noted that the area *C*, representing the amount of noise eliminated by the dynamic noise suppressor, comprises all but a very small portion of the total noise energy, and that the most annoying noise, which occurs in the higher frequency ranges, is eliminated entirely.

Preemphasized recordings have been used increasingly in recent years as a means of obtaining an improved signal-to-noise ratio. While record companies have not published data as to the exact amount of preemphasis used, indications are that 9 db at 8000 cycles is typical of records which have been widely sold. If the reproducing system is provided with an equivalent amount of deemphasis, the curve *A* becomes the curve *E*, and curve *B* becomes curve *F*. The total area *H* plus *G* represents the total noise, while *G* represents the relatively large proportion eliminated by the suppressor and *H* is the relatively small amount of remaining noise, which is even smaller than the equivalent area *D* without preemphasis.

Figure 2 shows also the low-frequency noise taken from Bauer's data (which were on a constant-velocity basis), adjusted for the normal reproducing characteristic used with a 500-cycle turn-over point between constant-amplitude and constant-velocity recording. It should be noted that the scales for the low-frequency chart are different from the high-frequency charts in order to provide satisfactory illustration of the noise-reduction effect. The break between the low and high-frequency charts was positioned at 500 cycles, which is a conventional crossover point in recording characteristics. It will be noted from curve *J* that low-frequency noise increases rapidly below 200 cycles, reaching a power level 1000 times as high at 50 cycles as at 1000 cycles, and still 100 times higher at 30 cycles. This illustrates why many record-reproducing systems have incorporated low-frequency cutoff circuits to reduce rumble trouble and acoustic feedback.

The action of the noise suppressor is the opposite of the low-frequency noise characteristic in that the noise attenuation increases as the frequency is decreased. Consequently, the remaining noise is approximately as shown by curve *K*, and is negligible at even very low frequencies. The total area *L* plus *M* represents the total low-frequency noise, the area *L* being that eliminated by the suppressor, and the area *M* representing the remaining noise. It will be noted that *M* represents a negligible part of the total noise area. Use of the suppressor is consequently of tremendous benefit in systems having extended or boosted bass response, and the suppressor becomes more important as the bass response is improved.

Aural Balance

There is a further important advantage in the simultaneous control of the low and high frequencies which is totally independent of the noise-suppression effect but is of prime importance in presenting what to the ear appears to be constant reproduction of a wide frequency range.

It is well known that restriction of one end of the frequency range is less noticeable if the other end of the range is also restricted, thus maintaining substantially constant the product between the high-frequency and the low-frequency cutoffs of the system. Of course, if the noise-suppression system were perfect, and the frequency ranges attenuated always fell beyond the range of audibility, the question of maintenance of aural balance would be of no importance, since, so far as the ear could determine, there would be no restriction of the frequency range. As a practical matter, however, this theoretically ideal condition is not always obtained.

Many people like to operate their radios or phonographs at a fairly high level, and, particularly where a high degree of compression is used in the transmission or the recording, the low-level portions of the program may be heard at a higher level than normal. This is also true for people sitting unusually close to the loudspeaker when the volume is adjusted for satisfactory level in a fairly large room. Under either of these conditions, the range during the low-level portions of the program may be restricted somewhat within the audible limits. Also, all program material will not follow exactly the actual frequency distribution of the curve *d* of Fig. 1. In fact, the actual frequency distribution of the music is constantly varying not only from orchestra to orchestra or from instrument to instrument, but also from instant to instant. Any curve such as those of *c* or *d*, therefore, represents merely an average condition.

Since these particular curves are based upon most probable levels, variations will normally fall below the curves, but occasionally variations will fall above the curves, and under these conditions also, if the variations occur at very high or very low frequencies, the aural balance might be upset. Independent control of low-level high-frequency cutoffs provides best fidelity for a wide range of signal types and best aural balance for variations in listening conditions.

A third condition goes back to the generally accepted reaction of the average listener in regard to noise versus high fidelity. Under conditions where a choice between fidelity and noise must be made, the listener will generally choose that condition which keeps the noise level practically inaudible during the actual program. With extremely noisy records, this may make desirable the setting of the control and gate circuits so as to provide somewhat greater frequency-range restriction, particularly at low levels, than that implied from theoretical considerations of curves *a* and *d*.

These conditions indicate the desirability of a system controlling both low and high frequencies, a desirability sufficiently great, in fact, to warrant control of both ends of the frequency spectrum even under conditions where noise is encountered at only one end.

Gate and Control Circuits

The heart of the noise-suppression system is a controlled bandpass filter known as the gate circuit. It has extremely sharp cutoff characteristics, particularly for the elimination of high-frequency noise. For varying applications, depending upon the type of signal and the type of noise, lowpass, bandpass or band-elimination characteristics may be desired. For the disc record application a bandpass characteristic is preferred, with a sharp cutoff at the high-frequency end. The sharpness of the low-frequency cutoff is of somewhat less importance, but a slope steeper than that obtained with the ordinary single-stage R-C tone control is desirable. The gate circuit is capable of rapid control without introducing audible thumps into the output.

The control circuit which actuates the gate circuit adjusts independently and continuously both high and low cutoffs of the system, so that they always coincide with the respective points of intersection of the curves for the threshold of audibility and the frequency distribution of the particular signal. The control must be sufficiently fast to permit satisfactory reproduction of transient sounds and to follow each individual note in the music, so that noise shall not be heard in the background between adjacent notes in music of a staccato or percussion character, such as from the piano. When properly operated, the system shows no noticeable evidence of a rising and falling background noise varying in accordance with the musical signal.

CIRCUITS TO COME

For patent reasons, the author has found it necessary to omit circuit diagrams from this paper.

In view of the great interest aroused by demonstrations of the dynamic noise suppressor at the National Electronics Conference, the editors feel that this description of the underlying principle should nevertheless be published.

Mr. Scott has promised complete details of both broadcast-station and home equipment for publication in an early issue.

The noise levels encountered in the upper and lower frequency ranges over which the cutoffs may be varied are considerably higher than the musical components existing in those ranges, except during a small portion of the playing time. Consequently the sensitivity of the control circuit must be reduced in the ranges over which the cutoffs are controlled in order that control shall reside in the signal, rather than in the noise or rumble. This is very satisfactorily arranged when the reproduced signal is music, since the extremely high harmonics exist only with fundamentals of somewhat lower frequency, and control of the high-frequency cutoff can be exercised in accordance with musical components below the controlled range. Similarly, the deep bass fundamentals are accompanied by harmonics of appreciable amplitude which may be used to control the low-frequency cutoff.

Practical Equipment

The noise suppressor for home phonograph use involves only three vacuum tubes, two in the gate circuit and one in the control circuit, and this third and latter tube may often be combined with one of the tubes already in the set. Furthermore, the gate circuit may be made with an adjustable maximum bandwidth or rolloff and thus may be used to replace some of the usual tone-control circuits in the receiver and the 10-kc whistle filter for a-m reception, so that the additional parts required to include the suppressor in a radio-phonograph are few in number.

Further elaboration of the gate and control circuits will produce many advantages such as wider frequency range, lower distortion, lower hum level, greater flexibility of control, and the ability to cope satisfactorily with a wider range of signal and noise types. The first three of these characteristics are of relatively little importance in home radio-phonograph, since even the simpler circuits exceed the normal requirements of home radio-phonograph design in these respects. The other improvements involve too many extra parts and tubes for inclusion in the average home receiver. On the other hand, for broadcast applications, the best possible performance is more important than the actual cost of the equipment, and for these applications, a considerably more elaborate form of the noise suppressor has been designed and is pictured here.

Details of the circuits will be published in an article to appear in these pages as soon as patent actions are completed.

REFERENCES

(1) Smoothed version of data presented by Steinber, Montgomery and Gardner, Results of the World's Fair Hearing Tests, *Bell Sys. Tech. Jour.*, 19, p 533, October 1940.

(2) Prepared by Ralph P. Glover, based upon data published by the Bell Telephone Laboratories. See also "Frequency Range and Power Considerations in Music Reproduction", published by the Jensen Radio Mfg. Co., and Harvey Fletcher, Hearing, the Determining Factor for High-Fidelity Transmission, *Proc. IRE*, 30, p 266, June 1942.

(3) Smoothed version of data used by B. B. Bauer, Crystal Pickup Compensation Circuits, ELECTRONICS, p 128, Nov. 1945.

VIBRATION EXCITER for Structural Tests

Electromagnetic shaker units develop tremendous forces at mechanical resonance, for aircraft flutter tests and failure tests in structural members. Unique carrier-type a-f amplifier, phase shifter, and phase indicator circuits are employed

By PAUL J. HOLMES
Chief Engineer
The Rollin Company
Pasadena, California

Complete vibration exciter equipment for driving the two pairs of electromagnetic shaker on the floor. Power amplifier cabinet at left contains plug-in a-f oscillator for controlling exciting frequency of shakers, while cabinet at right contains plug-in phase shifter for varying phase relationship of signals fed from a-f oscillator to the two power amplifiers. Extra a-f oscillator on box between cabinets is plugged into cabinet at right in place of phase shifter when it is desired to use the two amplifiers independently, each with its own controllable a-f oscillator and pair of shakers

This electronic vibration exciting equipment was primarily designed for making flutter tests on large aircraft structures. It provides for separately exciting vibration at each mechanical resonant frequent of the structure being tested, as contrasted to brute-force apparatus wherein vibration is created through use of a rotating unbalanced mass driven by a constant-speed motor.

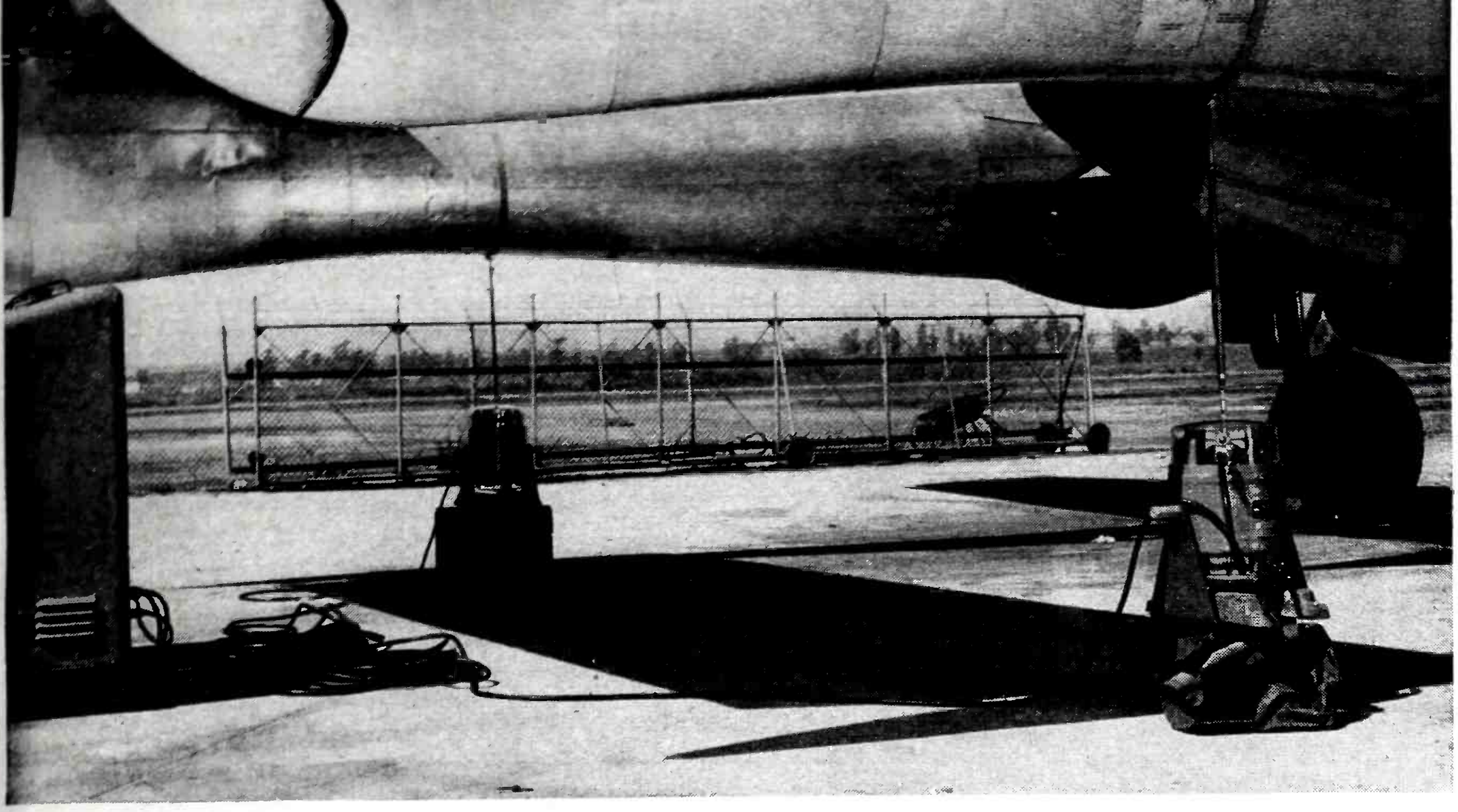
In comparison with a mechanical system for producing vibration, the electronic method offers flexibility and accurate control over the vibration forces being applied. When desired, vibration forces may be exerted simultaneously at several points on a structure. The operator has fingertip control over the phase and amplitude relationships of the several vibration forces being exerted, permitting excitation of torsional or bending modes of wings, either symmetrical or antisymmetrical, at will.

As an example, the Douglas C-74 (DC-7) airplane was caused to bounce vertically on its landing gear by applying vibration exciting forces to the wings, adjacent to each side of the fuselage. The mass of the airplane (30 tons) and the compliance of the tires resonated at a frequency of 114 cycles per minute. Two electromagnetic shakers were used and the peak force required to produce the vertical bounding was only 45 pounds per shaker. Thus, tremendous mechanical forces can be developed through the phenomenon of resonance.

In another test, the wing of a large airplane was excited in an anti-symmetrical bending mode. This imparted a torsional (rotational) motion to the fuselage, causing the tail assembly to whip from side to side. The extent of tail motion made the fuselage oil-can and produce snapping sounds like those of a child's metal cricket.

Many of the recent types of aircraft, both large and small, have been tested with the Rollin model 35 equipment described, including the Consolidated Vultee XB-36 (the Army's largest land-based bomber), the Northrop XB-35 flying wing, Douglas C-74, Northrup XF-15, and the Consolidated RY-3.

The use of the equipment is not limited to testing airframes, however. It may be employed to excite vibration in various types of structures, such as for making accelerated repeated load or fatigue tests (to the point of failure or destruction) to determine the physical properties of various structural members or certain materials. For instance, a resonant force of 200 pounds may be exerted alternately in tension and compression on a sample structural member for 80,000 cycles in two hours. A similar test employing motor-driven cam-operated apparatus operating at the rate of 10 cycles per minute would



Power amplifier cabinet just showing at left supplies exciting power to the two shakers on the ground, each attached to one of the fuselage sections of a Northrop F-15 photo reconnaissance plane

require well over 100 hours of running.

Electromagnetic Shaker Units

The driving force is produced by electromagnetic vibration motor or shaker units energized by a vacuum-tube oscillator and power amplifier. The frequency of the oscillator can be controlled over a range from 2 cycles per second (120 cpm) to over 500 cycles per second (30,000 cpm), and lower frequencies down to zero can be obtained by substituting a motor-driven sine potentiometer and a battery for the vacuum-tube oscillator.

A shaker unit comprises a movable armature coil suspended in the air gap of a magnetic circuit operated at high flux density. The field coils are wound with 100 pounds of copper wire. The complete shaker weighs about 225 pounds and can produce a peak blocked driving force of 150 pounds. A mechanical connection to the armature transfers this force to a structure.

A unique beryllium copper suspension system keeps the armature coil centered in the air gap during motion while permitting an armature excursion of over ¾ inch in both directions from the rest position. Less than 5 pounds of pull is required to move the armature from its rest position to a position of maximum excursion. This spring system has low mechanical damping as required for observance of weak resonant periods of vibration in the structure under test, and the mass of the driving element (primarily that of the armature coil) is low enough so it does not affect the resonant periods of the structure. Another requirement, minimum electrical damping, is obtained by keeping the internal resistance or impedance of the source of driving power (the amplifier output stage) high with respect to that of the armature coils. With a higher resistance, the back emf generated by armature coil motion cannot cause appreciable current flow which would constitute an electrical damping effect.

Many vibration tests require means for applying vibration forces of different phase to two points on a structure, such as for creating torsional (rotational) types of vibration. For this reason two identical exciters are provided, each in its separate cabinet and driving its own pair of shakers. The block diagram in Fig. 1 shows interrelationships of the two cabinets. If only one pair of shakers is required one cabinet and the phase shifter are disconnected, and the audio oscillator is fed directly into the other cabinet. The unused

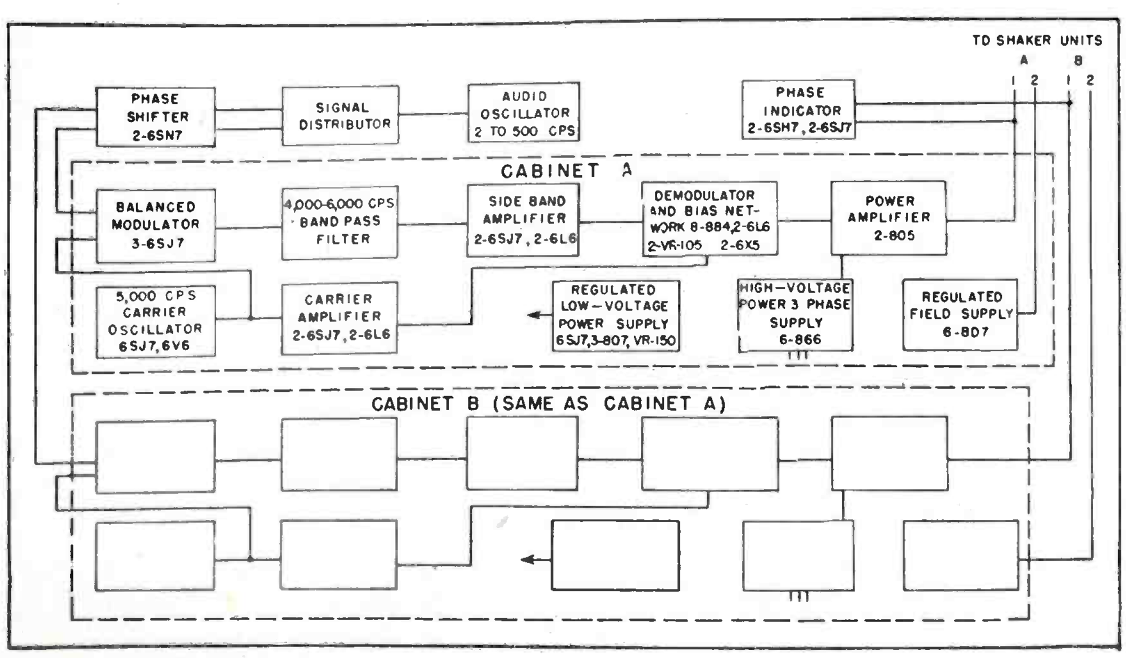


FIG. 1—Block diagram of complete vibration exciter equipment for driving two pairs of shakers

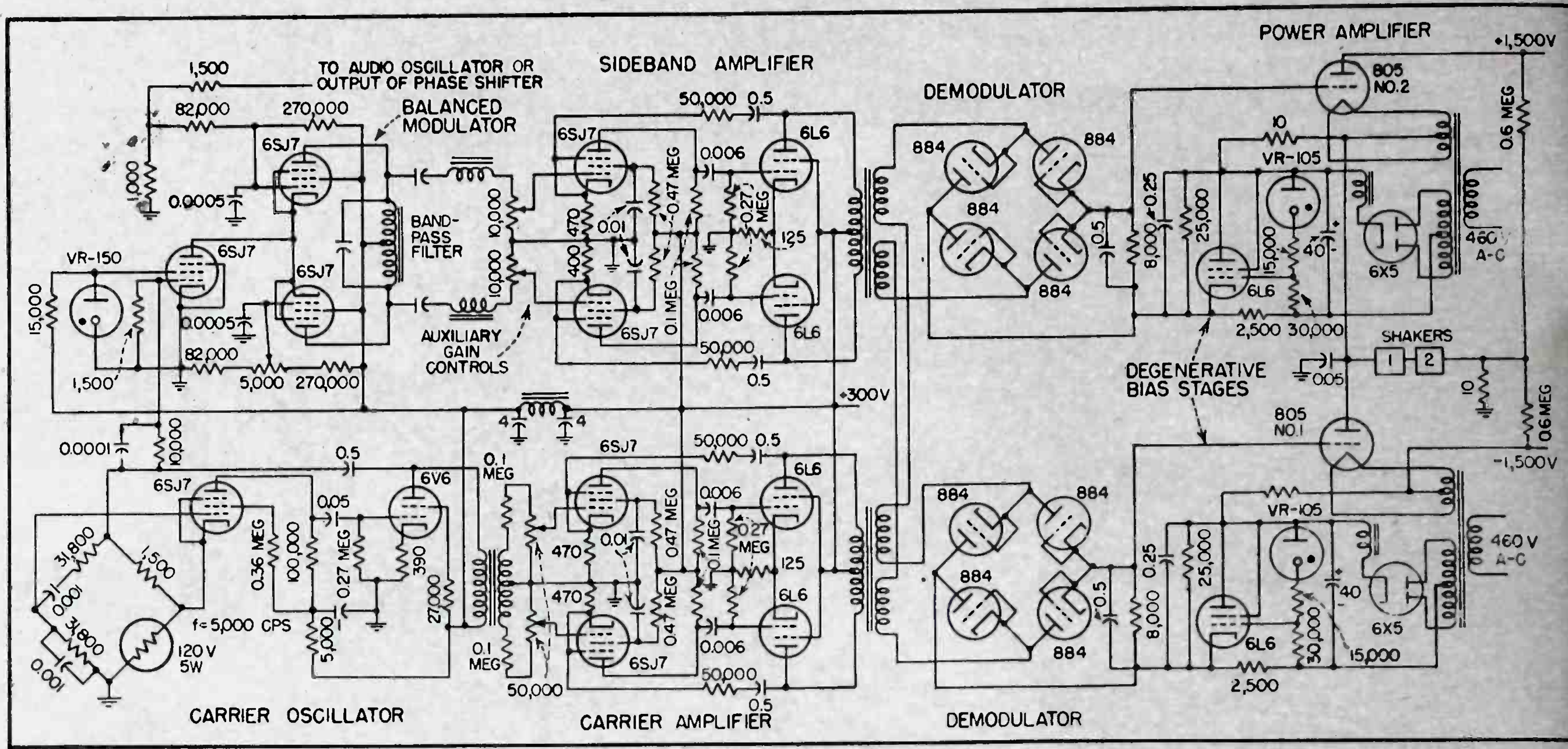


FIG. 2—Circuit of carrier-type power amplifier used for driving one pair of shakers

units serve as standby sets, a desirable feature since interruption of tests on a large airplane is quite expensive.

Operation of Exciter

Consider first the simplest setup whereby the audio oscillator is feeding directly into the balanced modulator of cabinet A in Fig. 1 and cabinet B is unused. To achieve satisfactory amplifier performance from 500 cycles down to zero frequency, a carrier system is employed and the class B output stage is of the cascade type. No output transformer is used.

The low-frequency signal from the 2 to 500-cycle oscillator (or from a still lower frequency motor-driven sine-wave generator) and a 5,000-cycle signal from the carrier oscillator are directly impressed on a novel degenerative type balanced modulator which will function to zero signal frequency and is extremely stable in operation. The modulator suppresses the 5,000-cycle carrier and creates sum and difference components in the output. The low-frequency signal (2 to 500 cycles) is also in the output, but is eliminated by a 4,000 to 6,000-cycle bandpass filter. The resulting desired sideband components are amplified in the sideband amplifier. The output from the carrier oscillator is separately amplified in another identincal amplifier.

The amplified outputs appear in transformers which have dual output windings. At this point the sidebands are recombined with the carrier so normal modulated envelopes are produced. A phase correction network (not shown on the block diagram) located between the carrier oscillator and the balanced modulator provides for proper phase between the carrier and sidebands when recombined.

The dual output windings feed separate demodulators 180 degrees out of phase, so that the demodulator output signals are suitable for driving the grids of the class B output tubes which drive the shakers.

Exciter Circuit

The complete circuit for driving one pair of shakers (housed in one cabinet) is given in Fig. 2. In addition to the low-frequency signals, the outputs of the demodulators contain a d-c voltage due to the carrier. This voltage would continuously bias the grids of the output tubes if it were not balanced out by an opposite bias voltage. Unique degenerative bias networks serve this purpose and also function as sources of d-c bias voltage which remain constant regardless of grid current flow through them.

The grids of class B tubes draw considerable current when the impressed signal is positive. Such current flow tends to increase the voltage across a bias network but the action of the degenerative network is to maintain the bias at a nearly constant value. Because of this grid current flow, the output impedance of the demodulators must be quite low and have good regulation. The low impedance is obtained by employing for the demodulators a bridge circuit using type 884 rectifiers and by having considerable negative feedback in the sideband and carrier amplifiers.

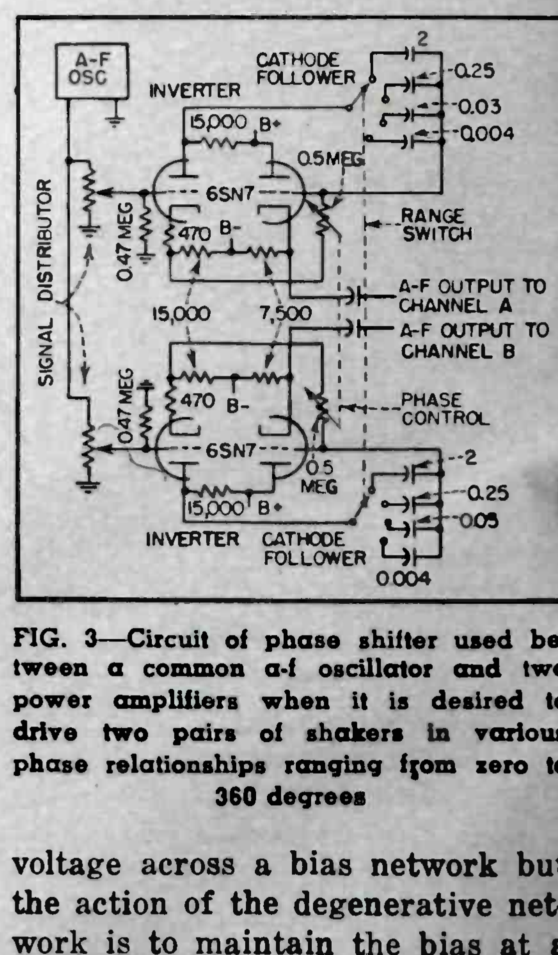


FIG. 3—Circuit of phase shifter used between a common a-f oscillator and two power amplifiers when it is desired to drive two pairs of shakers in various phase relationships ranging from zero to 360 degrees

Power Supply Circuits

The design of the power supplies is more or less conventional. Three-phase 460-volt power is employed ecause the rectified output from he power supplies is then simple to ilter and gives good regulation as equired for low-frequency amplifier operation. The positive and egative high-voltage supplies for he type 805 output tubes are obained from two Y-connected threehase half-wave rectifier circuits mploying a total of six type 866A ubes. In extremely low-frequency mplifier operation, the instantaeous peak plate current of the output tubes (750 milliamperes) beomes substantially a static current nd the high-voltage power supply s designed to supply this peak curent continuously.

The low-voltage power supply mploys a three-phase half-wave ircuit using three type 866A recifier tubes. Its output is filtered nd fed to an electronic voltage reglator which in turn supplies plate oltage to all vacuum tubes other han the type 805 output tubes.

Current Regulators

The rectified and filtered output f the low-voltage power supply is lso fed to two electronic current egulators which supply all necesary field current to the shaker nits. Each current regulator comrises three type 807 tubes conected as pentodes and used as contant-current devices to supply a ontrollable field current to its haker units and hold the current constant despite changes in field coil resistance during heating.

A resonant type constant-voltage transformer connected to one phase of the three-phase 460-volt power line supplies regulated 115-volt a-c power for the 2 to 500-cycle oscillator. This oscillator has a feedback circuit with a very low time constant and sudden variations in line voltage would cause low-frequency transients.

Phase-Shifter

For dual operation with cabinet A and cabinet B, the setup is as shown in Fig. 1. Each phase-shifting network in the phase shifter employs a dual-triode vacuum tube connected as in Fig. 3. The first section serves as a phase inverter to obtain equal voltages with respect to ground which are 180 degrees out of phase. Across the output terminals of the phase inverter is a series-connected *RC* network whose junction point goes to the grid of the second section of the dual triode, which is connected as a cathode follower.

The phase-shifted voltage at the grid of the cathode follower is the vector sum of two voltages whose magnitude and angle both change as the variable resistance of the *RC* network is changed. The magnitude of the resultant of these two voltages remains constant in amplitude while the phase angle is changed from zero to very nearly 180 degrees. Thus, the output of each cathode follower supplies a voltage whose phase may be continuously shifted by means of a variable resistance.

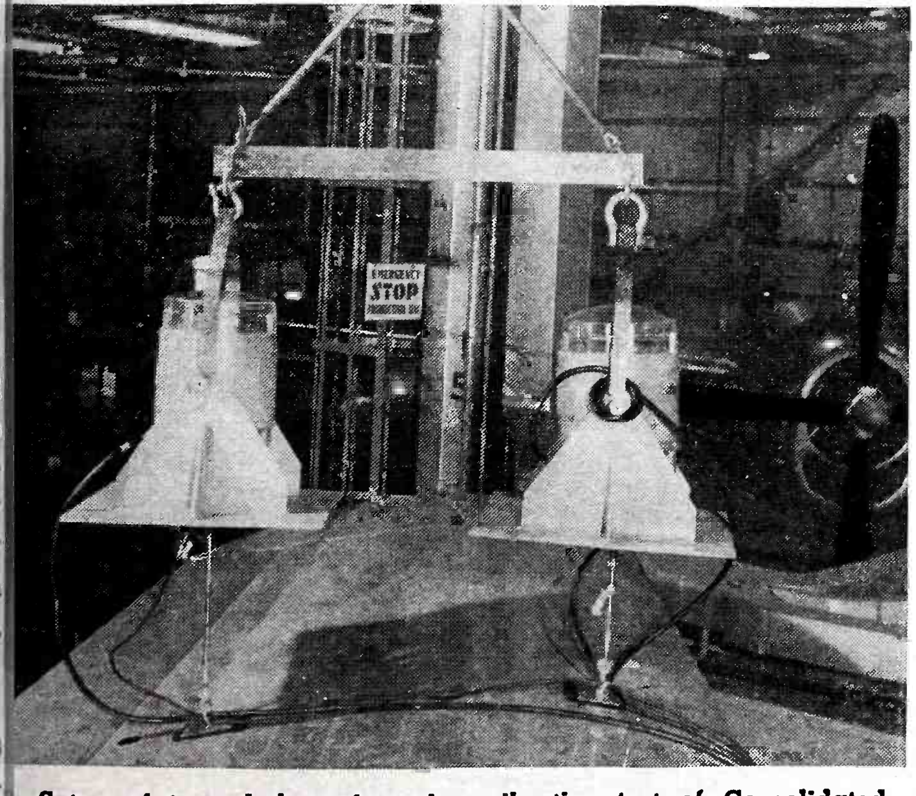
Signal Distributor

The signal distributor used between the phase shifter and the a-f oscillator provides for continuously varying the amplitude relationships of the forces exerted by the pairs of shaker units. With this control one pair of shakers can be caused to produce a low driving force while the other pair is producing a high driving force, and vice versa, or an equal driving force can be had from both pairs of shakers. Overall control of the forces is provided by a master control on the 2 to 500-cycle oscillator.

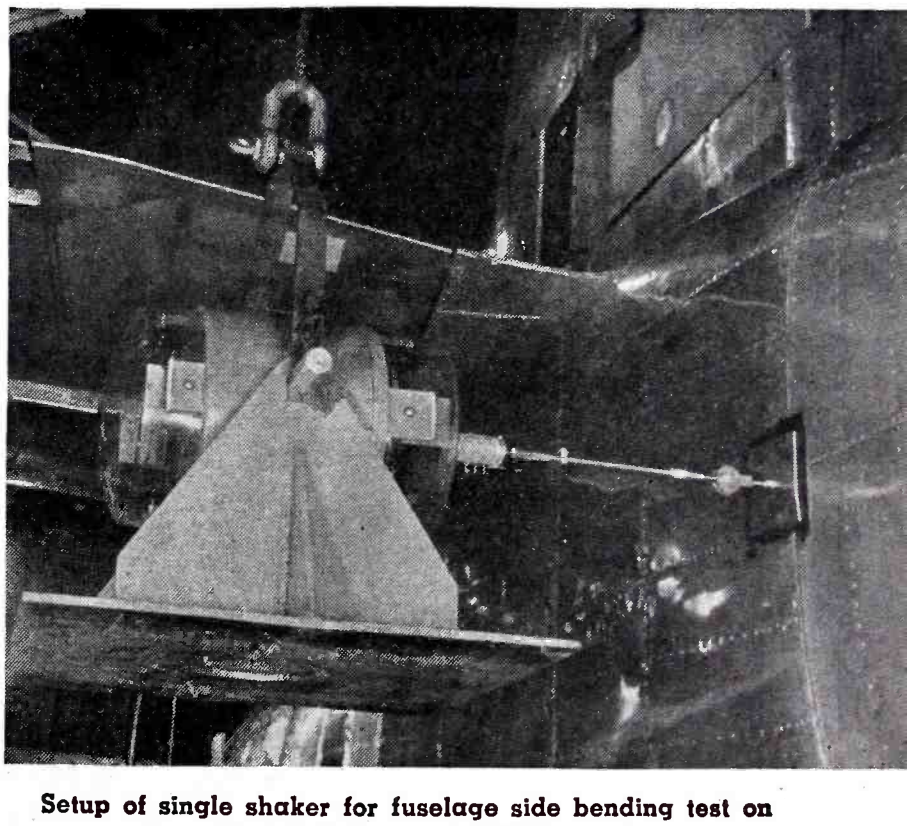
The variable resistances of the two phase-shifting networks are ganged to provide concurrent adjustment, advancing the phase in one output while retarding the phase of the other. The phase relationship can be adjusted from 0 to nearly 360 degrees in this manner.

Phase Indicator

The phase indicator (used only for dual operation) indicates phase differences of from 0 to 360 degrees on a calibrated linear scale, with the 180-degree point occurring



Setup of two shakers for wing vibration test of Consolidated Vultee model RY-3 airplane



Setup of single shaker for fuselage side bending test on Consolidated Vultee model RY-3 airplane

exactly at midscale. Continuous indication of phase is obtained, substantially independent of frequency over the range of from 2 to 500 cycles and very nearly independent of the amplitude relationship of the signals being compared for phase.

The circuit of the phase indicator appears in Fig. 4. In operation, a constant amplitude of current flows through the indicating meter for a time period determined by the crest point of the negative half-cycle of one signal and the corresponding point on the other signal. No current flows through the meter until the starting point of the first-mentioned signal again occurs. The repetition rate of current flow through the meter is determined by the frequency of the signals being compared. These on and off periods of current flow are primarily a function of the phase difference of the signals being compared. The ratio of these periods is independent of frequency. The deflection of the pointer of the indicating meter is directly proportional to the ratio of the on-off periods of current flow. Because of this, a linear phase indication is obtained.

A flip-flop or trigger circuit provides the on-off periods of current flow. Each side of this circuit is separately triggered by a spike or pip obtained from a differentiation network fed by a two-stage limiter amplifier. The two limiter amplifiers resolve each of the impressed sine waves to square waves and the differentiation networks produce spikes determined by the slope of the sides of the square waves. Only the negative spikes trigger the flip-flop circuit. Signals above the threshold operating point of the two-stage limiters do not increase the amplitude of the square waves produced. Therefore, the phase indication obtained is independent of the amplitude relationship of the two signals being compared for phase.

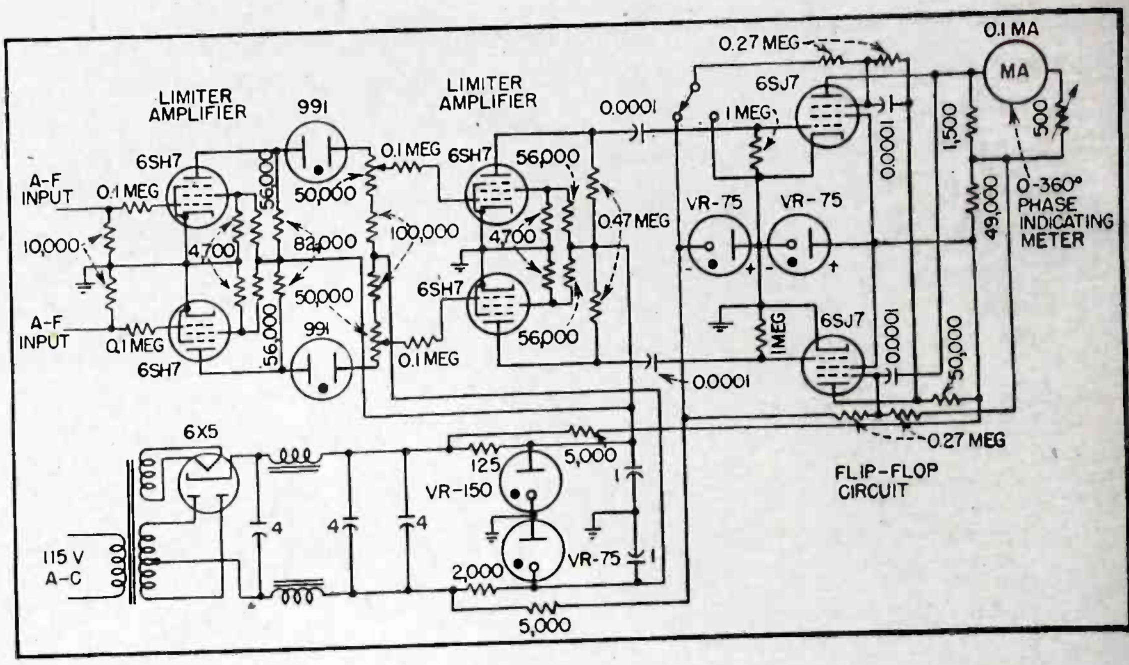
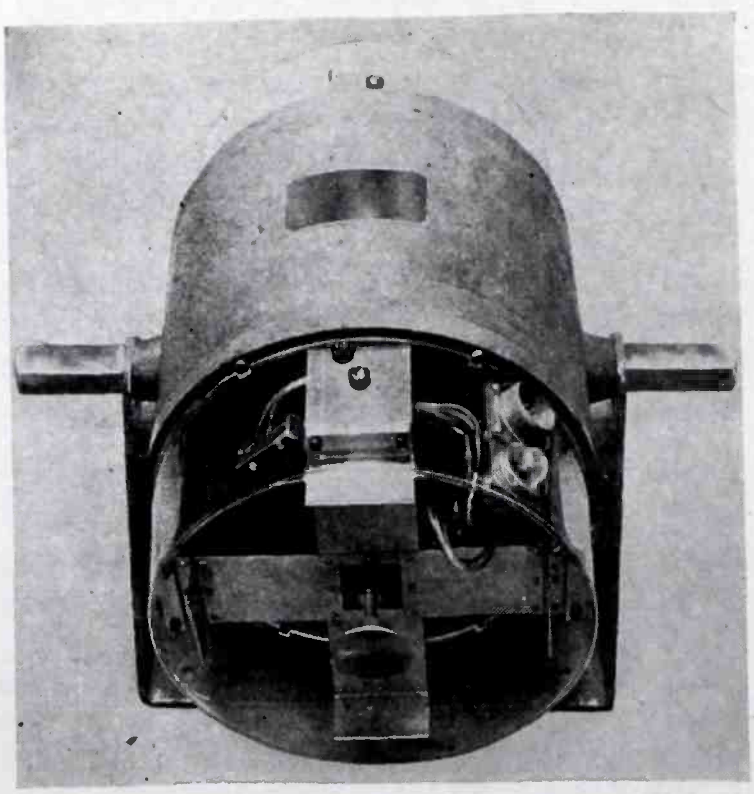
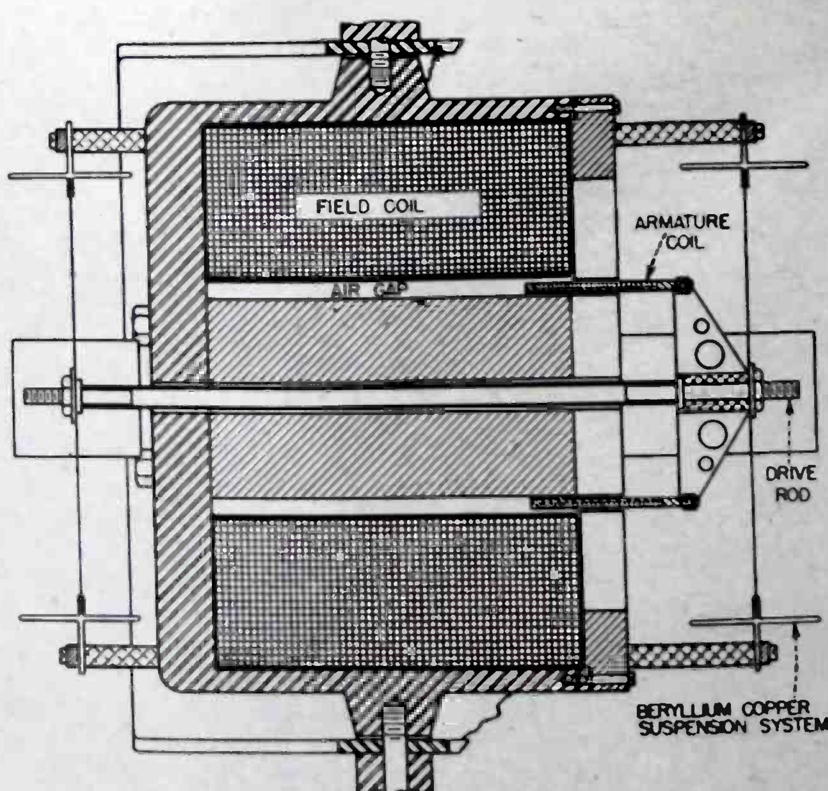


FIG. 4—Circuit used to indicate phase relationship between two a-f voltages

For their many helpful suggestions in the design and application of the electronic vibration equipment, the author is indebted to Lt. Col. B. Smilg of the Aircraft Laboratory, Wright Field; K. R. Jackman and Merle Brady, Test Laboratory, Consolidated Vultee, San Diego, California; E. A. Gardner, Engineering Department, Northrop Aircraft, Hawthorne, California, and R. E. Rawlins, formerly of Engineering Department, Lockheed Aircraft, Burbank, California.



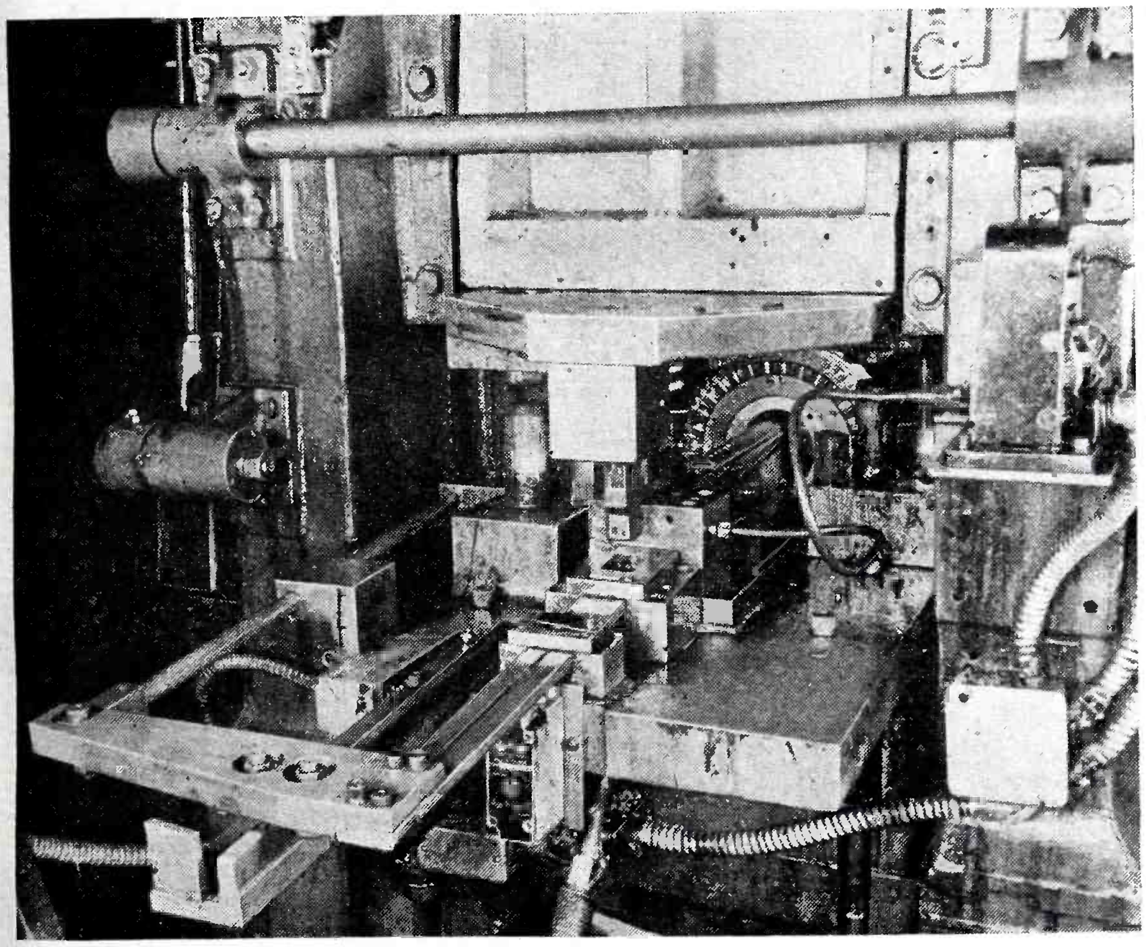
View of electromagnetic shaker unit. Plastic end bell protects armature and suspension system

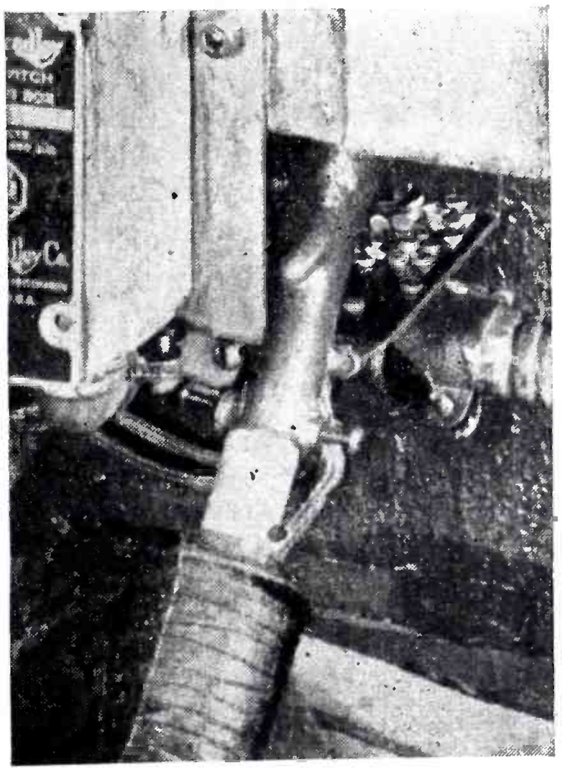


Cross-section of shaker. Armature is 4½ inches in diameter. Field coil uses 100 lb of copper wire

Punch Press Protector

When the slugs formed by a punch press are not cleared within three seconds, an electronic timer shuts off power. In normal operation slugs evacuated through a sensing unit prevent the timer starting





The die, compressed-air line, slug exit tube and sensing coil are shown in relation to the rear of the punch press. The detail above is the sensing coil that detects the passage of slugs

By JOHN ISAACS

Asst. Metallurgist
Norris Stamping and Mfg. Co.
Los Angeles, Calif.

In MANUFACTURING cylindrical steel cases for a special application it is necessary to punch a number of holes all around the sidewall. This is accomplished by clamping each case in an automatic indexing fixture that is installed in a regular punch press. Each stroke of the press punches out 16 holes in the side of the case. The fixture is then automatically indexed and the operation repeated. This continues until the case has made one complete revolution. The small round slugs that are punched out fall into the hollow die and are blown out with compressed air.

In manufacturing the cylinders it soon became apparent that a problem existed in eliminating the small steel slugs from the hollow die once they had been punched out. The exit hole in the die was of necessity rather small and the slugs, instead of ejecting when the compressed air was turned on, tended to jam in the die. After about seven strokes of the press, the die would be completely filled and then the punches or the die or both would be damaged. This failure resulted in needless lost time and repairs. Also, though on less frequent occasions, the compressed air supply failed, resulting in damage to the equipment. The solution depended, then, on devising some means of stopping the punch press in the event that the slugs were not properly ejected for any reason.

Variable-Inductance Sensor

First of all some sort of sensing unit had to be devised that would respond to the presence of the slugs as they were being ejected. It was also advisable that this sensing unit be sensitive to the number of slugs present. This ability was necessary since it was discovered that occasionally a few pieces stuck in the die after each stroke of the press and slowly built up an obstruction.

It was decided to make use of the magnetic properties of the slugs, whereupon the coil and funnel arrangement in Fig. 1 was devised. This unit was attached to the press in such a manner that slugs pass into the funnel and through the coil as they are ejected from the die. Another coil, identical with the first, was mounted about 6 inches from the press near the first coil. These coils, marked L_1 and L_2 in the wiring diagram of Fig. 2 form the two reactance arms of a simple bridge circuit. A fixed resistance and a series fixed and variable resistance combination make up the other two arms of the bridge. The variable resistance in one arm is used to balance the bridge circuit. Now, with the primary

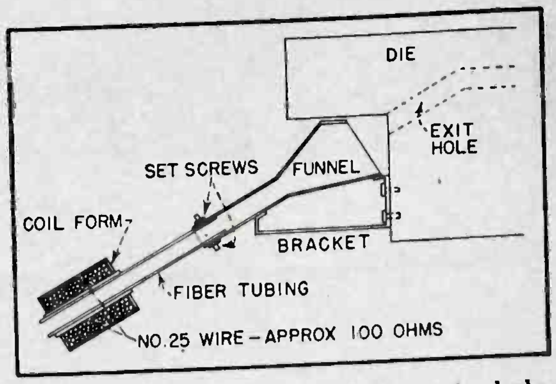


FIG. 1—Diagram of the die exit hole, funnel, and sensing coil mounted on fiber tube. Punchings are blown through this channel

of transformer T_1 energized and the bridge balanced, the presence of steel in the sensing coil causes a change in the inductance of this coil and so unbalances the bridge. This unbalance voltage appears across the primary of transformer T_2.

The coil and bridge arrangement satisfied the original requirement that the presence of the slugs be detected. However, the output of the bridge circuit at maximum unbalance was still rather small so it was necessary to amplify this voltage. It was done by the use of a conventional two stage amplifier using a 6SJ7, pentode connected, and a 6C5. Since this amplifier must amplify the line frequency (50 cycles), 0.1 microfarad coupling capacitors have been used and the plate circuit of each tube is bypassed to ground to prevent any high frequency feedback or regeneration that might be introduced. A test jack is provided in the plate circuit of the 6C5 so that an a-c voltmeter can be inserted when it is desired to balance the bridge.

Since compressed air is used to blow the metal slugs from the die, they pass through the sensing coil at a relatively high velocity. The bridge is only unbalanced for a fraction of a second so that an ordinary relay can not be made to operate satisfactorily on the amplified voltage. The relay is therefore connected in the plate circuit of a 2051 gas tetrode. In this type of tube when the plate is positive the tube will fire once the negative grid voltage is reduced to a critical value. When the tube fires the gas ionizes and the grid no longer has any control over the flow of plate current. Thus the amplified signal from T_3 is applied to the grid circuit of the 2051. When the instantaneous grid potential is reduced to the critical value the tube fires and relay K_1 is energized. Switch MS_2 is opened by the punch-press cycle and the unit is again ready to detect the presence of the metal slugs in the sensing coil.

It is necessary that the press be shut down if the die is not cleared after about three strokes. This is

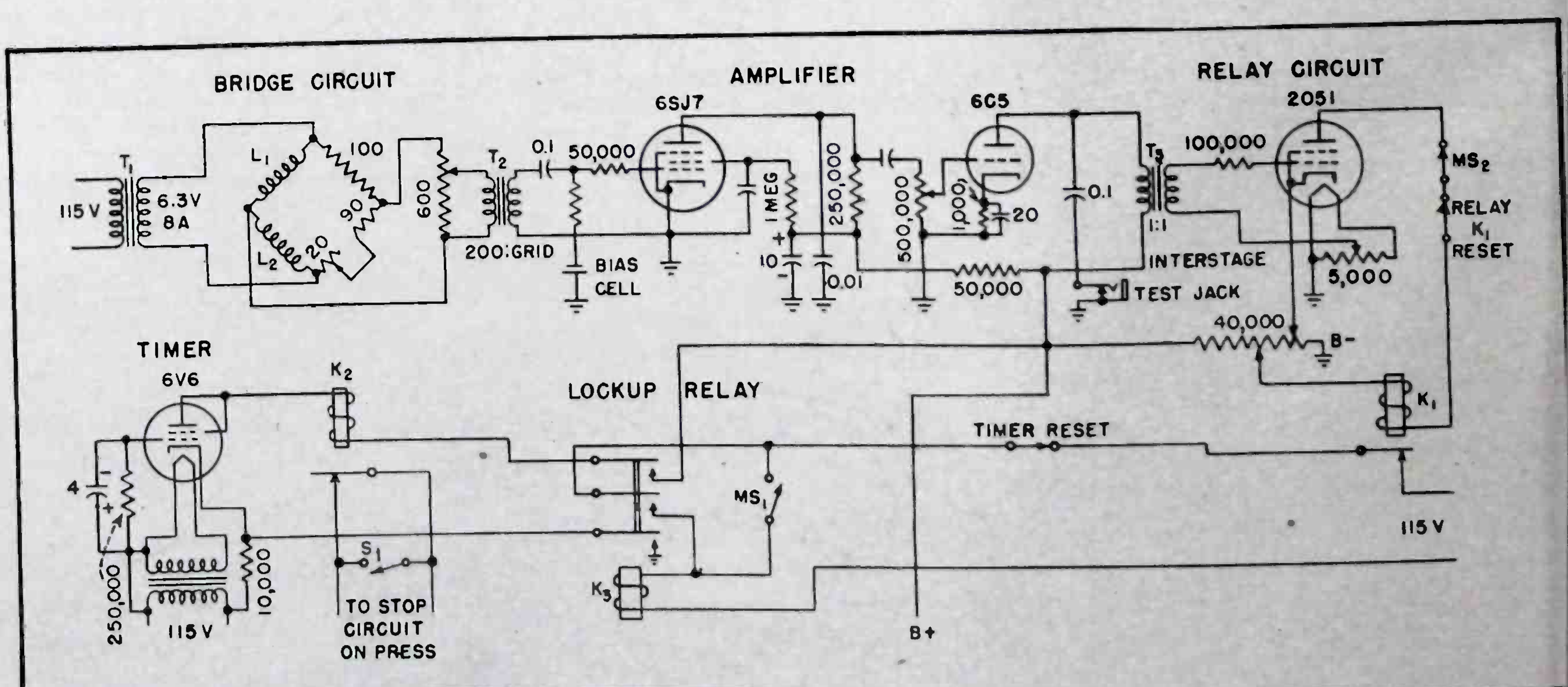


FIG. 2—Simplified schematic wiring diagram of the press-stopping circuit. Power supply, fuses, and no-voltage protection elements have been omitted for clarity

accomplished by the use of an electronic timer. The time delay is set for about 4 seconds (three strokes of the press) determined by the 4-microfarad capacitor and the 250,000-ohm resistor. When the plate and cathode circuits of the type 6V6 tube are disconnected through relay K_3 the cathode is connected to the hot side of the 115-volt line through the 10,000-ohm resistor. The capacitor and resistor combination connect from the control grid to the ground side of the line. The capacitor now charges because the grid and cathode constitute a half-wave rectifier. The charge leaves the grid negative with respect to ground. When relay K_3 is energized the plate and cathode circuits are connected normally. No current flows through K_2 in the plate circuit of the 6V6 tube because of the negative voltage on the grid. The 250,000-ohm resistor discharges the capacitor so that the grid bias is decreased and plate current rises sufficiently to cause the relay to pull in. This relay remains energized until the plate and cathode circuits are again broken.

Sequence of Operations

Now that the various components of the press protector have been described, their operation as a whole can be considered. The cycle of the punch press begins with the punch at the top of its stroke and the steel cylinder clamped in position over the die. As the punch starts down, a switch operates the solenoid valve that controls the flow of compressed air into the die. This blast blows out the steel slugs left in the die from the previous cycle. The slugs pass through the sensing coil, and cause relay K_1 to become energized.

As the punch reaches the bottom of the stroke the compressed air is turned off. At the same time, MS_1 is closed momentarily. A contact on relay K_1 in series with this switch completes the circuit through the coil of relay K_3 unless the contacts of K_1 are opened by the action of the emerging slugs. If relay K_3 operates it will close the plate and cathode circuits of the electronic timer that will then start through its cycle. In other words, as long as the slugs are ejected from the die, relay K_1 will become energized and prevent the timer from starting. In the event that relay K_1 does not become energized during three strokes of the press, the timer will complete its cycle and operate K_2, opening the contacts that stop the press.

As the punch reaches the top of its stroke switch MS_2 is actuated, causing the plate circuit of the 2051 to be broken. This mechanical operation is necessary because once plate current starts to flow the grid loses control and relay K_1 remains continuously energized.

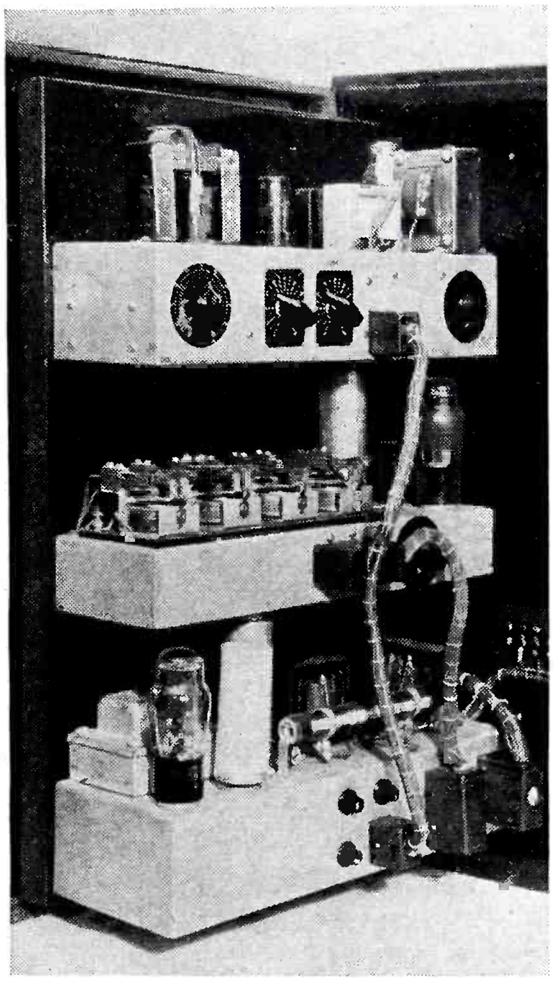


FIG. 3—Complete control unit is mounted in a cabinet on a hinged panel. The three replaceable chassis from top to bottom include: bridge circuit and amplifier, control sequence relays and timer, and power supply

Functionally, although it sounds complex, the entire unit is actually made up of only two basic parts; the amplifier that actuates a relay each time the steel slugs pass through the coil; and the electronic timer that is reset each time the relay is actuated. Such a system is adaptable to a number of similar applications and in some instances a simple snap-action switch can be the detecting or sensing device. This method could be used when relatively large articles were being turned out by a high-speed punch press or similar machine.

Practical Arrangement of Equipment

The mechanical construction of any piece of electronic equipment must receive prime consideration if it is to be used in an industrial plant. There is usually severe vibration in the vicinity of heavy machinery, especially a punch press of any size. This motion usually takes the form of sudden jolts.

Attaching the equipment directly to the machinery should be avoided if vibrations will affect its performance or reliability. The assembly of the press protector is shown in Fig. 3. From bottom to top, the power supply is mounted on the first chassis, the relays and the timer on the second, and the amplifier on the third. These chassis are mounted on a front panel that swings outward from the cabinet which houses the entire unit for ease in servicing and making adjustments. The chassis are connected together with cables and plugs. Any one of the three chassis can be quickly and easily replaced if it becomes defective. A cable that plugs into the power supply chassis is wired to a terminal board attached to the inside of the cabinet. The entire unit can thus be removed without disturbing the electrical connections to the terminal board. All electrical circuits are of course properly fused. A relay (not shown in Fig. 2) is connected so that if the power to the unit is disconnected or a fuse blows, the press is immediately shut off. A switch (S_1) is also provided so that when it is closed the press protector has no effect on the operation of the press. This is necessary so that the die setters can make adjustments on the press without having it shut off because no steel slugs are being ejected.

CASCADE PHASE SHIFT

Simple new modulator circuit for f-m transmitters is easy to adjust and maintain, requires only standard tubes, and has minimum inherent amplitude modulation. Adding phase shifts of six crystal frequency stages permits low order of frequency multiplication

By M. MARKS

Broadcast Equipment Division
Raytheon Manufacturing Co.
Chicago, Illinois

It is fairly evident that the direct crystal control which is characteristic of phase modulators offers a more reliable and straightforward circuit than systems using center-frequency correction, especially with the aid of a new simple phase modulator which has the necessary low distortion and low noise level.

The development of such a new modulator, closely approaching the ideal, has resulted from an exhaustive theoretical and experimental investigation of a large variety of phase shift modulators. This new modulator, known as the cascade phase shift modulator, allows the use of a relatively low order of frequency multiplication by adding the phase shift of a number of stages operating at the crystal frequency. The basic phase shift circuit accomplishes the task of modulation with a minimum of inherent amplitude modulation. Figure 1 is a simplified block diagram of the complete system.

Characteristics of Phase Shift Modulators

This paper will give a brief general review of phase shift modulators, showing the relationship between phase and frequency modulation, then develop the theory of the new modulator and give performance data.

When the phase of a carrier wave of constant frequency is advanced or retarded, the instantaneous frequency of the carrier also changes; the frequency deviation is proportional to the rate of change of phase.[1] The operation of all phase modulators depends on this important relationship, which may be visualized by considering a sinusoidal voltage of constant frequency. If the phase of this wave is advanced, say by 90 degrees, through insertion of a suitable phase shifting device, it can be seen that during the time taken for the phase to change to the new advanced value, the wave actually has to move faster than it would have moved if no change had taken place. Therefore, while the phase is changing, the effect is the same as if the frequency were higher. In a like manner, delaying the phase results in a lower frequency while the change is taking place. As soon as the shift in phase is stopped, the wave continues on at the original frequency.

From this, it follows that the more rapidly the phase is shifted, the greater will be the resulting frequency deviation. Thus, if the phase of an r-f signal is shifted by plus and minus 90 degrees at a sinusoidal audio-frequency rate of 100 cycles, the frequency would deviate (in accord with a cosin

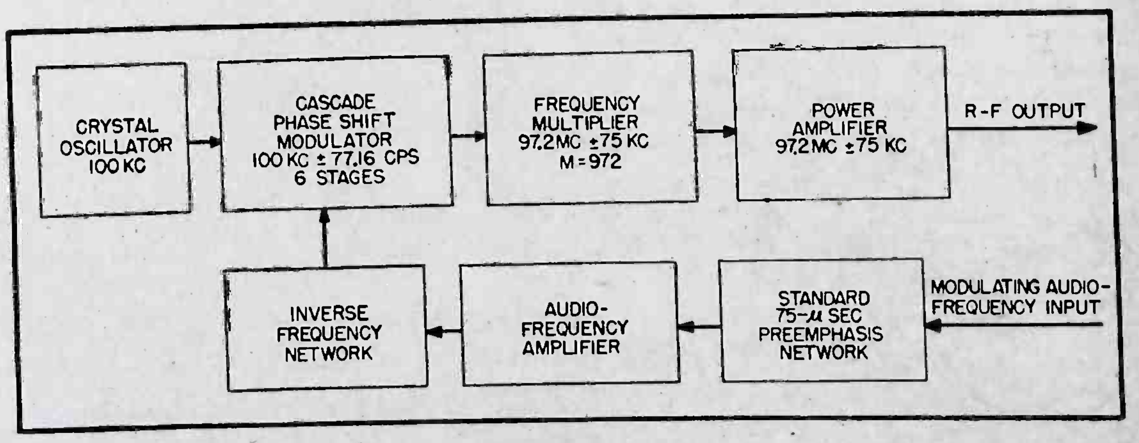


FIG. 1—Block diagram of f-m transmitter using cascade phase shift modulator

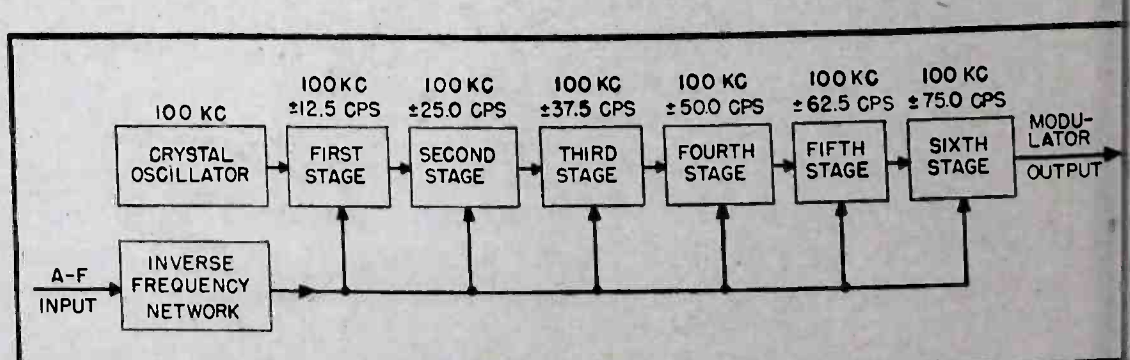
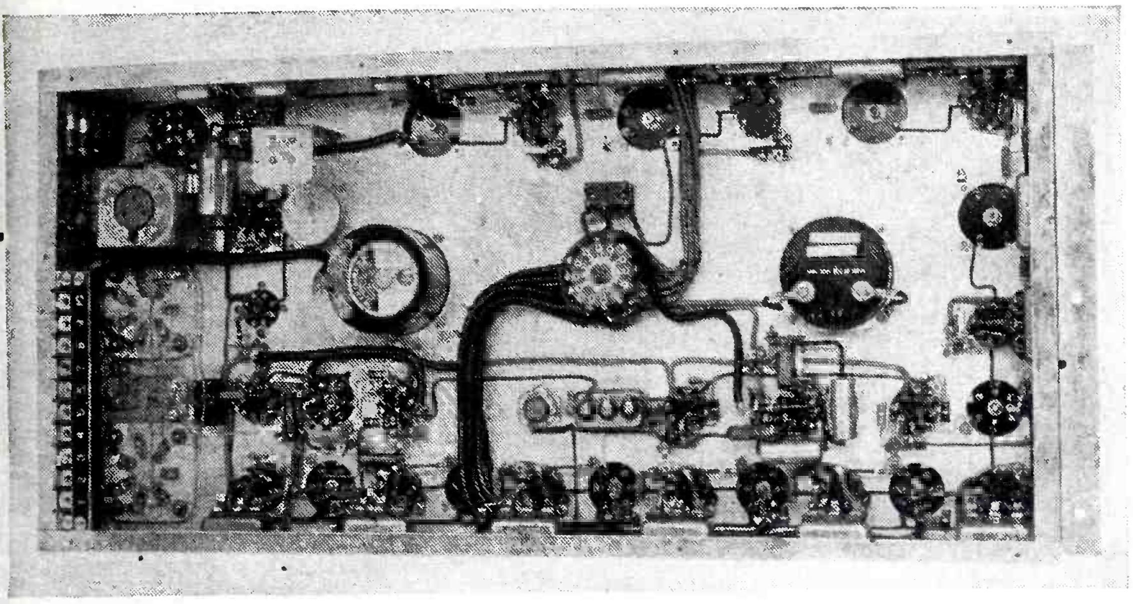
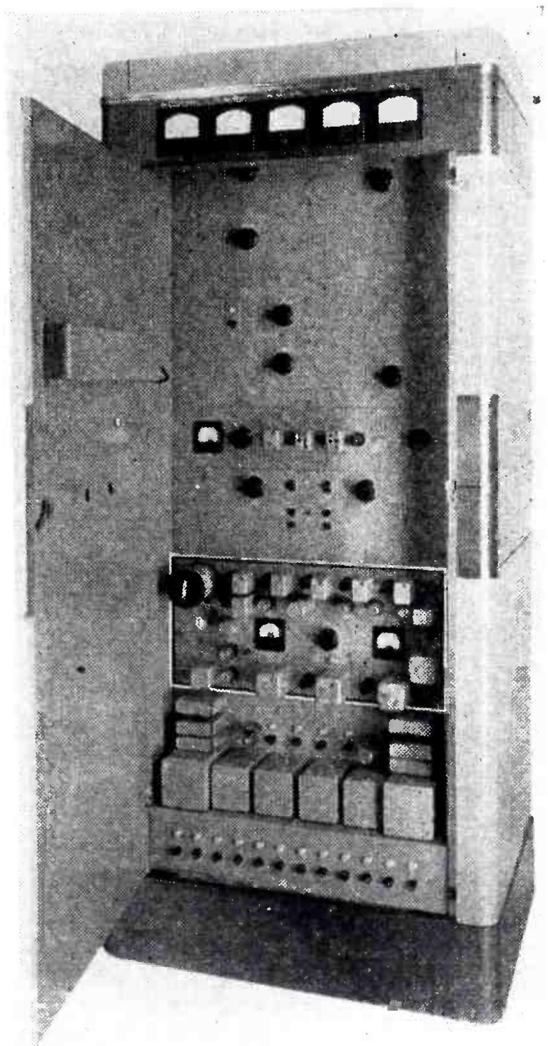


FIG. 2—Block diagram showing individual stages of cascade phase shift modulator. A maximum phase shift per stage of plus or minus 23.9 degrees is required for a 30-cycle signal at full frequency deviation

MODULATOR



Back view of cascade phase shift modulator for 250-watt f-m transmitter



Cascade phase shift modulator (second panel from bottom, outlined) installed in 250-watt f-m broadcast transmitter

function) 157 cycles above and below the original frequency; if the audio frequency rate of phase shift is now increased tenfold to 1,000 cycles, the frequency deviation will likewise be increased ten times to give 1,570 cycles deviation. The frequency deviation in cycles, therefore, can be seen to equal the product of the audio frequency (also in cycles) and the phase shift in degrees, divided by a constant (the number of degrees per radian).

Inverse Frequency Network

Inasmuch as the frequency deviation must be held constant at 75,000 cycles for 100-percent modulation, regardless of the modulating frequency, the number of degrees phase shift must be varied inversely with the modulating audio frequency. This effect is readily accomplished by use of an integrating circuit (also known as an inverse frequency network), consisting of a series resistance and a shunt capacitance, usually placed between the source of modulating signal and the phase modulator. The higher modulation frequencies are thus attenuated in precisely the desired manner for true frequency modulation.

The phase shift obtainable with low distortion from conventional phase modulator circuits rarely exceeds 25 degrees. The resulting frequency deviation for a 30-cycle modulating signal may be readily calculated to be equal to 13.1 cycles. Since this small deviation falls far short of the required 75,000 cycles, it becomes necessary to multiply the original frequency deviation by a factor M approximately equal to 6,000 in order to attain the required final frequency deviation. The well-known fact that multiplication of frequency produces a like multiplication of frequency deviation is used for this purpose to good advantage in practically all phase modulators.

There is a good practical reason, however, for keeping M not much over 1,000. Assuming the lowest usable crystal frequency as 75 kc (5 times the highest audio frequency) and an operating frequency of 100 mc, a factor M equal to 1,333 is obtained. To attain higher multiplication factors than this, it is necessary to resort to the use of heterodyne frequency converters.

Frequency Converters

In general, frequency converters are undesirable because the spurious beat frequencies present in their output circuits must be carefully discriminated against by means of tuned circuits and adequate shielding. In addition, there is the possible production of additional spurious beats caused by voltages from the low-frequency stages entering one or more of the broad pass bands of the stages following the converter. Hence, if M can be reduced to approximately 1,300 or less, the above difficulties will not materialize.

Addition of Phase Shifts

Large values of M are a direct consequence of the limited phase shift of which conventional modulators are capable. It is possible, however, to increase the useful phase shift of a modulator substantially by adding the individual phase shifts of two or more stages connected in cascade. The block diagram of Fig. 2 illustrates the manner of connecting the phase shift stages in cascade for the transfer of r-f energy, but in parallel as far as the a-f signal is concerned. The progressive increase of frequency deviation from stage to stage is also given for N, the number of cascaded stages, equal to

Cascade Phase Shift

Simple new modulator circuit for f-m transmitters is easy to adjust and maintain, requires only standard tubes, and has minimum inherent amplitude modulation. Adding phase shifts of six crystal frequency stages permits low order of frequency multiplication

By M. MARKS

Broadcast Equipment Division
Raytheon Manufacturing Co.
Chicago, Illinois

It is fairly evident that the direct crystal control which is characteristic of phase modulators offers a more reliable and straightforward circuit than systems using center-frequency correction, especially with the aid of a new simple phase modulator which has the necessary low distortion and low noise level.

The development of such a new modulator, closely approaching the ideal, has resulted from an exhaustive theoretical and experimental investigation of a large variety of phase shift modulators. This new modulator, known as the cascade phase shift modulator, allows the use of a relatively low order of frequency multiplication by adding the phase shift of a number of stages operating at the crystal frequency. The basic phase shift circuit accomplishes the task of modulation with a minimum of inherent amplitude modulation. Figure 1 is a simplified block diagram of the complete system.

Characteristics of Phase Shift Modulators

This paper will give a brief general review of phase shift modulators, showing the relationship between phase and frequency modulation, then develop the theory of the new modulator and give performance data.

When the phase of a carrier wave of constant frequency is advanced or retarded, the instantaneous frequency of the carrier also changes; the frequency deviation is proportional to the rate of change of phase.[1] The operation of all phase modulators depends on this important relationship, which may be visualized by considering a sinusoidal voltage of constant frequency. If the phase of this wave is advanced, say by 90 degrees, through insertion of a suitable phase shifting device, it can be seen that during the time taken for the phase to change to the new advanced value, the wave actually has to move faster than it would have moved if no change had taken place. Therefore, while the phase is changing, the effect is the same as if the frequency were higher. In a like manner, delaying the phase results in a lower frequency while the change is taking place. As soon as the shift in phase is stopped, the wave continues on at the original frequency.

From this, it follows that the more rapidly the phase is shifted, the greater will be the resulting frequency deviation. Thus, if the phase of an r-f signal is shifted by plus and minus 90 degrees at a sinusoidal audio-frequency rate of 100 cycles, the frequency would deviate (in accord with a cosine

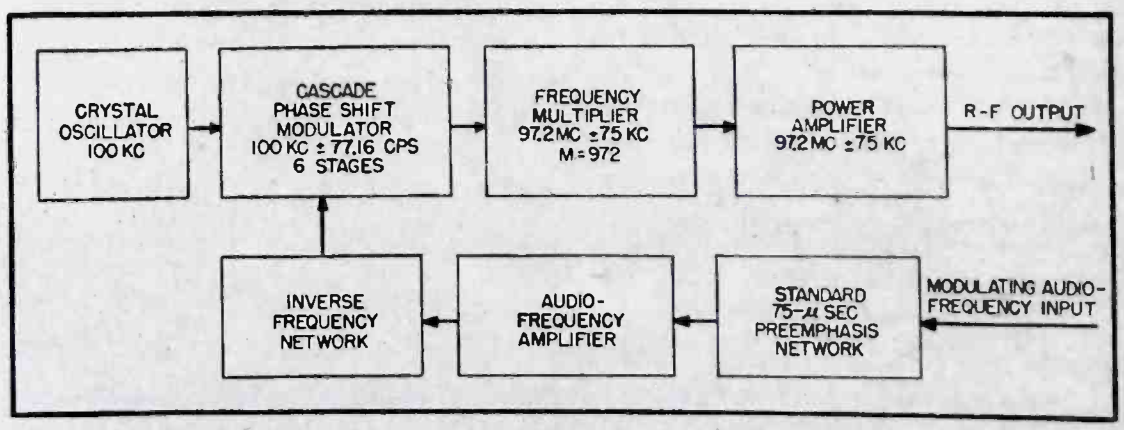


FIG. 1—Block diagram of f-m transmitter using cascade phase shift modulator

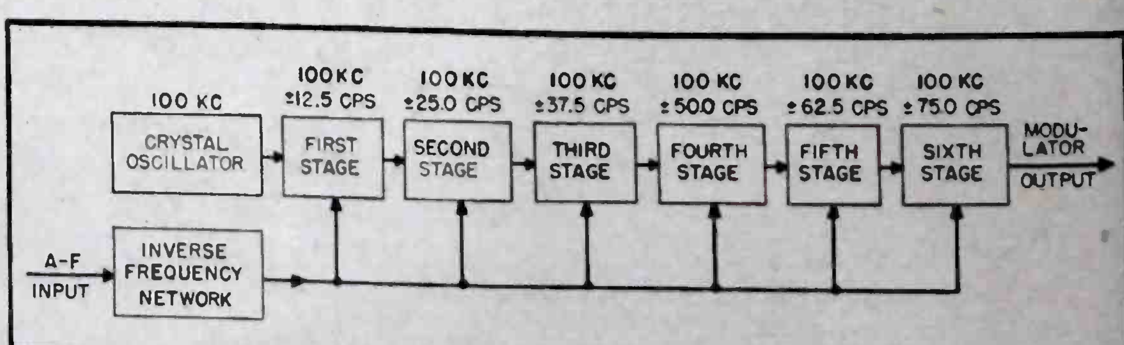
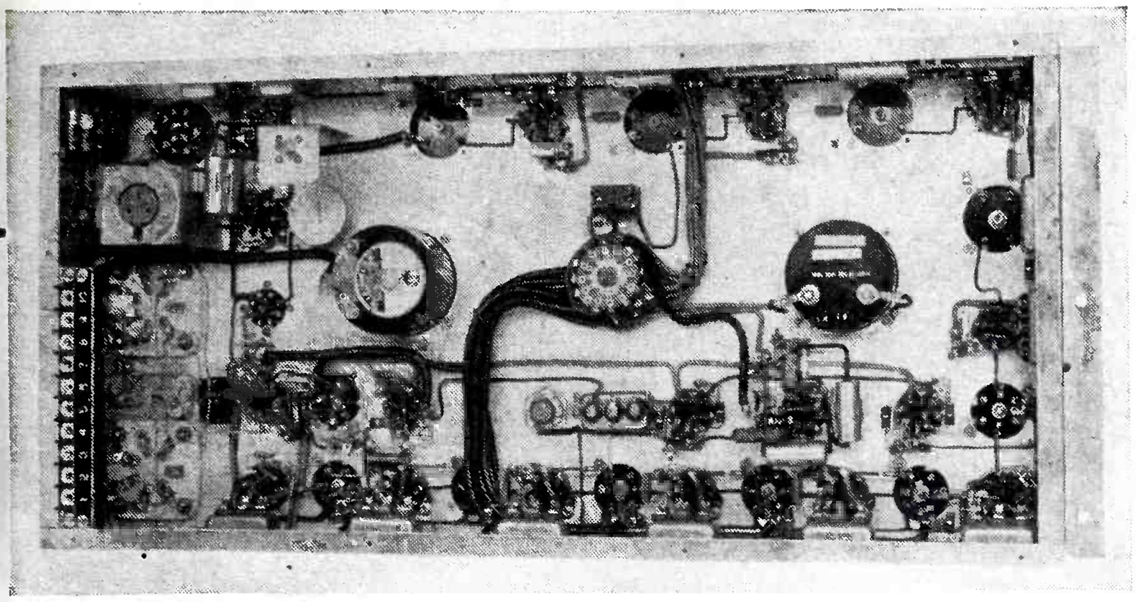
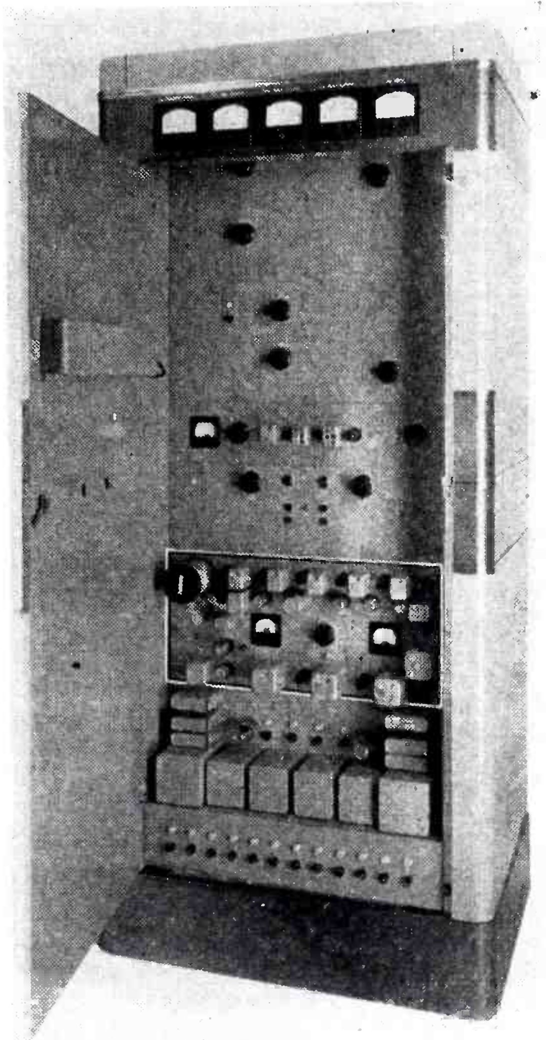


FIG. 2—Block diagram showing individual stages of cascade phase shift modulator. A maximum phase shift per stage of plus or minus 23.9 degrees is required for a 30-cycle signal at full frequency deviation

MODULATOR



Back view of cascade phase shift modulator for 250-watt f-m transmitter



Cascade phase shift modulator (second panel from bottom, outlined) installed in 250-watt f-m broadcast transmitter

function) 157 cycles above and below the original frequency; if the audio frequency rate of phase shift is now increased tenfold to 1,000 cycles, the frequency deviation will likewise be increased ten times to give 1,570 cycles deviation. The frequency deviation in cycles, therefore, can be seen to equal the product of the audio frequency (also in cycles) and the phase shift in degrees, divided by a constant (the number of degrees per radian).

Inverse Frequency Network

Inasmuch as the frequency deviation must be held constant at 75,000 cycles for 100-percent modulation, regardless of the modulating frequency, the number of degrees phase shift must be varied inversely with the modulating audio frequency. This effect is readily accomplished by use of an integrating circuit (also known as an inverse frequency network), consisting of a series resistance and a shunt capacitance, usually placed between the source of modulating signal and the phase modulator. The higher modulation frequencies are thus attenuated in precisely the desired manner for true frequency modulation.

The phase shift obtainable with low distortion from conventional phase modulator circuits rarely exceeds 25 degrees. The resulting frequency deviation for a 30-cycle modulating signal may be readily calculated to be equal to 13.1 cycles. Since this small deviation falls far short of the required 75,000 cycles, it becomes necessary to multiply the original frequency deviation by a factor M approximately equal to 6,000 in order to attain the required final frequency deviation. The well-known fact that multiplication of frequency produces a like multiplication of frequency deviation is used for this purpose to good advantage in practically all phase modulators.

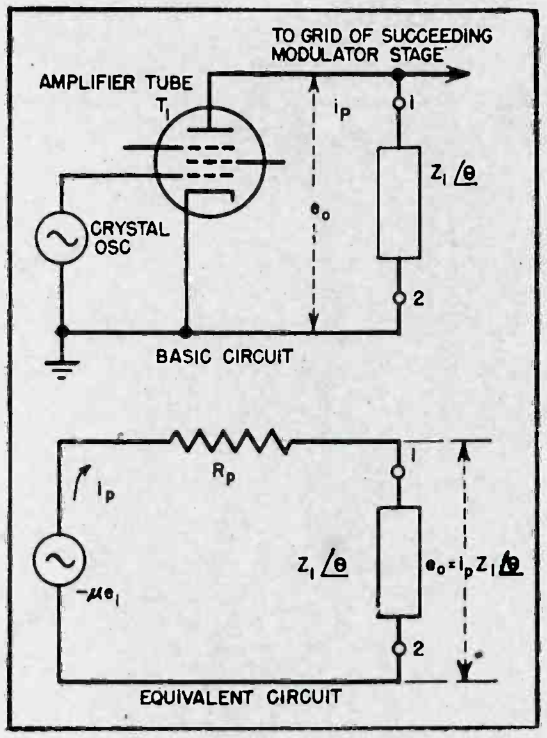
There is a good practical reason, however, for keeping M not much over 1,000. Assuming the lowest usable crystal frequency as 75 kc (5 times the highest audio frequency) and an operating frequency of 100 mc, a factor M equal to 1,333 is obtained. To attain higher multiplication factors than this, it is necessary to resort to the use of heterodyne frequency converters.

Frequency Converters

In general, frequency converters are undesirable because the spurious beat frequencies present in their output circuits must be carefully discriminated against by means of tuned circuits and adequate shielding. In addition, there is the possible production of additional spurious beats caused by voltages from the low-frequency stages entering one or more of the broad pass bands of the stages following the converter. Hence, if M can be reduced to approximately 1,300 or less, the above difficulties will not materialize.

Addition of Phase Shifts

Large values of M are a direct consequence of the limited phase shift of which conventional modulators are capable. It is possible, however, to increase the useful phase shift of a modulator substantially by adding the individual phase shifts of two or more stages connected in cascade. The block diagram of Fig. 2 illustrates the manner of connecting the phase shift stages in cascade for the transfer of r-f energy, but in parallel as far as the a-f signal is concerned. The progressive increase of frequency deviation from stage to stage is also given for N, the number of cascaded stages, equal to



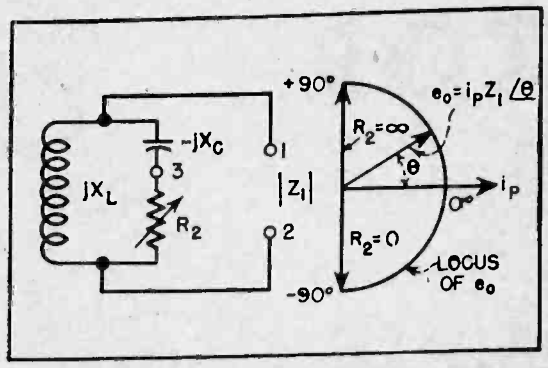


FIG. 4 (above)—Constant-impedance network and corresponding vector diagram

FIG. 3 (left)—Basic phase shift stage operating at crystal frequency, and equivalent circuit

6, and for a maximum phase shift per stage of 23.9 degrees (required for a 30-cycle a-f signal at full deviation). It should be noted that if only the first stage were used ($N = 1$), the conventional modulator would result for which M must be 6,000 (75,000 cycles/12.5 cycles); if all six stages are used ($N = 6$), M is reduced to 1,000 (75,000 cycles/75 cycles)—the latter condition obviating the need for a frequency converter.

From the preceding discussion it follows that N may be considered as effective as M in producing the final frequency deviation. This relationship may be stated as follows: The frequency deviation at the operating frequency in cycles is equal to the product of the audio frequency in cycles, the phase shift per modulator stage in degrees, the factor M, and the factor N, divided by the number of degrees per radian (57.3).

There is yet another advantage which comes from keeping M relatively low. When an unmodulated r-f signal is passed through a vacuum tube amplifier, it becomes modulated by the random noise voltages which are ever present; one portion produces amplitude modulation of the r-f signal and the other produces irregular fluctuations in its phase.

The amplitude modulation is readily removed by the limiting action of subsequent multiplier stages, but the irregular fluctuations in the phase of the signal represent a noise modulation. The frequency deviation corresponding to these fluctuations increases for the higher audio frequencies because there is no inverse frequency network to attenuate them. The magnitude of the resulting phase shift of the r-f wave due to the noise may be shown[2] to be approximately equal to 57.3 times the value of noise voltage divided by the signal voltage. Hence, assuming a noise of 10 microvolts and a signal of 10 volts, the phase shift would be approximately 0.0000573 degrees.

For $N = 1$ and $M = 6{,}000$, approximately 0.05 degree phase shift is required at 15,000 cycles to produce 100 percent modulation. The ratio, then, of the phase shift for 100 percent modulation to the noise phase shift, expressed in db, should give the f-m noise level at the output frequency. For the above case ($M = 6{,}000$) the noise level is 58.8 db below 100 percent modulation. Performing the same calculation for $M = 1{,}000$ and $N = 1$, the phase shift required is 0.3 degree, and the noise level for this source of noise becomes 74.4 db below 100 percent modulation.

Cascading of Stages

The foregoing calculations considered the case of an unmodulated r-f signal for $N = 1$. The effect on the noise level of adding N modulator stages in cascade will now be taken up. As previously mentioned, the phase shift appearing at the modulator output terminals is equal to the sum of the phase shifts produced in the individual stages. But the random nature of fluctuation noise produced in each modulator stage makes it necessary to take the rms sum of these voltages in order to find the resultant noise voltage at the modulator output terminals. Therefore, N modulator stages will add $\sqrt{N}$ times the noise of one stage. If four stages are cascaded, there will be a fourfold increase in phase shift, but only a twofold increase in the noise of the system. In actual practice, noise is also produced in other parts of the transmitter, so that the relative contribution of the modulator section to the total noise is even smaller.

In order to minimize harmonic distortion under certain conditions of modulation, it is desirable to use a modulator circuit in which the percentage of amplitude modulation produced concurrently with phase modulation is very small. This distortion becomes a maximum when the percentage of phase modulation is such as to produce only the first pair of sidebands.[3] The effect in this case consists of a change in the relative magnitudes of the sideband, and any subsequent limiting action which may remove the amplitude variation will still be powerless to restore the relationship between the carrier and sidebands necessary for low distortion. Therefore, a further requirement for the design of the modulator is that any amplitude modulation produced along with the desired phase modulation be kept at a minimum.

Theory of Cascade Phase Shift Modulator

The basic phase shift stage in Fig. 3 consists of an amplifier tube T_1 and its plate load impedance, the two-terminal network Z_1 connected across terminals *1* and *2*.[4] T_1 serves both as an amplifier which isolates the cascaded phase shift stages from one another and as a source of constant current for Z_1.

From the equivalent circuit it follows that the phase of the output voltage e_o must vary as the phase angle of Z_1. This is so because the load impedance is much smaller than the plate resistance R_p and therefore can have practically no part in determining the plate current i_p. Since the product of the plate current and the vector impedance, $Z_1 \angle\theta$, is equal to the output voltage, any change in phase of this impedance must therefore result in phase modulation of the output voltage. It also follows that any change in the magnitude of Z_1 will result in amplitude modulation of the output voltage.

The two-terminal network shown in Fig. 4 may be designed to maintain a substantially constant impedance while phase modulation is taking place. The general expression for the impedance of this network is[5]

$$|Z_1| = X_L \sqrt{\frac{1 + \left(\frac{1}{b}\right)^2}{1 + \left(\frac{1}{b}\right)^2 \left(\frac{1}{a} - 1\right)^2}} \tag{1}$$

where

$$a = X_C / X_L \tag{2}$$

$$b = R_2 / X_C \tag{3}$$

A study of Eq. 1 will show that when the quantity $(1/a) - 1$ is set equal to unity, the quantity under the radical sign will also be equal to unity and therefore $|Z_1|$ will remain constant and equal to X_L regardless of any variation of b. This condition occurs when a is set equal to 0.5. Substituting this solution in Eq. 2, it follows that $|Z_1|$ will be constant when

$$X_L = 2X_C \tag{4}$$

This network is used as the plate load of a vacuum tube whose plate resistance is over 100 times greater than $|Z_1|$, and since the parallel resistance of a coil with a Q of about 30 is also of the same high order of resistance, the effect of these two quantities on the magnitude of Z_1 may be neglected. These two quantities, however, do play a minor part in determining the phase angle of the network. Therefore, the phase characteristic of the network[6], calculated for a coil Q of 30, is shown in Fig. 5 for values of a equal to 0.4, 0.5 (the constant-impedance solution), and 0.6.

A mental picture of the phase shift action to which the output voltage in this circuit is subjected may be obtained by considering the two extremes of resistance, bearing in mind that the inductive reactance is equal to twice the capacitive reactance (Eq. 4). For R_2 open, the current through terminals *1* and *2* of Fig. 4 must be inductive. Therefore, the output voltage will lead the plate current by approximately 90 degrees.

When R_2 is short-circuited, the current taken by the capacitive branch will be twice as great as that taken by the inductive branch, thus making the net current into terminals *1* and *2* capacitive. The output voltage, therefore, will lag behind the plate current by approximately 90 degrees for this other extreme. Intermediate values of R_2 will cause the locus of the output voltage vector to follow the semicircle depicted in Fig. 4.

The most important part of the basic shift stage is the device which converts the a-f modulating signal into a corresponding a-f variation of resistance. This device, which is known as the modulator or resistance tube, replaces R_2 of Fig. 4 in the practical circuit. To obtain low distortion, the characteristic of resistance versus control voltage of this device must be made to approximate the curvature of the phase angle characteristic (Fig. 5). This requirement is important mainly for low-frequency signals in the band from 30 to 50 cycles, where a maximum phase shift of about plus and minus 25 degrees per stage is required for full frequency deviation.

Conventional vacuum tube circuits utilizing the dynamic plate resistance of a tube as a function of control grid voltage cannot be used because the adjustment of bias becomes too critical when the above requirement must be met. Therefore, the circuit shown in Fig. 6 was developed to do the job. With the r-f voltage assumed to be zero, the circuit behaves not unlike a cathode follower. The plate is bypassed to ground through C_2, the a-f modulating signal e_s is applied between control grid and ground (across the shunt capacitance C_1 of the inverse frequency network), and an output voltage (the gain is less than one) appears between cathode and ground. For this condition of operation the resistance looking into terminals *2* and *3* may be given as[7]

$$R = \frac{1}{\frac{1}{R_k} + \frac{1}{R_p} + \frac{\mu}{R_p}} \tag{5}$$

where R_k is the resistance connected externally between cathode and ground, R_p is the effective plate resistance of the tube at its oper-

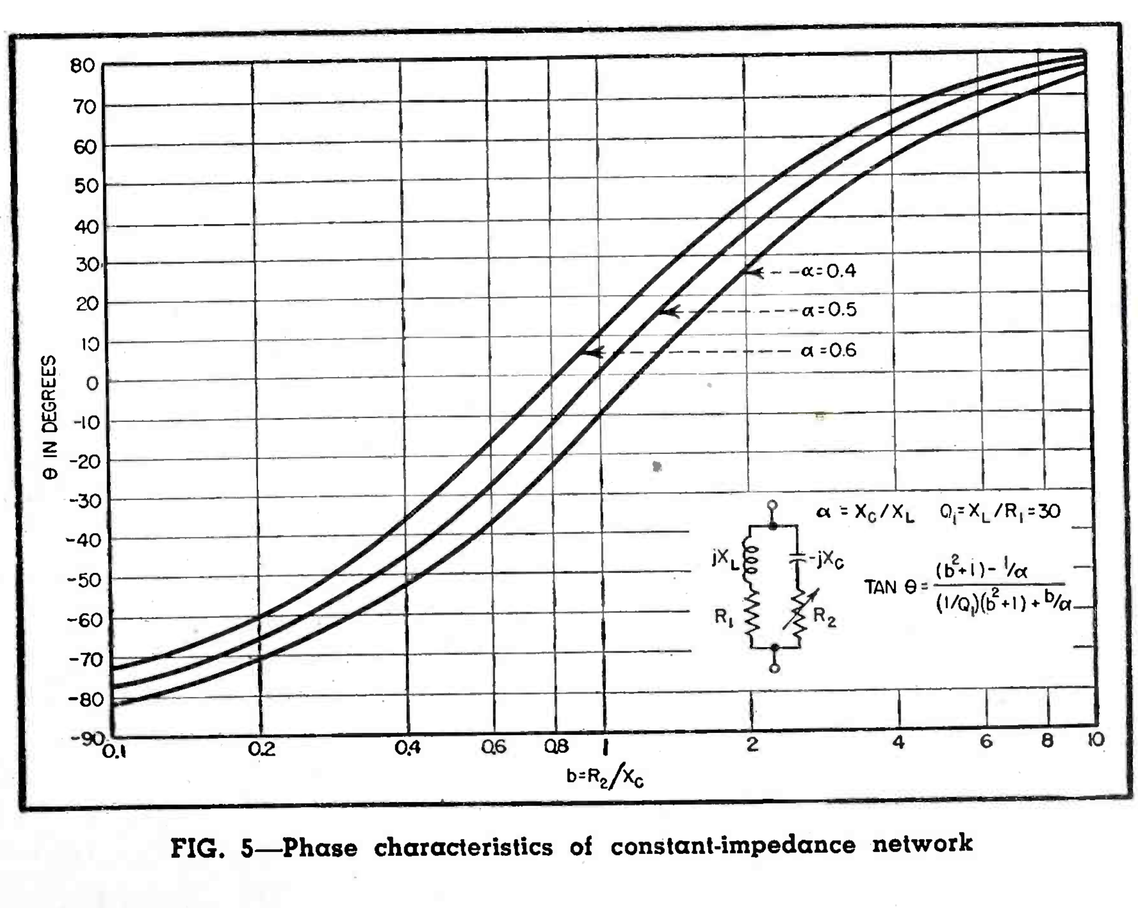


FIG. 5—Phase characteristics of constant-impedance network

ating point, and μ is the amplification factor of the tube at its operating point.

Analysis of R-F Cycle

Now consider the circuit from the standpoint of the r-f voltage e_o, which is the voltage across the constant impedance Z_1 in Fig. 3. Assuming the modulating signal e_s in Fig. 6 equal to zero, the circuit behaves like a grounded grid amplifier because C_1 effectively puts the grid at ground potential for r-f. Thus, any r-f voltage between cathode and ground is also applied between control grid and cathode of T_2. Under normal conditions of operation, the relatively high value of R_k never allows grid current to flow during the positive portion of the r-f cycle. However, if the r-f grid-to-cathode voltage is high enough, tube T_2 will be cut off during some part of the cycle, the point of cutoff being a definite function of the instantaneous grid-to-cathode and plate-to-cathode voltages.

The modulating a-f signal e_s thus determines the fraction of the r-f

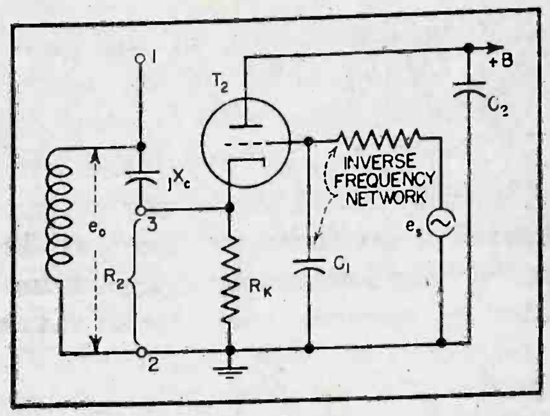


FIG. 6—Basic circuit of resistance-tube stage

cycle during which the plate current flows through T_2. In other words, during the time the modulating signal is positive, the angle of flow is increased, and during the balance of the modulating signal cycle, the reverse is true.

During the part of the r-f cycle cycle over which T_2 is cut off, R_2 is equal to R_k. For the remainder of the r-f cycle, R_2 must be equal to R as defined by Eq. 5. By proper choice of r-f voltage level and the value of R_k, the curvature of the resistance tube characteristic can be made to match the curve in Fig. 5, so that no bias adjustment is necessary.

Modulator Tuning Procedure

In the final design of the modulator portion of an f-m transmitter using the cascade phase shift modulator, six cascade stages are followed by several frequency multipliers with a factor M of 12, as shown in Fig. 7. The final multiplier provides an M equal to 81, so that the overall M is 972. A built-in tuning meter enables the operator to make adjustments without the aid of external measuring equipment.

Assuming that the crystal oscillator stage is operating normally, the r-f voltage level at the grid of each cascade amplifier (T_1 through T_9) is adjusted to a predetermined setting on the tuning microammeter. Although this meter reads the grid current, it acts as a peak-reading vacuum-tube voltmeter. A variable capacitor in each amplifier grid circuit provides the means of adjustment by forming a simple voltage divider with the associated coupling capacitor. This r-f voltage

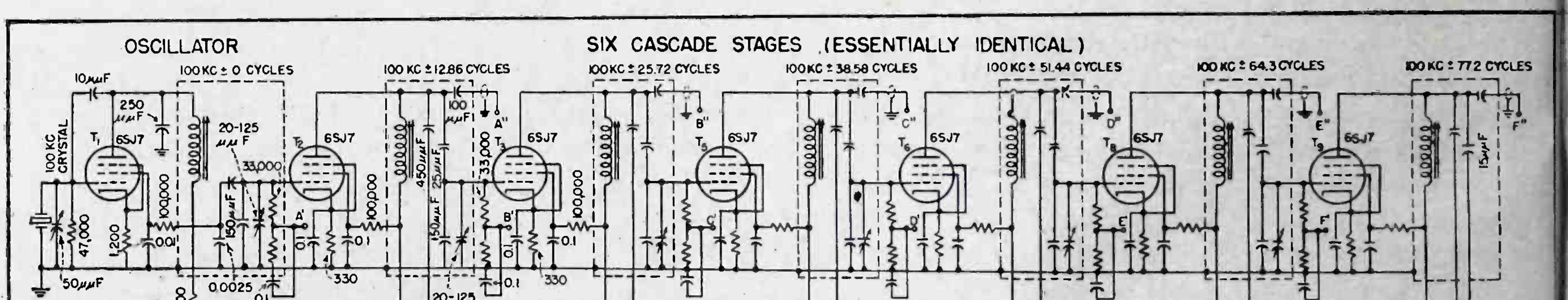


FIG. 7—Schematic diagram of modulator of f-m transmitter using the cascade phase shift modulator

level setting fulfills the requirement for curve matching of the resistance tubes.

For the next step, the inductance X_L of the constant-impedance network in each amplifier must be adjusted to conform with Eq. 4. Ordinarily this would present a difficult problem because the coil cannot be peaked to the crystal frequency—the actual resonant frequency being the crystal frequency divided by 1.414. However, this difficulty may be overcome by taking advantage of the theory which states that a minimum of amplitude modulation will be observed at the plate of each amplifier tube when the inductance of its constant impedance network is adjusted correctly (X_L equal to $2X_c$).

Accordingly, an a-f modulating signal is applied through the normal a-f channel, of a level sufficient to bring about full frequency deviation and of a frequency low enough to produce a reasonably large phase shift in each modulator stage. Then use is made of a built-in amplitude modulation detector and amplifier (the double triode T_{17}) which uses the microammeter as a modulation indicator. Sample r-f voltages from each phase shift amplifier plate are piped over to this detector via the meter switch, and thus any plate may be selected at will.

Starting with the first stage, each inductance in turn is adjusted for minimum meter deflection of the amplitude modulation indicator. Of course, if the coils are found to be so far out of adjustment as to materially alter the r-f voltage set up in the initial step, then both steps must be repeated. That is all there is to the adjustment of the modulator proper.

Transmitter Alignment

The only other adjustments are those of the multiplier and amplifier coupling transformers. These transformers are designed so they will pass a band wide enough to accommodate twice the highest modulating frequency, but attenuate the undesired adjacent harmonics produced in the preceding stages. These requirements usually lead to a slightly double-peaked selectivity curve corresponding to a coupling greater than critical.

Misalignment of such transformers invariably causes asymmetrical selectivity curves, which usually increase the harmonic distortion and may even reduce the frequency deviation for the higher modulating frequencies. It is important, therefore, that overcoupled transformers be properly aligned.

The method of alignment of overcoupled transformers adopted for use in this transmitter is simple, requires no external equipment and gives the right answers in terms of performance. A pushbutton switch is provided on all overcoupled transformers. A damping resistance is permanently connected to the top of the secondary of each transformer, and when the pushbutton switch is pressed, the free end of the damping resistance is grounded. This action has the effect of decreasing the secondary impedance. Because the ground side of the resistance is switched, there is no appreciable change of circuit capacitance due to the switching action.

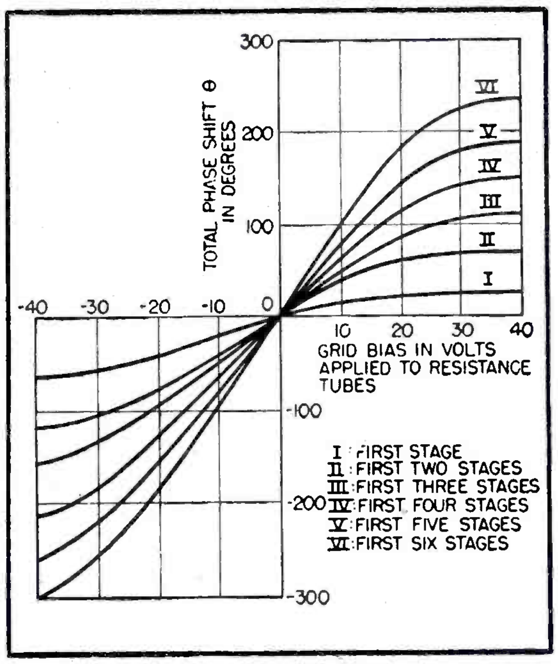


FIG. 8—Operating characteristics of cascade phase shift modulator

It is well known that a decrease of secondary impedance in an overcoupled transformer reduces the coupling. Thus, with proper choice of damping resistance, the coupling is reduced to a value below critical and the transformer may be easily and accurately tuned for maximum output at the center frequency provided by the preceding stage.

Upon releasing the pushbutton, the transformer again becomes overcoupled and gives the symmetrical pass band required for high-quality performance. All band-pass transformers are aligned in this manner. Normal transmitter tuning technique is used for the higher-powered portions of the transmitter. It is possible to adjust all tuning elements shown in Fig. 7 in less than ten minutes.

Performance of Cascade Phase Shift Modulator

A static characteristic curve giving the total phase shift in degrees as a function of the grid bias applied to the resistance tubes for 1, 2, 3, 4, 5, and 6 cascade stages is shown in Fig. 8. The linearity of the curve for six stages is attested by harmonic distortion measurements, for 75-kc frequency deviation, of 1.25 percent for 30 cycles and less than 0.6 percent for 50 to 15,000 cycles. Distortion for 100-kc frequency deviation is less than 1 percent from 50 to 15,000 cycles. The f-m noise has been measured at 72 db below a frequency deviation of 75 kc.

The author wishes to express his appreciation for the perseverance and help given by W. E. Phillips and S. G. Jones, under whose direction this modulator was developed, and to D. A. Skinrood, G. L. Dufield, L. Schultz, E. A. Andrade, and Y. K. Luk of the Broadcast Equipment Division of Raytheon Manufacturing Co.

References

(1) Hund, August, "High-Frequency Measurements", McGraw-Hill Book Co., New York, p 368, 1933.

(2) Hund, August, "Frequency Modulation", McGraw-Hill Book Co., New York, p 104, 1942.

(3) Reference 2, p 59.

(4) Seeley, S. W., Kimball, C. N., and Barco, A. A., Generation and Detection of Frequency-Modulated Waves, RCA Review, p 276, Jan. 1942. A variation of this circuit is described.

(5) "Reference Data for Radio Engineers", First Edition, Federal Telephone and Radio Corp., New York, p 52, 1944. Eq. 1 may be obtained by proper manipulation of the formula given for magnitude of impedance.

(6) Reference 5, p 53. The phase characteristic equation in Fig. 5 may be obtained by modifying the formula given for phase angle of two parallel impedances.

(7) Pacini, Humbert P., Cathode Follower Calculations, ELECTRONICS, p 137, Oct. 1944.

ating point, and μ is the amplification factor of the tube at its operating point.

Analysis of R-F Cycle

Now consider the circuit from the standpoint of the r-f voltage e_o, which is the voltage across the constant impedance Z_1 in Fig. 3. Assuming the modulating signal e_s in Fig. 6 equal to zero, the circuit behaves like a grounded grid amplifier because C_1 effectively puts the grid at ground potential for r-f. Thus, any r-f voltage between cathode and ground is also applied between control grid and cathode of T_2. Under normal conditions of operation, the relatively high value of R_k never allows grid current to flow during the positive portion of the r-f cycle. However, if the r-f grid-to-cathode voltage is high enough, tube T_2 will be cut off during some part of the cycle, the point of cutoff being a definite function of the instantaneous grid-to-cathode and plate-to-cathode voltages.

The modulating a-f signal e_s thus determines the fraction of the r-f

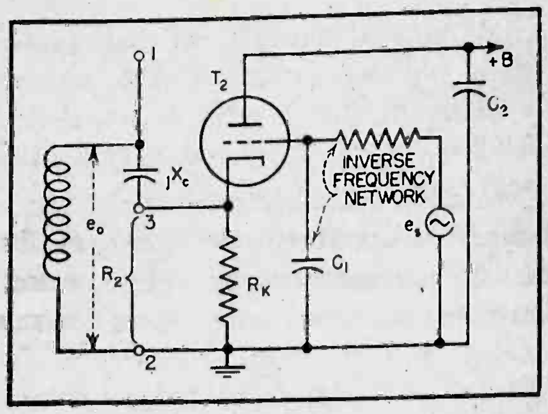


FIG. 6—Basic circuit of resistance-tube stage

cycle during which the plate current flows through T_2. In other words, during the time the modulating signal is positive, the angle of flow is increased, and during the balance of the modulating signal cycle, the reverse is true.

During the part of the r-f cycle cycle over which T_2 is cut off, R_2 is equal to R_k. For the remainder of the r-f cycle, R_2 must be equal to R as defined by Eq. 5. By proper choice of r-f voltage level and the value of R_k, the curvature of the resistance tube characteristic can be made to match the curve in Fig. 5, so that no bias adjustment is necessary.

Modulator Tuning Procedure

In the final design of the modulator portion of an f-m transmitter using the cascade phase shift modulator, six cascade stages are followed by several frequency multipliers with a factor M of 12, as shown in Fig. 7. The final multiplier provides an M equal to 81, so that the overall M is 972. A built-in tuning meter enables the operator to make adjustments without the aid of external measuring equipment.

Assuming that the crystal oscillator stage is operating normally, the r-f voltage level at the grid of each cascade amplifier (T_1 through T_9) is adjusted to a predetermined setting on the tuning microammeter. Although this meter reads the grid current, it acts as a peak-reading vacuum-tube voltmeter. A variable capacitor in each amplifier grid circuit provides the means of adjustment by forming a simple voltage divider with the associated coupling capacitor. This r-f voltage

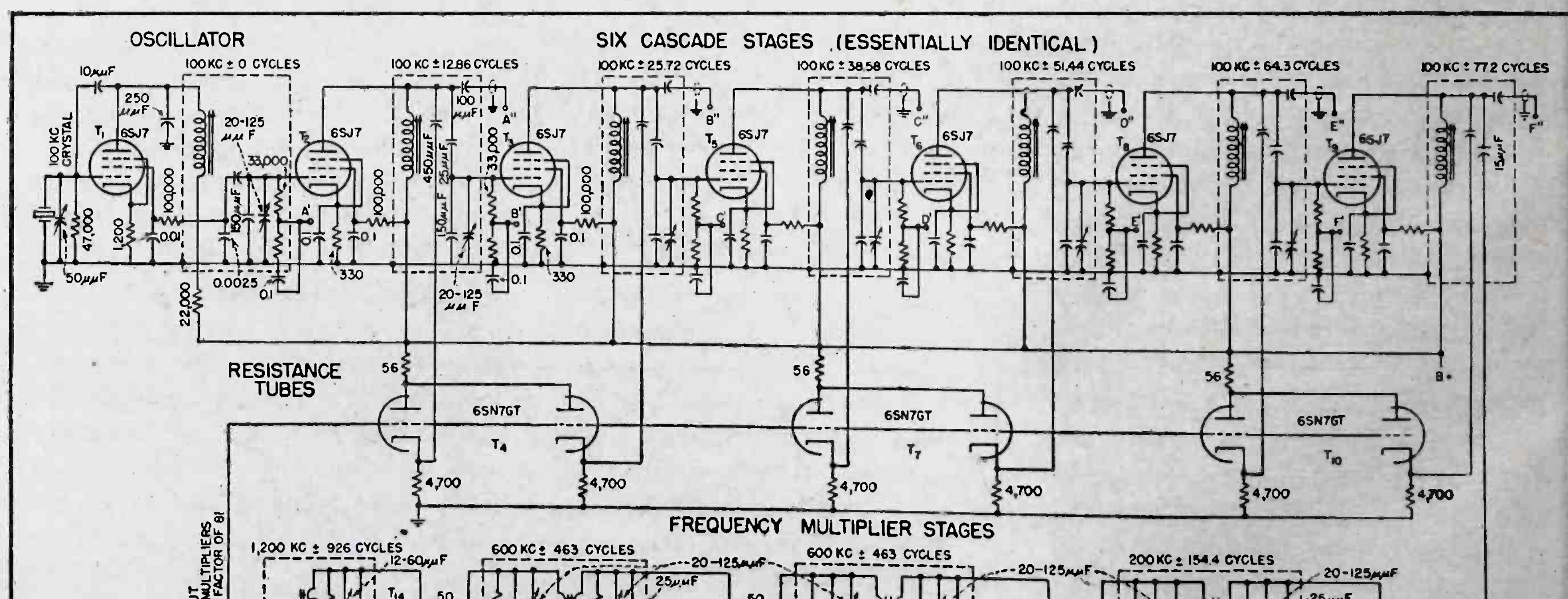


FIG. 7—Schematic diagram of modulator of f-m transmitter using the cascade phase shift modulator

level setting fulfills the requirement for curve matching of the resistance tubes.

For the next step, the inductance X_L of the constant-impedance network in each amplifier must be adjusted to conform with Eq. 4. Ordinarily this would present a difficult problem because the coil cannot be peaked to the crystal frequency—the actual resonant frequency being the crystal frequency divided by 1.414. However, this difficulty may be overcome by taking advantage of the theory which states that a minimum of amplitude modulation will be observed at the plate of each amplifier tube when the inductance of its constant impedance network is adjusted correctly (X_L equal to $2X_C$).

Accordingly, an a-f modulating signal is applied through the normal a-f channel, of a level sufficient to bring about full frequency deviation and of a frequency low enough to produce a reasonably large phase shift in each modulator stage. Then use is made of a built-in amplitude modulation detector and amplifier (the double triode T_{17}) which uses the microammeter as a modulation indicator. Sample r-f voltages from each phase shift amplifier plate are piped over to this detector via the meter switch, and thus any plate may be selected at will.

Starting with the first stage, each inductance in turn is adjusted for minimum meter deflection of the amplitude modulation indicator. Of course, if the coils are found to be so far out of adjustment as to materially alter the r-f voltage set up in the initial step, then both steps must be repeated. That is all there is to the adjustment of the modulator proper.

Transmitter Alignment

The only other adjustments are those of the multiplier and amplifier coupling transformers. These transformers are designed so they will pass a band wide enough to accommodate twice the highest modulating frequency, but attenuate the undesired adjacent harmonics produced in the preceding stages. These requirements usually lead to a slightly double-peaked selectivity curve corresponding to a coupling greater than critical.

Misalignment of such transformers invariably causes asymmetrical selectivity curves, which usually increase the harmonic distortion and may even reduce the frequency deviation for the higher modulating frequencies. It is important, therefore, that overcoupled transformers be properly aligned.

The method of alignment of overcoupled transformers adopted for use in this transmitter is simple, requires no external equipment and gives the right answers in terms of performance. A pushbutton switch is provided on all overcoupled transformers. A damping resistance is permanently connected to the top of the secondary of each transformer, and when the pushbutton switch is pressed, the free end of the damping resistance is grounded. This action has the effect of decreasing the secondary impedance. Because the ground side of the resistance is switched, there is no appreciable change of circuit capacitance due to the switching action.

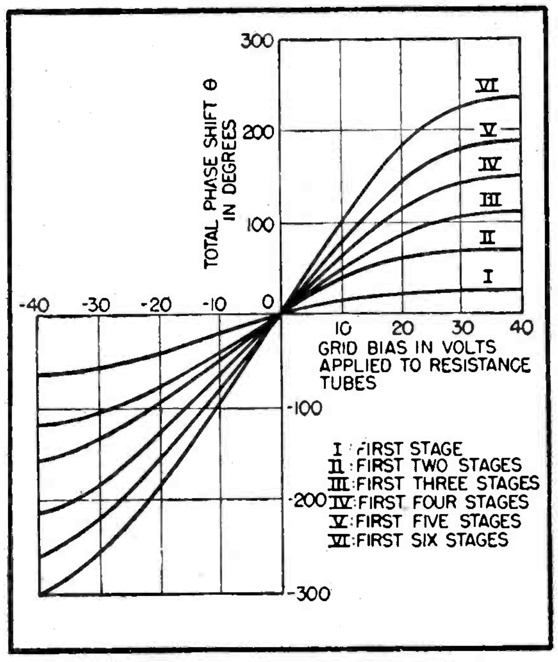


FIG. 8—Operating characteristics of cascade phase shift modulator

It is well known that a decrease of secondary impedance in an overcoupled transformer reduces the coupling. Thus, with proper choice of damping resistance, the coupling is reduced to a value below critical and the transformer may be easily and accurately tuned for maximum output at the center frequency provided by the preceding stage.

Upon releasing the pushbutton, the transformer again becomes overcoupled and gives the symmetrical pass band required for high-quality performance. All band-pass transformers are aligned in this manner. Normal transmitter tuning technique is used for the higher-powered portions of the transmitter. It is possible to adjust all tuning elements shown in Fig. 7 in less than ten minutes.

Performance of Cascade Phase Shift Modulator

A static characteristic curve giving the total phase shift in degrees as a function of the grid bias applied to the resistance tubes for 1, 2, 3, 4, 5, and 6 cascade stages is shown in Fig. 8. The linearity of the curve for six stages is attested by harmonic distortion measurements, for 75-kc frequency deviation, of 1.25 percent for 30 cycles and less than 0.6 percent for 50 to 15,000 cycles. Distortion for 100-kc frequency deviation is less than 1 percent from 50 to 15,000 cycles. The f-m noise has been measured at 72 db below a frequency deviation of 75 kc.

The author wishes to express his appreciation for the perseverance and help given by W. E. Phillips and S. G. Jones, under whose direction this modulator was developed, and to D. A. Skinrood, G. L. Dufield, L. Schultz, E. A. Andrade, and Y. K. Luk of the Broadcast Equipment Division of Raytheon Manufacturing Co.

References

(1) Hund, August, "High-Frequency Measurements", McGraw-Hill Book Co., New York, p 368, 1933.

(2) Hund, August, "Frequency Modulation", McGraw-Hill Book Co., New York, p 104, 1942.

(3) Reference 2, p 59.

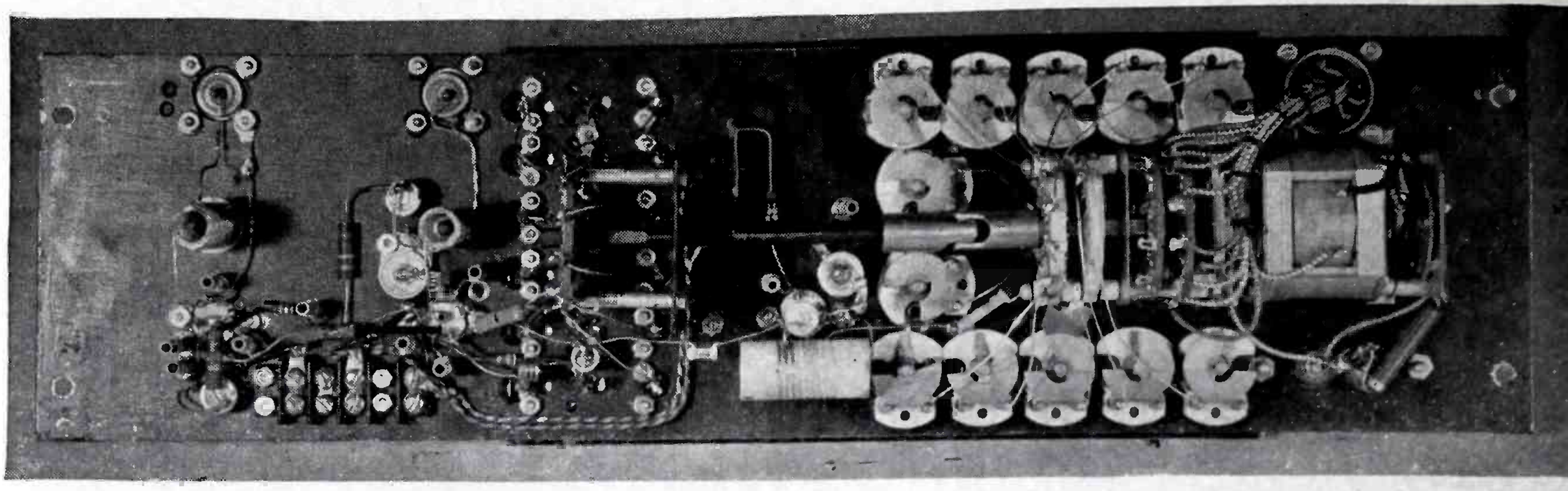
(4) Seeley, S. W., Kimball, C. N., and Barco, A. A., Generation and Detection of Frequency-Modulated Waves, RCA Review, p 276, Jan. 1942. A variation of this circuit is described.

(5) "Reference Data for Radio Engineers", First Edition, Federal Telephone and Radio Corp., New York, p 52, 1944. Eq. 1 may be obtained by proper manipulation of the formula given for magnitude of impedance.

(6) Reference 5, p 53. The phase characteristic equation in Fig. 5 may be obtained by modifying the formula given for phase angle of two parallel impedances.

(7) Pacini, Humbert P., Cathode Follower Calculations, ELECTRONICS, p 137, Oct. 1944.

TWELVE-CHANNEL



Rear view of converter panel, showing rotary actuator (extreme right) used to drive the 12-position selector switch

By J. E. YOUNG and W. A. HARRIS

Radio Corporation of America
RCA Victor Division
Camden, N. J.

THIS 12-channel converter was designed for use with a remotely-controlled prewar 42 to 50-mc f-m receiver to permit reception of stations in the new 88 to 108-mc f-m band.

Since there appeared to be no satisfactory method of rapidly setting a ganged capacitor with the accuracy required at 100 mc, 12 sets of fixed-tuned circuits were provided. These were well adapted to incorporation in the Strowger dial system used in remote operation of the original receiver. This system provides facilities for telephone-type dial selection from any one of twelve stations on each of the a-m, f-m, and television receivers, plus volume control, audio-bandwidth control, and loudspeaker selection.

The desirability of obtaining a satisfactory signal from broadcast stations over 75 miles away required that the sensitivity of the converter be of the order of a microvolt for 20-db quieting. In addition, the presence of other f-m stations within a few miles of the receiver and other services in adjacent frequency bands imposed severe requirements as to selectivity, stability, and spurious frequency response.

The complete converter circuit is shown in Fig. 1. The input circuit inductor of the r-f amplifier is tuned by a powdered iron slug in a relatively high impedance circuit which is broad-band enough to require no tuning adjustment to cover the 88 to 108-mc band. It was considered that any attempt to provide fixed tuned circuits at this point for each desired frequency would result in a circuit having such a low impedance and low antenna transformer stepup that the signal-to-noise ratio would be adversely affected. Coupling from the input transmission line was effected by tapping the line directly on the input inductor, thereby eliminating the effect of coupling coil inductance.

The 6AK5 tube was chosen because it possesses relatively high input resistance at the frequencies involved. This high input resistance, together with careful adjustment of the coupling ratio, permits obtaining an input circuit gain high enough so that it is possible to realize a sensitivity of 1.5 microvolt for 20 db of quieting at any frequency in the band.

To obtain good image rejection, the coupling circuit between the r-f amplifier and the mixer was designed to have high Q. By use of high values of capacitance, the impedance was kept low enough so that the gain of the 6AK5 tube was not sufficient to permit self-oscillation. The low circuit impedance makes it possible to use parallel feed to the plate of the 6AK5.

Mixer Circuit

To obtain a high image rejection ratio, it was necessary that the mixer input circuit be tuned. However, its tuning has little effect on the oscillator stability, so ceramic trimmer capacitors having a range of from 7 to 45 $\mu\mu$f were used to resonate the inductor and an 18-$\mu\mu$f fixed capacitor was connected in series with the switch arm. With this arrangement, the relatively large variable capacitors minimize the effects of switch and stray capacitances, while the series capacitor keeps the maximum total shunt circuit capacitance down to the desired value.

The coupling capacitor and its leads are so proportioned that in spite of necessarily long leads virtually the full a-c plate voltage developed by the 6AK5 tube is realized across the grid circuit of the 6AS6 mixer tube.

Oscillator injection is provided to one grid of the mixer tube. A coupling coil of the proper size to match a 50-ohm line to the mixer plate is used, since it was expected that the 42-mc receiver used as the i-f amplifier would be located too

F-M CONVERTER

Telephone-dial selection of any of twelve stations in new f-m band is achieved remotely with prewar f-m receiver by use of three-tube converter in which mixer input and oscillator are tuned by preset trimmers connected to 12-position rotary selector switch

far away to permit using a high-impedance coupling circuit. Coil L_3 lowers the frequency of a parasitic plate circuit sufficiently so that feedback conditions do not support oscillation.

Oscillator Circuit

The circuit chosen for the oscillator was one in which the plate is at r-f ground. To minimize the effect of alternating current on the heater and to eliminate trouble from variable heater-cathode capacitance, the heater is kept at the same r-f potential as the cathode. This was accomplished by connecting one side of the heater to the cathode, permitting the heater current to flow through the tank inductor and return through a choke. Tuning was effected by varying the capacitance from grid to ground.

The method of tuning made it necessary to use either a grounded plate or grounded grid oscillator. The former was selected because the anode acts as a tube shield, minimizing the effect of external objects on the oscillator frequency, and no plate feed choke is required.

The vernier adjustments for the oscillator tuning capacitors were constructed by tapping a hole in the panel adjacent to an individual tuning capacitor shaft and inserting a knurled-head screw to extend near the capacitor stator. Variation in the position of the shank shifts the frequency 100 to 200 kc.

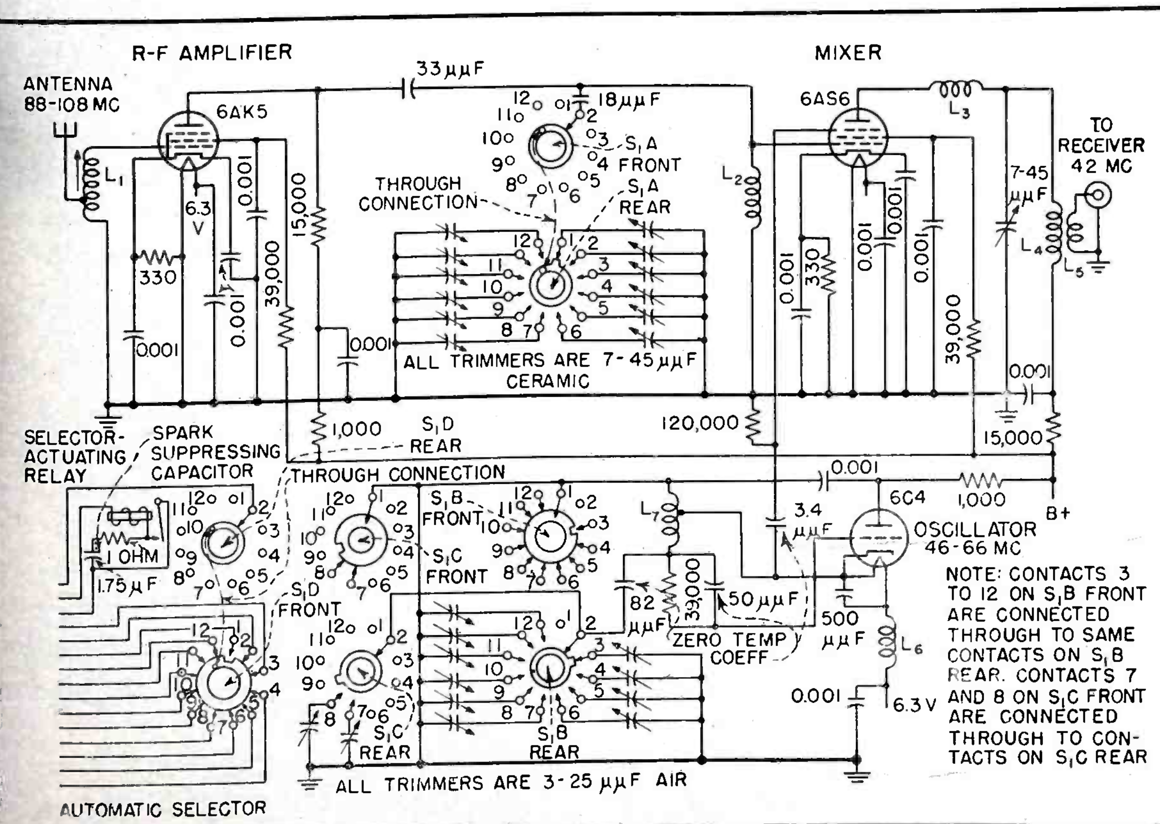
Mechanical Features

A rotary actuator (Price Electric Corp. type 8500 automatic selector) provides the means for driving the standard 12-position wafer switches used to select the proper tuned circuits in each stage.

Poor stability and resetting difficulties in early tests resulted because the shaft of the selector switch was insulated and electrically loaded by the switch mechanism to be near quarter-wave resonant at the oscillator frequency. It was necessary to ground the rubber-mounted switch frame with a flexible copper strap to break up the resonant circuit.

The selector switch actuator was designed to operate on a 24-volt d-c circuit, but after the proper capacitor-resistor combination for use across the contacts had been determined, satisfactory operation on 115 volts a-c was obtained.

Sensitivity is such that 20-db quieting is obtained with an input signal of less than 1.5 microvolts applied in series with a 70-ohm resistor, and spurious frequency response is more than 70 db below the wanted signal at any frequency except the 42-mc i-f image, where suppression is 50 db. Overall warmup drift of the system is almost the same as the warmup drift of the 42-mc receiver.



Coil Winding Data

L_1 — 5 turns No. 18, 7/16" long on 1/2" diam. polystyrene form, tapped 1¼ turns from ground end, with 3/8" diam. by 1/2" long carbonyl iron core

L_2 — 4 turns No. 16, 5/16" long, 7/32" diam. mandrel, self supporting

L_3 — 6 turns No. 20, 5/16" long, 3/16" diam. mandrel, self supporting

L_4 — 5 turns No. 22 dcc, 7/16" long on 1/2" diam. polystyrene form

L_5 — 2 turns No. 22 dcc, close wound 3/32" from L_4

L_6 — 13 turns No. 18, spaced 1 wire diam. on 1/2" diam. ceramic standoff insulator

L_7 — 3 turns No. 18, on 3/4" diam. ceramic tube grooved 12 turns per inch, tapped 1 5/8 turns from plate end

FIG. 1—Complete circuit of converter. Leads at lower left go to remote control system

Wideband

Design criteria are presented for L-C and R-C phase shifting networks that develop a constant phase difference over a wide frequency band. The technique is to introduce two phase shifts such that, although they vary with frequency, their difference does not

It is frequently desirable to derive from a given voltage two new voltages of the same frequency but with the phase angle between the new voltages held substantially constant over a wide frequency range, each derived voltage having an amplitude characteristic linearly variable with the amplitude of the input voltage independently of frequency.

To produce the phase difference between the two voltages, two networks whose phase angles increase substantially linearly with the logarithm of the frequency are used. Thus, if the two networks are properly matched, the phase difference between them remains nearly constant over a wide range of frequency.

Network Development

One way of producing the two voltages is to derive both of them from a single source and arrange that the output of either channel is independent of frequency, but that both have phase angles with respect to the input voltages varying in such a way that over a wide band of frequencies

$$\phi_1 - \phi_2 = K \qquad (1)$$

where ϕ_1 : phase angle of output No. 1
ϕ_2 : phase angle of output No. 2
K : a constant
ϕ_1 and ϕ_2 are each their own function of f, the frequency

One possible configuration for these functions is

$$\phi_1 = C + \log f \qquad (2)$$

$$\phi_2 = C + \log kf \qquad (3)$$

where C and k are constants

Substituting Eq. 2 and 3 in Eq. 1

$$\begin{aligned}\phi_1 - \phi_2 &= C + \log f - C - \log kf \\ &= \log f - \log f - \log k \\ &= -\log k \equiv K \qquad (4)\end{aligned}$$

Thus it is only necessary to find a network configuration which will yield a phase angle which varies as the logarithm of the frequency over a wide range of frequency. The network must also have no change in output amplitude with frequency. The latter limitation usually restricts the final network configuration to lattice types because finite ladder types with any phase shift must be accompanied by amplitude variations. In order to avoid the use of transformers in the lattice structure, a half-lattice will be chosen with the input terminals excited by two equal voltages 180 degrees out of phase. Such voltages are readily available from vacuum tube phase inverters consisting of a tube with equal cathode and anode loads.

L-C Lattice

A circuit having enough independent parameters to permit the designer to shape the phase angle curve to the required logarithmic form and the basic design equations of the circuit are shown in Fig. 1A. It will be noted from the equation for the phase angle (Fig. 1A) that an arbitrary factor s is included. The choice of s is up to the designer.

If s lies between 3 and 5, a fairly straight line for ϕ is obtained when plotted against a logarithmic frequency scale. As will be shown later, if a second curve for a second similar network, but with a resonant frequency f_o which is 4.53 times the resonant frequency of the first curve, is plotted, the phase

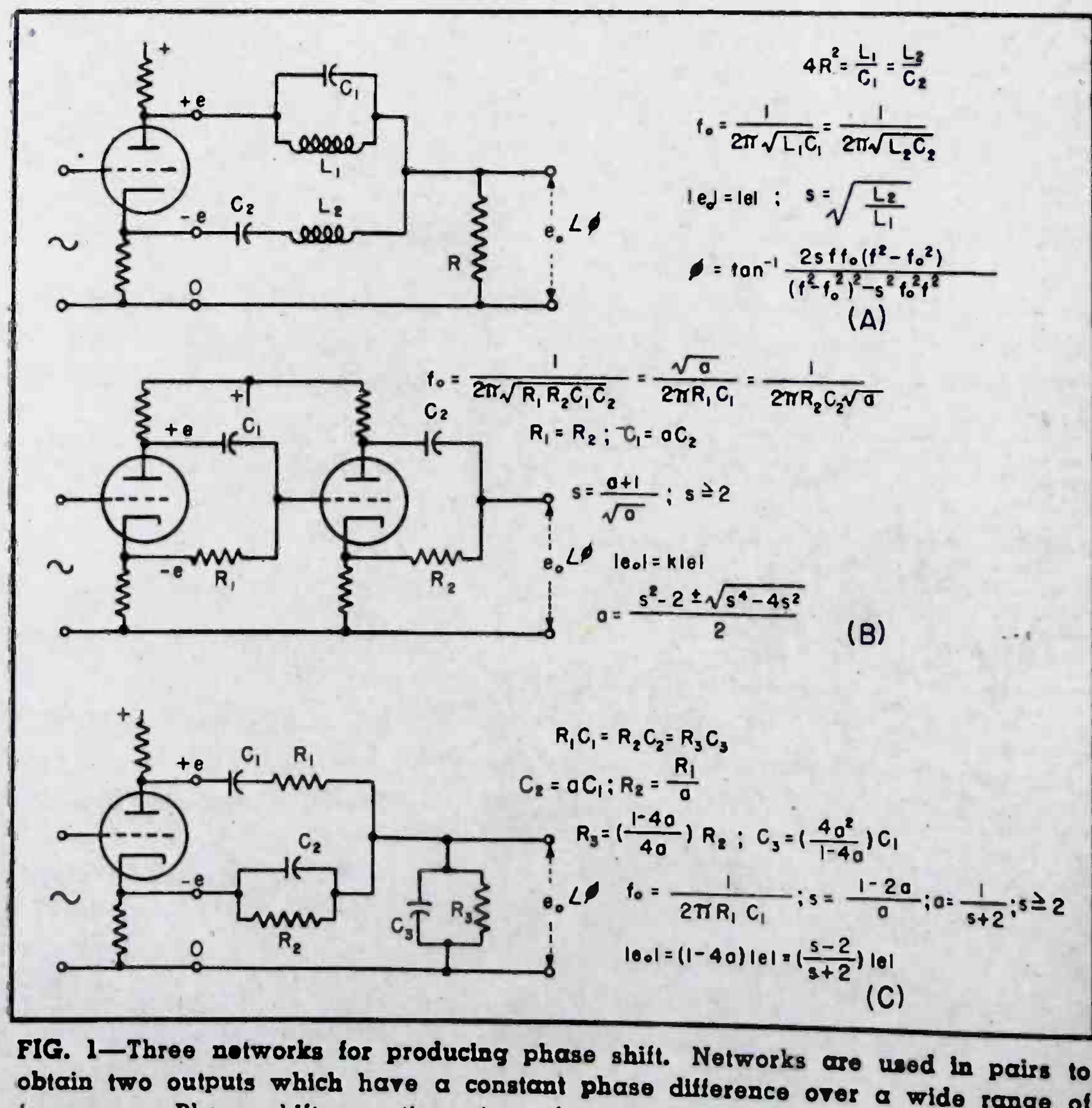


FIG. 1—Three networks for producing phase shift. Networks are used in pairs to obtain two outputs which have a constant phase difference over a wide range of frequency. Phase shift equation given for network of Fig. 1A holds for other two networks

Phase Shift Networks

By R. B. DOME

Receiver Division
General Electric Co.
Bridgeport, Conn.

Applications

THE wideband phase shift networks described herein are applicable to:

Single sideband telephony accomplished directly at the final carrier frequency without multiple modulators or sharp cutoff filters.

High efficiency broadcast transmitters radiating carrier, upper, and lower sidebands from three separate antennas.

Frequency variation of crystal controlled carrier of communication transmitters either for carrier control or frequency-shift keying.

Circular display on cathode-ray tubes over a wide frequency band without adjustment of the phase shift network.

Variable speed operation of three-phase a-c motors.

angle difference between these two curves is maintained within 90 ±4 degrees over a fairly wide range of frequency if $s = 4$, and is quite satisfactory for voice frequencies because the upper to lower frequency ratio is approximately 28 to 1, as for example would occur in a band from 130 to 3,600 cps.

The band can be widened indefinitely by adding more elements to the bridge arms with the result that the frequency range is expanded more until remarkably good performance is obtained over the full audio range from 30 to 15,000 cps.

The use of inductances in filters is to be avoided if possible because of the inability to obtain a pure inductance; there are always the inevitable series resistance and shunt capacitance. Other objections to the use of inductors are that they may pick up unwanted signals from stray magnetic fields and that they are not constant in inductance with applied voltage. As a consequence, a resistance-capacitance type of half-lattice network would be preferable providing the required type of phase curve were obtainable from them.

R-C Lattice

In order to provide a wide range of operation, two simple resistance-capacitance networks can be used in cascade with isolating tubes between them as shown in Fig. 1B. A single network has restricted bandwidth. No terminating resistor can be used in this type of network.

The phase angle of the final output voltage can be adjusted exactly as in the L-C circuit of Fig. 1A because the phase angle equation is identical. The only limitation with this network is that s must be greater than 2, however as previously found, for best results s should be approximately 4, and hence lies well above 2.

The number of stages included in cascade may, of course, be increased to any desired number. When six such stages are used, the frequency ratio for which a phase angle difference between two sets of networks can be maintained within 90 degrees ±3 degrees becomes approximately 200 to 1, or what would cover an audio frequency band of 50 to 10,000 cps, which is adequate for high quality broadcast service.

Another R-C network, which does not require an isolation tube, is shown in Fig. 1C. This network somewhat resembles the L-C network of Fig. 1A but differs in output voltage. The output voltage is a proper fraction of the input voltage. The factor a must be less than 0.25, or s must be greater than 2, when using this network. As previously pointed out, for best results s should be approximately 4, or $a = 0.167$, which will yield an output voltage of about 0.33 times the input voltage.

The phase angle equation (Fig. 1A) is seen to be identical to those for the previously described networks. In order to find the proper values for f_0 in the two networks which are to yield a phase angle difference of 90 degrees, assume a geometric mean frequency between the upper and lower frequency limits of usable phase angle difference. This mean frequency is not critical, but a value of 700 cps has been suggested as a practical frequency (O. B. Hansen, Down to Earth on 'High Fidelity', Radio Technical Planning Board, Report on Standards and Frequency Allocations for Post-War FM Broadcasting, Panel 5, June 1, 1944, Section VIII). Having decided on the mean frequency of the system, it is merely necessary to design the two phase shift networks so that one has a phase angle of 180 − 45 degrees at 700 cps, and the other a phase angle of 180 + 45 degrees at 700 cps.

Basis for Design

Suppose the value for f_0 of the first network is to be determined, then, designating f_0 of the first network as f_{01} and letting f equal the mean frequency, designated as F, the phase angle equation (Fig. 1) becomes

$$\tan \phi = \frac{2sFf_{01}\,(F^2 - f_{01}^2)}{(F^2 - f_{01}^2)^2 - (sf_{01}F)^2}$$

Setting $\phi = 135$ degrees and $s = 4$, clearing fractions and solving for f_{01} gives $f_{01} = 2.126F$, which, for $F = 700$ cps, gives $f_{01} = 1{,}488$ cps.

By reciprocal relationships, the value of f_{02}, the f_0 of the second network, is $f_{02} = F/2.126$; at $F = 700$ cps, $f_{02} = 329$ cps.

The parameters of the two networks can now be calculated. For convenience and to establish values of impedance into which vacuum tubes can work satisfactorily, assume that $R_1 = 20{,}000$ ohms in each

Table I—Determination of Network Parameters

First Network

$$f_{01} = 1488 \text{ cps}$$
$$s = 4.00$$
$$a = 0.1666$$
$$R_1 = 20{,}000 \text{ ohms}$$
$$C_1 = \frac{1}{2\pi f_{01} R_1} = \frac{1}{2\pi 1488 \times 20000} = 0.00535\ \mu f$$
$$C_2 = a\,C_1 = 0.166 \times 0.00535 = 0.000892\ \mu f$$
$$C_3 = \left(\frac{4a^2}{1-4a}\right) C_1 = 0.333\, C_1 = 0.333 \times 0.00535 = 0.001785\ \mu f$$
$$R_2 = \frac{R_1}{a} = \frac{20000}{0.166} = 120{,}000 \text{ ohms}$$
$$R_3 = \left(\frac{1-4a}{4a}\right) R_2 = \left(\frac{1-0.666}{0.666}\right) 120{,}000 = 60{,}000 \text{ ohms}$$

Second Network

$$f_{02} = 329 \text{ cps}$$
$$s = 4.00$$
$$a = 0.1666$$
$$R_1 = 20{,}000 \text{ ohms}$$
$$C_1 = \frac{1}{2\pi f_{02} R_1} = \frac{1}{2\pi 329 \times 20000} = 0.0242\ \mu f$$
$$C_2 = a\,C_1 = 0.166 \times 0.0242 = 0.00403\ \mu f$$
$$C_3 = \left(\frac{4a^2}{1-4a}\right) C_1 = 0.333\, C_1 = 0.333 \times 0.0242 = 0.00806\ \mu f$$
$$R_2 = \frac{R_1}{a} = \frac{20000}{0.166} = 120{,}000 \text{ ohms}$$
$$R_3 = \left(\frac{1-4a}{4a}\right) R_2 = \left(\frac{1-0.666}{0.666}\right) 120{,}000 = 60{,}000 \text{ ohms}$$

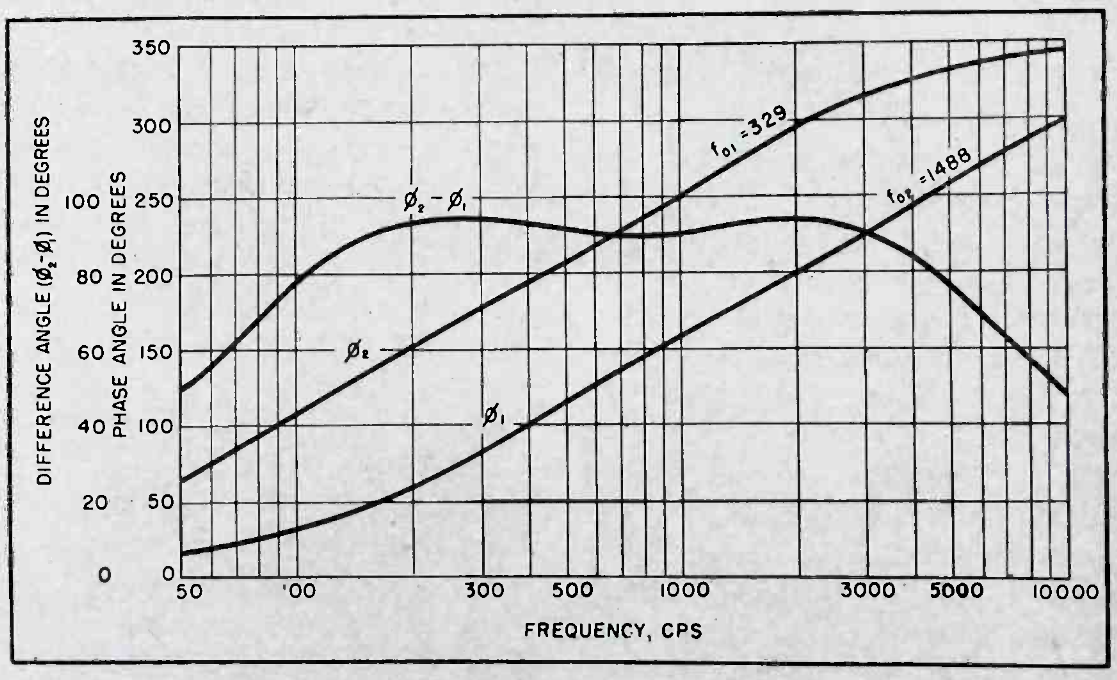


FIG. 2—Phase shift characteristics of networks whose values are given in Table I

network. The calculations are summarized in Table I.

The phase shift curves for these two networks are shown in Fig. 2. Note the long frequency range over which these curves are substantially parallel. The difference angle is plotted to facilitate comparison. Note that this difference angle holds fairly close to 90 degrees over a range of frequencies from 130 to 3,600 cps. This range is quite adequate for a voice frequency channel.

Such a network can be used to build a simple single sideband transmitter without the necessity of using sharp cut-off filters and double or triple modulation. This simplification may be done by combining the outputs of two balanced modulators: one balanced modulator is fed with radio frequency cos ωt and audio frequency $m\cos(\mu t - \theta)$, and the other balanced modulator is fed with radio frequency cos $(\omega t \pm \pi/2)$ and audio frequency $m\cos(\mu t - \theta \pm \pi/2)$. If the plus signs are used and the balanced modulator outputs are added, the resultant output would be $m\cos[(\omega - \mu)t + \theta]$, which is the lower sideband.

Single Sideband Telephony

An experimental system of this type has been constructed and operated using carrier frequencies in the broadcast band. No untoward difficulty was encountered and results were fully up to expectations. The transmitter was modulated with audio signals taken from the output of a broadcast receiver. The single sideband transmission was received by a second broadcast receiver into whose input terminals was also fed an unmodulated continuous wave radio frequency from a signal generator to furnish the missing carrier. The signal generator frequency was adjusted until the reproduced program sounded most natural. No auxiliary filters were used in the radio section of the transmitter to aid in reducing the unwanted sideband.

The question may arise as to how much of the unwanted sideband is permitted to get through the system if not exactly 90 degrees phase difference is obtained between the two audio channels. The ratio of the weaker sideband to the stronger sideband is given by the equation

$$\text{RATIO} = \sqrt{\frac{1-\cos\delta}{1+\cos\delta}} \cong \frac{\delta}{2}$$

where δ is the deviation of the difference phase angle from $\pi/2$, with δ expressed in radians for the approximate formula. A deviation from 90 degrees of 6 degrees is required before the weaker sideband becomes 5 percent as strong as the stronger sideband, so that the phase angle curve of Fig. 2 is probably commercially useful over a range in frequencies included between 84 degrees on the low side of the center to 84 degrees on the high side of the center.

A second application for the system is that of providing a closer-to-zero frequency single sideband telephone or broadcast transmission when filters are used. For example, a single sideband transmitter may be constructed along conventional lines with a quartz crystal type of band-pass filter to operate on 100 kc. Suppose the pass band extends from 100,600 to 108,000 cps. It is seen that frequencies below 600 cps are attenuated in such a system. Now if the single sideband system described in the present paper were to be used in conjunction with a filter, the filter could transmit from 100,000 to 108,000 cps, and the region between 27 and 600 cps could be taken care of by the audio phase shift system, letting the filter remove the undesired sideband from 99,400 down to 92,000 cps. Thus the resultant radiation could contain single sideband components corresponding to an audio frequency range of 27 to 8,000 cps instead of being limited to a range of 600 to 8,000 cps. The addition of the 27 to 600-cps range will add considerably to the naturalness of male speech and organ music. Frequencies between 0 and 27 cps should be removed from the original audio being fed into the system.

High Efficiency Transmitter

A high efficiency broadcast transmitter can be constructed by employing three power amplifiers and three antennas arranged so that an unmodulated carrier is radiated on a central antenna and the upper and lower sidebands are radiated respectively on two side antennas, which are on a straight line through the central antenna but on opposite sides equidistant from it. The sidebands are generated in much the same manner as described in the preceding section. Only one set of audio phase-shift filters are required, for the upper and lower sidebands can be obtained by simply adjusting the phases of the radio frequencies fed into the two sets of balance modulators.

This system of transmission could be accomplished with the following installed relative power capacity

Carrier	1.00
Upper Sideband	0.25
Lower Sideband	0.25
Total	1.50

When modulating 100 percent, this system will have an overall efficiency of about 66 percent, resulting in a d-c power consumption of 2.25 maximum. This consumption graduates down to 1.5 for zero modulation. For an average modulation of 50 percent the power consumption would thus be about 1.875.

The conventional double sideband plus carrier class-B amplifier must have an installed power capacity of 4.0 for handling the peaks of 100 percent positive modulation and the transmitter runs at 33 percent efficiency, requiring a continuous input power of 3.0 from the d-c supply. Thus the saving in d-c power consumption would be about 1.125 based on the carrier rating, or for a 50-kw transmitter, the saving would amount to 56.25 kw. Besides the savings in power costs, the system would have lower first costs in the water cooling system, power rectifiers and transformers, and in high power vacuum tubes. The replacement tube cost also would be less.

In the operation of emergency communications transmitters it is often desirable to change the radiated carrier frequency a few hundred or a few thousand cycles to avoid either intentional or accidental jamming, yet it is also desirable to retain the benefits of precise frequency control such as is provided by a quartz crystal. One solution is to have available a large number of crystals lying on closely adjacent frequencies selectable by a rotary switch. Another scheme might be to adjust the air gap or shunt capacitance across the crystal. All of these methods have their objectionable features.

Adjustable Carrier Frequency

An alternative arrangement is to make use of the single sideband generator already described. By way of example, suppose the assigned frequency of a transmitter were 4,500 kc. One could then use a crystal oscillator on 4,498 kc in conjunction with the balanced modulator and a 2-kc variable frequency oscillator to produce the required 4,500-kc carrier. The oscillator could then be adjusted to other nearby frequencies to avoid jamming, by having it cover a range of roughly 0 to 4 kc and thus be able to change the radiated frequency plus or minus 2 kc about the assigned frequency.

The frequency stability of the system would be quite similar to the master quartz frequency stability and hence could be classified as precise. Wider ranges of control could of course be obtained by utilizing submultiple crystal frequencies or wider oscillator range, within the limits of stability of the final frequency.

Frequency Shift Keying

A transmitter equipped as above could be easily converted into a telegraph transmitter with precise frequency shift keying. By way of example, suppose the 4,500-kc transmitter were required to radiate 4,499.9 kc with the key down and 4,500 kc with the key up. All that would be necessary would be to shift the low frequency oscillator from 2.0 kc to 1.9 kc. This shift could be accomplished by keying in a shunt capacitance, and the resulting frequencies would be both precise and stable, maintaining the 0.1-kc difference quite accurately over long periods of operation.

Other Applications

The two 90 degree phase angle displaced voltages can be fed into the X and Y deflection plates of an electrostatic deflection type of cathode-ray tube to obtain a circular trace. The pattern will remain circular for wide changes in frequency if one of these phase-shift networks is used. The circular pattern is a useful indication of the closeness to 90 degrees of the phase shift obtained from these circuits and can be used to determine their performance.

By employing the 90 degree phase angle displaced voltages and a reversed Scott connected transformer, three phase power can be developed from a single phase source. Such a circuit could be used to control the speed of a three phase synchronous motor. Varying the frequency of the original source would vary the motor speed.

PHOTOELECTRIC DUST METER

A phototube in an illuminated air duct continuously measures the quantity of light reflected by dust particles passing through the system. Applications include testing and rating the efficiency of air-cleaning devices

By GUY F. BARNETT and A. L. FREE
Research Division, Philco Corporation Philadelphia, Pa.

CONVENIENT quantitatively meaningful methods for determining the dust content of air are needed.

The problem is of particular interest to the air-conditioning engineer who is confronted with the task of testing and rating air-cleaning devices, and to the experimenter in this field who desires quick but accurate measurements. An ideal measuring system for these purposes would be one which would give a direct and instantaneous indication of cleaning efficiency at all times, and would present this indication so that an untrained worker could read it accurately.

Former Methods

Previous measurement techniques have fallen short of the ideal. The following examples are cited to acquaint the reader with the nature of the prior art and its limitations.

(1) In one method, air is impinged onto a viscously-coated slide by the stroke of a piston, and the size and number of particles per unit area noted with the aid of a high-powered microscope.

Error arises from optical and mechanical discrimination against small particles[1], and human variations in making the count. Preparation and handling of the slide, and adjustment of the pump orifice, present complications. There is obviously considerable time consumed in making such a measurement, and the services of a trained worker are necessary.

(2) The increase in weight of a coated slide may be determined. This reduces the human error, but, in a weight determination, there is no way of knowing whether a given weight represents one particle of 1000 microns in diameter or a billion particles one micron in diameter.

(3) Dust-laden air may be forced through some filtering material or device, such as a cloth, at a uniform rate[2]. The time necessary to produce a given increment in weight or coloration of the filter may be taken as an indication of the dust-content of the air. Again the method is long and cumbersome, and appreciably selective in the size of particles retained.

In view of the limitations inherent in physical dust-measuring means, the authors have developed an overall system for testing the efficiency of air cleaners which gives an instantaneous and direct indication. The nucleus of this system is a phototube and a light source; the amount of dust in the air determines the illumination of the phototube and hence the current from it. This effect, when amplified, gives a continuous meter indication of the amount of dust in the air. By observations made before and after the cleaning device, the cleaning efficiency can be obtained by meter readings referred to a previously constructed calibration curve.

Photoelectric System

The first experimental test system is indicated schematically in Fig. 1. By means of this system the various parameters involved in the efficiency measurements could be examined. The system consisted of a closed air path; however, if the duct-work was opened at *A* (or

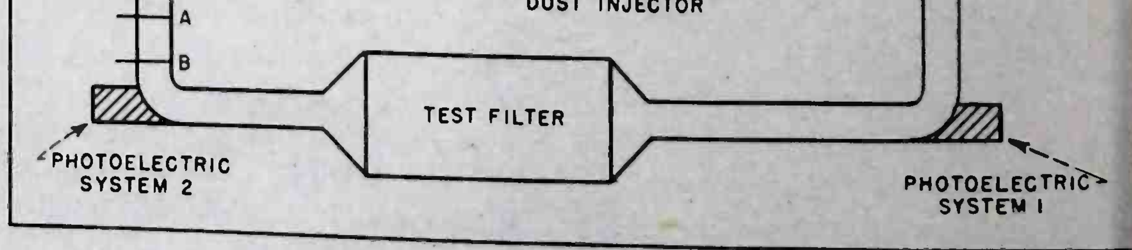
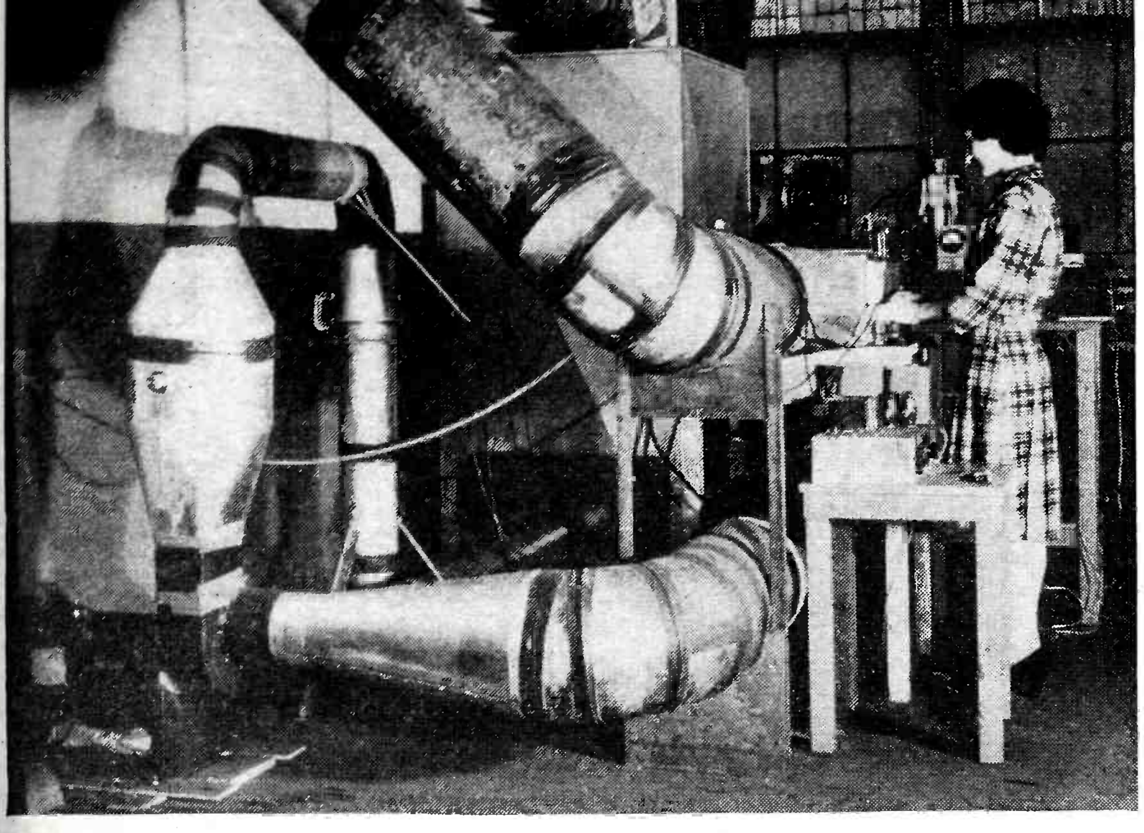


FIG. 1—Block diagram of an experimental dust measuring system



Photoelectric system for testing the efficiency of a filter for an air-conditioning unit

A') and B, air could be drawn through opening A (or A') and expelled through opening B.

The blower was capable of delivering 300 cubic feet per minute, the air velocity being controlled by adjustable dampers in the line. After leaving the fan, air passed through a section of duct containing a pitot tube for measuring the air velocity. Next in the system was the dust injector, which was connected to a compressed air line. By proper adjustment of the air pressure, dust could be fed into the system at a controllable and nearly uniform rate. From here the air passed into the bottom of the settling chamber, which was 3 × 3 feet in cross-section and 6 feet in height. Any large agglomerations of particles which might have existed in the air stream tended to settle out while travelling this six-foot vertical path at a low velocity.

The air stream then passed through a section of circular duct, and through an elbow on which was mounted a collimated light source and a collimated phototube. Next came the section in which the filter on test was placed. Following this was another elbow containing a dust measuring system, and a return duct back to the blower.

Quantities Measured

The photoelectric method of dust density measurement implies a determination of either (1) the quantity of light scattered onto a phototube by dust in the air, or (2) the quantity scattered away from the phototube by the dust. In the first arrangement, the phototube is shielded from the direct rays of the illuminating source and from extraneous reflections; ideally, the only light to reach the phototube is that scattered in a particular direction by the dust.

The second method uses a light beam shining directly at the phototube, which is collimated to look only at the source; dust between source and phototube then causes a decrease in phototube illumination by scattering light out of the beam. The precise nature of the scattering depends on the particle size and the wavelength of the light used.

One principal difficulty occurs in the case of direct viewing of the illuminating source by the phototube. The change in phototube current caused by dust in the intervening air is small compared to the constant current corresponding to clean air, unless the dust densities are excessively high or the light path exceedingly long. This means a loss in effective sensitivity.

Special measures might be taken to minimize this difficulty[3]. For example, a lens might focus the light onto a small absorbing target near the phototube, thus protecting the latter from direct rays. Another lens could then direct diffracted and reflected light to the phototube cathode. However, the use of lenses in a dust-laden system of this sort is generally undesirable since dust collected on them scatters light just as does airborne dust. These factors and other practical considerations favored the adoption of the indirect-viewing method.

Indirect Viewing

With an indirect viewing system, the illuminated dust particles are viewed at an angle to the illuminating beam. The use of an optical system here would serve only to increase the sensitivity of the phototube system. This same function can be performed by a suitable electronic amplifier, which is more desirable than an optical system. Since extreme sensitivity is available with the use of photo-multiplier tubes and high-gain amplifiers, a consideration of relative intensity of light scattered along, versus normal to, the incident beam is of little importance in this connection.

If the dust has a random particle size distribution ranging in size from larger to smaller than the wavelength, λ, of the incident light, the light scattered normal to the beam would be made up of that due to reflection from the larger particles and that due to absorption and reradiation from the particles smaller than λ. This latter is the well-known Rayleigh scattering, the law of which predicts that the shorter wavelengths should be scattered more intensely than the longer ones due to an inverse fourth-power dependence on wavelength.

As a further consideration, the particle distribution before the air passes through the cleaner would differ from that after cleaning, since any air cleaner is somewhat selective with regard to the ease with which it collects particles of a particular size[4, 5]. This means that the ratio of reflected to reradiated light would have changed after cleaning.

Since reflection depends on the square of the particle radius, and reradiation depends on the radius cubed, interpretation of results would become very difficult. For the above reasons it was desirable to restrict the types of dust to those with particle diameters all larger or all smaller than the wavelengths of the illuminating radiation to which the phototube is sensitive. If the phototube current is to be directly proportional to the number of particles in the air, then they should also be sufficiently similar in size to make the selectivity of the cleaner negligible over the range of particle sizes.

When all the above conditions are met, the intensity of illumination of the phototube cathode will be proportional to the number of dust particles in the air. If the relation between phototube illumination and phototube current is known, the observed phototube current will be a direct indication of the number of particles per unit volume of air.

A relation for efficiency in terms of the meter currents, involving the various parameters, may be obtained as follows: Suppose we assume two complete and independent measuring systems, one before and one after the cleaning device. The primed quantities refer to the latter system.

i = Current through indicating meter in microamperes
C_t = Current response of phototube to illumination in μa per lumen
C_a = Gain of amplifier
I_o = The number of lumens from the light source falling on an area perpendicular to the lightbeam, this area being defined by the intersection of the lightbeam limits and the projected limits of the phototube cathode
A_s = Dimensionless reflection and scattering constant due to the surfaces of the apparatus viewed by the phototube
A_d = Dimensionless reflection and reradiation constant due to the airborne dust
r = Dimensionless constant representing reflection from airborne dust
s = Dimensionless constant representing reradiation from airborne dust
$f(d)$ = Dimensionless value representing the effect of the particle size distribution of airborne dust
P = Number of particles of airborne dust per unit volume (dust density), dimensionally a reciprocal volume

Then the meter currents, i before cleaning, and i' after cleaning, are given by

$$i = C_tC_aI_o\,(A_s + A_d)$$
$$\text{and } i' = C'_tC'_aI'_o\,(A'_s + A'_d)$$
$$\text{or } i = mA_d + i_o \text{ where } m = C_tC_aI_o$$
$$\text{and } i_o = C_tC_aI_oA_s = mA_s$$
$$\text{and } i' = m'A'_d + i'_o \text{ where } m' = C'_tC'_aI'_o$$
$$\text{and } i'_o = C'_tC'_aI'_oA'_s = m'A'_s$$
$$\text{but } = A_d = arsf(d)P$$

where a is the proportionality constant (dimensionally a volume)

$$\text{or } P = kA_d \text{ where } k = \frac{1}{arsf(d)}$$

The efficiency E is then

$$E = \frac{P - P'}{P} = \frac{\frac{k}{m}i - \frac{k'}{m'}i' - kA_s + k'A'_s}{\frac{k}{m}(i - mA_s)}$$

The efficiency is seen to be an explicit function of the various parameters. A calibration run associated with each set of measurements is obviously necessary when two independent systems are used.

Ideally, the use of dust of a uniform particle size of a single material will cause the difference between k and k' to become negligible. Assuming a linear response of the phototube system, a single light source, phototube, amplifier, and meter for each measurement would cause m and m' to become equal,

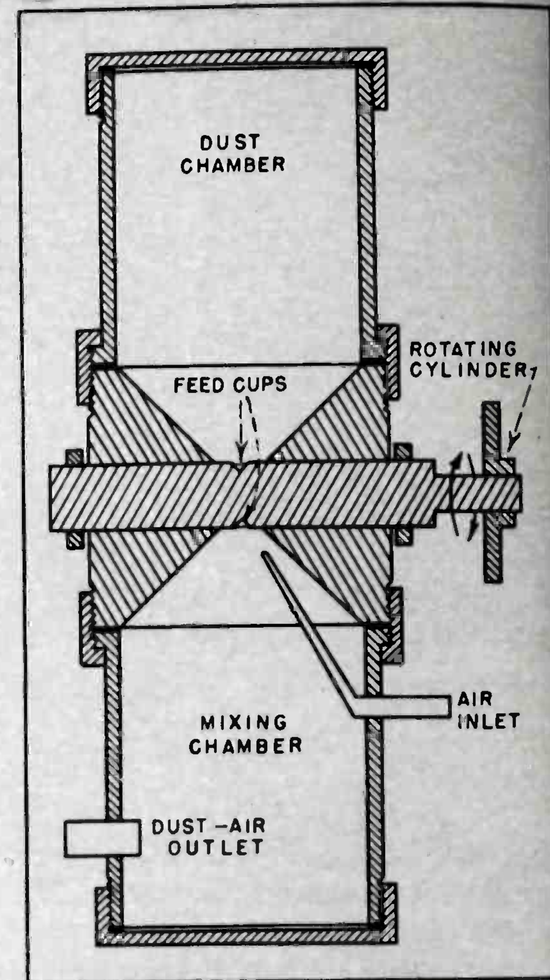


FIG. 3—Simple dust-metering device. The feed cups on the rotating cylinder carry dust from the upper chamber into the mixing chamber

and proper design would cause A_s and A'_s to become negligibly small. The equation for efficiency would then reduce to

$$E = 1 - i'/i.$$

Circuit

When the test stand was put into operation, certain problems arose affecting the accuracy of results. Due to the high sensitivity of the response of the multiplier type of phototube to variations of electrode voltages, the use of a power supply with good regulation was imperative. Figure 2 shows a schematic diagram of the complete electronic circuit. A mu-bridge type of regulator is used to insure constancy of the phototube electrode voltages.

The noise level in this type of phototube is proportional to its d-c output. This permitted the use of an a-c amplifier in the measuring system, which is desirable because of its simplicity compared to an equally stable d-c amplifier.

The resistance-capacitance network associated with the microammeter has a sufficiently long time constant to allow the meter reading to be an average indication of the response of the phototube. This expedient was resorted to because

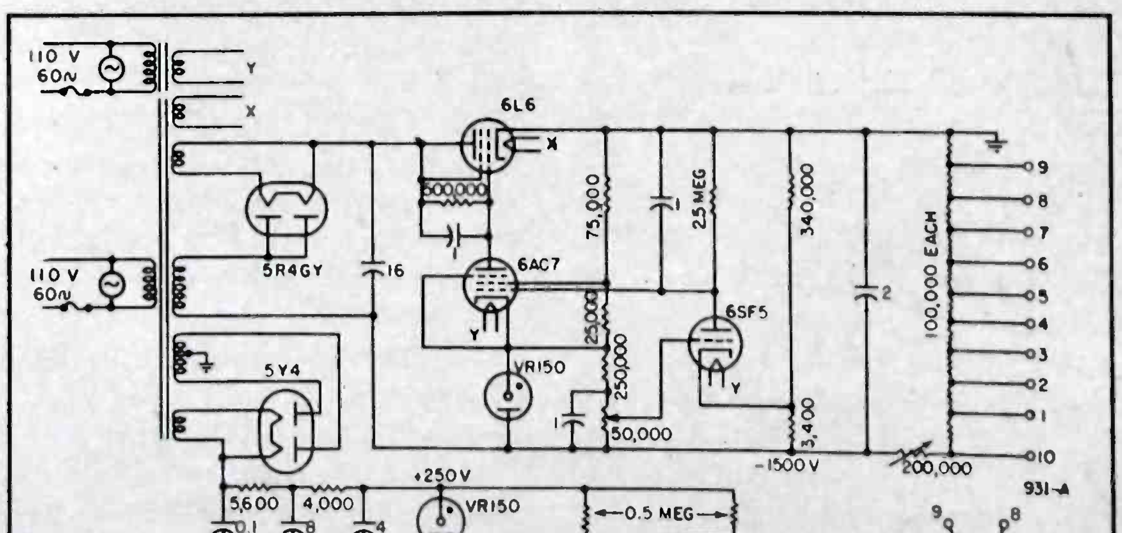


FIG. 2—Circuit of the a-c amplifier and voltage-regulated power supply for the phototube

of the failure of the original dust injector system to give an entirely uniform feed at the low dust levels desired. A metering type of dust injector shown in Fig. 3 was finally adopted. The dust content of the air can be varied by varying the speed of rotation of the notched cylinder.

Calibration

Silicic acid dust was used in the tests. As it came from the manufacturer, it was found to have a considerable range of particle size. Uniformity of particle size was obtained by a settling fractionation technique, using water as a settling medium. To reduce the tendency to agglomerate after drying, the yield was heated to a temperature appreciably below the sintering point.

Using the system as a closed circuit, calibration runs at low dust levels were made by the successive introduction of known quantities of dust at equal time intervals. Under this condition the reading of the indicating meter was proportional to the increase of the dust density. The range of dust densities over which this linear response was observed embraced values from approximately normal room densities to an order of magnitude higher than normal room densities.

When the same type of measurement was repeated using dust densities ranging from normal room density to values approximately two orders of magnitude higher, the response was observed to deviate from linearity. Two effects were found to be responsible for this deviation. The first and most obvious effect was the tendency of dust to settle and adhere to the surfaces of the apparatus. Density changes due to this effect would be roughly proportional to the density. Secondly, the phototube system was found to have, very closely, a square-law response to illumination.

This measurement was made by stopping down the light source while keeping the color temperature of the lamp filament constant, an expedient necessary to eliminate any effect of color sensitivity of the phototube. From quantitative data on the decrease in dust density due to settling and adhesion, and the use of the phototube system response curve, it was found possible to predict the nonlinear response which was observed over the wide range of dust densities used.

Final Design

With the experience gained in the previous investigations a redesign of the test system was undertaken. Figure 4 shows a diagram of this design. Efficient filters clean the intake air to give a zero dust level. The whole system is on the low-pressure side of the blower to facilitate the introduction of dust or smoke.

A single unit of phototube and associated electronic equipment is used to observe the dust level on both sides of the cleaning device. To minimize mechanical difficulties, two light sources are used, but those are made easily interchangeable so that the effect of any differences due to them are readily observed and taken into account. With proper design and occasional easy cleanings, the difference in zero dust level reading of the two observation points may be made negligible.

The air velocity is maintained at a sufficiently high value to minimize the retention of particles on the duct walls. A value of 6.5 feet per second was originally used, but experience indicated the advantage of somewhat higher velocities. In this connection, one must not lose sight of the variation of filter efficiency with air velocity.

A dust measuring system similar to that shown in Fig. 4, incorporating the above features and observing the suggested precautions, gives quick and accurate results. The indication is continuous, and hence of great value to the experimenter when observing the relation between any of several variables and the quantity of dust in the air. When working in the region of dust levels where the phototube response is linear, efficiency readings will be quite accurate, since they are obtained from relative readings. The technique is also applicable to factory checking of air filters, since the equipment, once adjusted, will provide efficiency ratings simply and rapidly in the hands of an untrained operator.

A major part of the work covered by this article was done under the direction of Wilson P. Boothroyd.

References

(1) Tufty, H. G., and Mathis, E., An Improved Method of Determining Efficiency of Air Filters, *American Society Heating and Ventilating Engineers Journal*, Jan. 1927.

(2) Dill, R. S., A Test Method for Air Filters, paper presented before A.S.H.V.E. in June, 1938.

(3) Photoelectric Smoke Recorder, *Engineering*, p 165, August 5, 1932.

(4) Penny, G. W., A New Electrostatic Precipitator, *Electrical Engineering*, Jan. 1937.

(5) Penny, G. W., A New Air Cleaner, *The Electrical Journal*, August 1937.

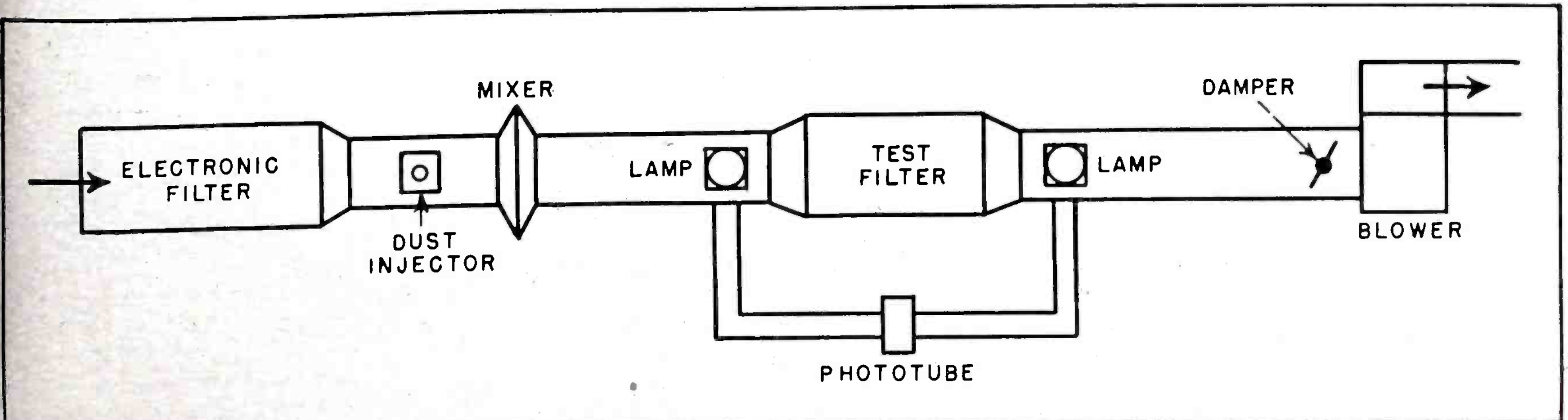


FIG. 4—In the final design of the dust measuring system, air is introduced into the duct at low velocity. One phototube serves both sides of the filter

NOISE and

By EMERICK TOTH

Associate Head, Receiver Section
Ship-Shore Radio Division
U. S. Naval Research Laboratory
Washington, D. C.

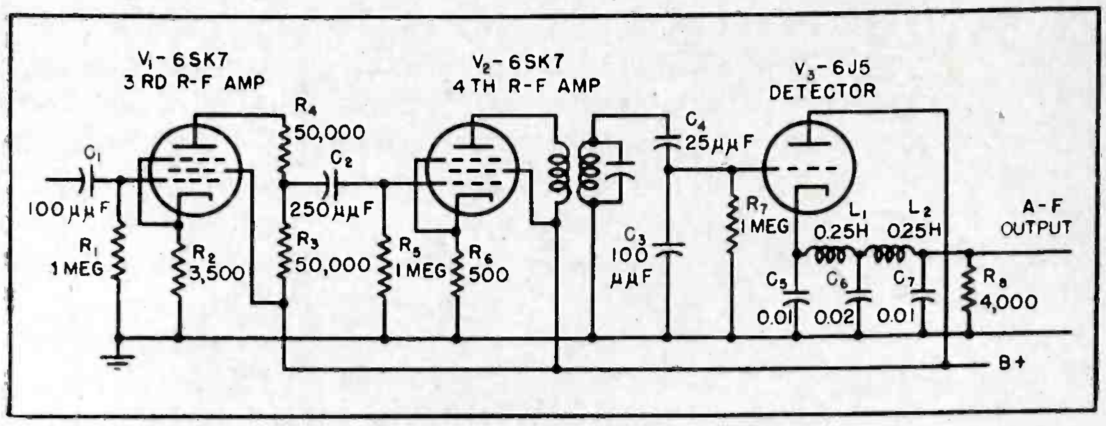


FIG. 14—R-f output limiter depending on plate current saturation in the last two r-f stages, with low-pass filter following the detector to further improve the signal-to-noise ratio of the receiver

INSTANTANEOUS series-type, balanced, and shunt-type noise-peak limiters acting in conjunction with a diode second detector were analyzed in the first part of this paper, (p114, Nov. 1946), along with a noise-peak limiter that acts entirely in the i-f amplifier system. The next circuits to be considered are output limiters, which differ from the instantaneous noise-peak limiters primarily in that they simply present a continuous limit on the maximum power output from one or more amplifiers at some predetermined level. They are, in general, difficult to bias automatically to provide limiting at a desired depth of modulation of the carrier independent of the absolute carrier value, and are therefore mainly useful on c-w (telegraph) operation.

R-F Output Limiter

R-f output limiting (with incidental r-f noise limiting) is quite satisfactorily achieved with the simple circuit arrangement of Fig. 14, which depends on vacuum-tube plate current saturation and control grid cutoff, with maintenance of a high input impedance in the control grid circuits of the saturated tubes. The third and fourth r-f amplifier stages are used as saturation limiters by operating with about 45 volts applied to both screen and plate circuits. The two stages combined provide the equivalent gain of one r-f amplifier stage at a much lower limiting level than is feasible with one stage alone, by virtue of r-f voltage dividers R_3-R_4 and C_3-C_4. The single tuned circuit following the fourth stage filters out r-f distortion caused by the preceding lim-

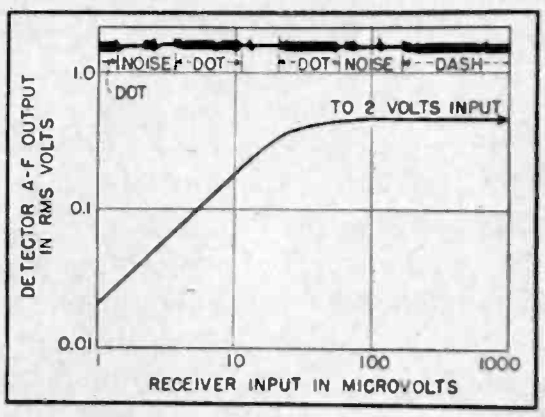


FIG. 15—Resonant overload characteristics of receiver using r-f output limiter for long-wave c-w reception, and oscillogram of letter V as received from an overseas transmitter in presence of 12-volt noise peaks. Input signal frequency is 16 kc, unmodulated; beat oscillator is on; a-f output frequency is 1,000 cycles. Distortion figures for detector output are 0.7 and 0.1 percent respectively for 2nd and 3rd harmonics with receiver input of 10 microvolts, and 2.9 and 0.9 percent for 500,000-microvolt input

iter circuits and provides further selectivity, while the low-pass filter following the detector further purifies the audio output and improves signal-to-noise ratio.

The initial a-c input resistance of the third r-f amplifier tube is about one megohm, until the applied signal voltage exceeds the negative bias supplied by the voltage drop across cathode resistor R_2 to the control grid, when it drops to about one-half megohm because the grid becomes, in effect, a diode rectifier conductive for that portion of the positive half-cycle during which the signal exceeds the grid bias.

The negative bias thus developed across grid leak R_1 by grid rectification is applied to the control grid to limit the increase in space current. During a noise peak, then, the effective positive instantaneous voltage on the grid is the difference between the rectified voltage across R_1 (maintained by charging C_1) and the positive half-cycle voltage of the noise peak, with limiting effects in the plate circuit due to plate saturation.

On the negative half-cycle of r-f input, grid cutoff limits the change in plate current of the tube. The phase shift from grid to plate circuit results in the positive noise peaks applied to the grid of the third r-f amplifier tube appearing as modified negative peaks at the grid of the fourth r-f amplifier, where they are further limited by grid cutoff, the positive peaks at this point being also limited in the

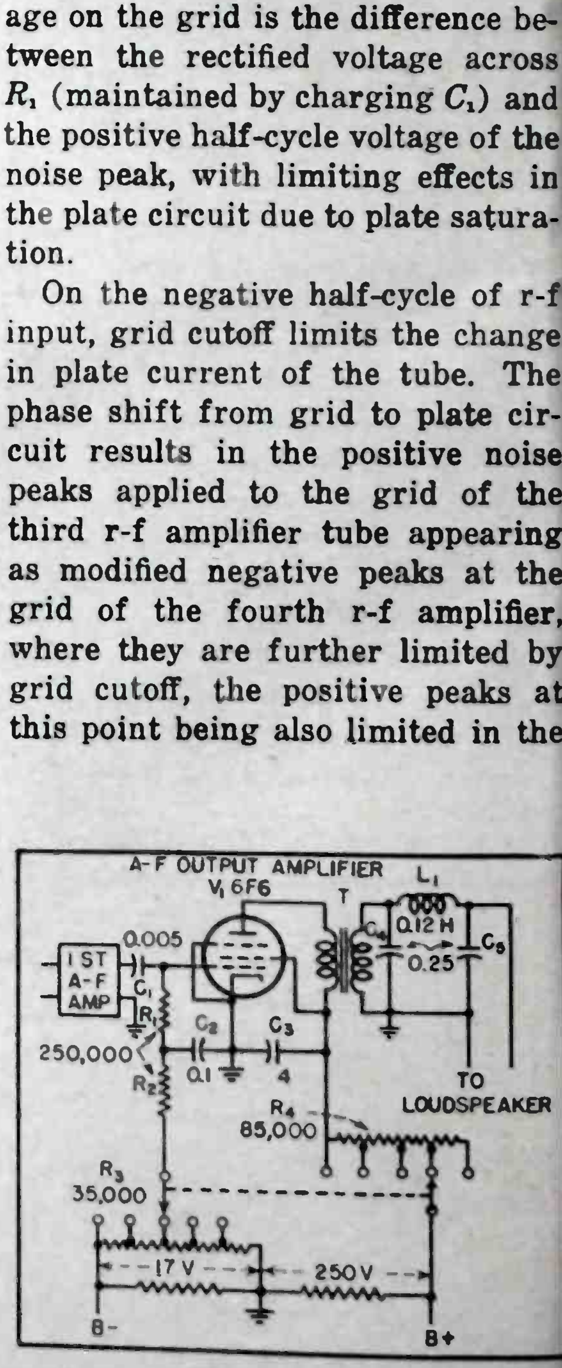


FIG. 16—A-f saturation-type output limiter

OUTPUT LIMITERS

Part II

Six versions of r-f and a-f output limiters, an f-m discriminator for a-m limiting, limiter design considerations, and recommendations of best choices for mcw and c-w operation conclude this comprehensive survey of limiters for a-m communications receivers

ourth amplifier plate circuit by aturation effects. The combined ffect of the two limiter tubes thus s to limit both peaks of applied r-f oltage, whether due to signals or ioise peaks.

Conventional bypass capacitors ind screen filters are not shown in he circuit diagram but are actually ised in the circuits themselves. The letector, an infinite-impedance or athode-follower type, is used prinarily for its low output impedance, nd does not provide any desired imiting action. This saturationype limiter is useful chiefly for c-w eception at very low carrier freuencies, though with a suitable aturation limit and an exceptionlly good avc system controlling the receding r-f gain to just below imiting level on the desired signal, istortion on mcw reception can be ept low over a considerable range f carrier input values.

Use is made in f-m receivers of imilar limiting in the i-f system, xcept in those having limiting disriminators of the ratio type. Such f limiters usually do not, however, utilize voltage dividers. They are designed for higher limiting levels than the circuit of Fig. 14, and operate to reduce amplitude variations of the f-m carrier appearing at the discriminator to the greatest practicable extent. The avc voltage may be taken from the final limiter grid resistor, or the preceding one if there is more than one limiter stage.

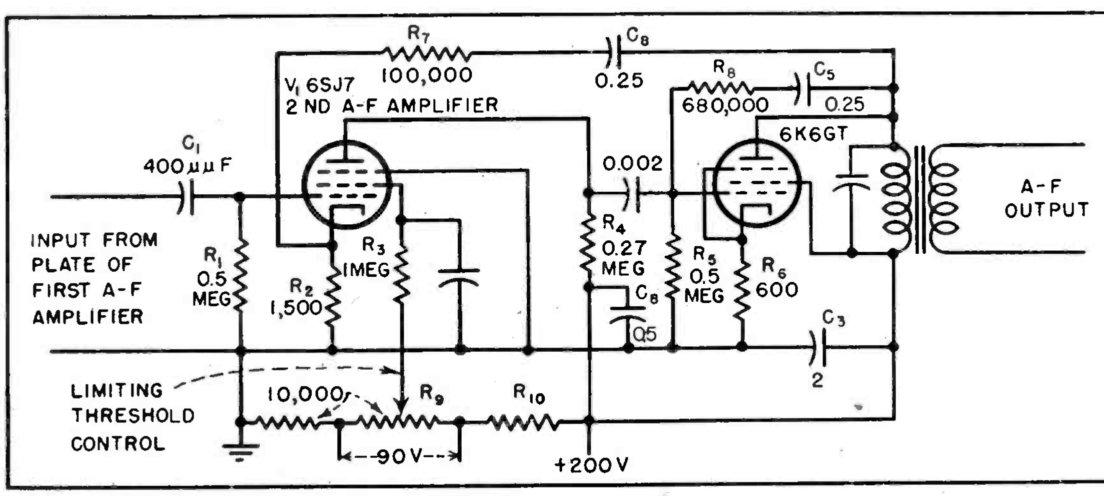


FIG. 18—Interstage a-f output limiter

Figure 15 shows the resonant overload and distortion characteristics of a receiver utilizing this type of limiter and oscillogram of the letter V as received at 16 kc from an overseas transmitter in the presence of 12-volt noise peaks.

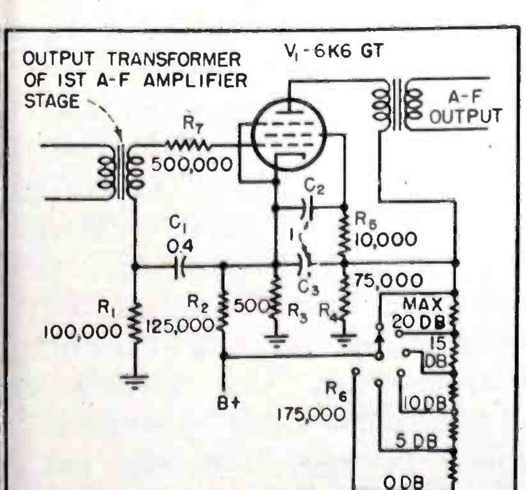


FIG. 17—Modified saturation-type limiter

A-F Saturation-Type Output Limiter

Control of the saturation level of the a-f output pentode tube at various screen, plate, and control grid voltages provides audio output limiting action without use of additional tube circuits (Fig. 16). A low-pass filter ($L_1 C_4 C_5$) filters out distortion produced in the output stage; its cutoff frequency is 1,200 cps, and hence for a 1,000-cps tone signal the harmonics will be filtered out to a considerable degree.

The control grid, screen, and plate voltages in this limiter are varied by a double-pole switch that contacts taps on resistors R_3 and R_4. The voltages thus obtained maintain the gain below saturation fairly constant for all switch settings, while at the same time permitting control of the limiting level. This circuit is useful for c-w reception only. Below limiting threshold, there is a change in gain of about 3 db for a 20-db range of limiting threshold. It is highly desirable with output limiters that the gain below limiting threshold remain as nearly constant as possible for all settings of the threshold control.

Modified A-F Saturation-Type Limiter

By using a partly fixed-bias and partly self-bias arrangement in the cathode circuit of the output tube, output saturation threshold control is obtained in the circuit of Fig. 17 by varying only the common d-c plate and screen grid voltage supply to the tube. This is done in steps giving changes of 5 db in output limiting level. Resistor R_7

in the control grid circuit of the output tube reduces a-c loading, and prevents excessively high direct current through the secondary winding of the interstage a-f transformer when rectification occurs in the grid circuit of the output tube. This limiter is useful for c-w reception only. There is some loss in gain below limiting threshold for the lower levels of limiting, amounting to about 5 db for about 21 db of threshold adjustment.

Interstage A-F Output Limiter

The circuit of Fig. 18 obtains its output limiting effect in the a-f stage preceding the output stage, and employs some degenerative feedback to the limiting amplifier from the output amplifier as an aid in maintaining the gain below the limiting threshold as nearly constant as possible.

Limiting is done interstage primarily because of the low limiting level of 60 microwatts required in this case for the minimum threshold value, this low level being difficult to obtain with the audio output tubes usually incorporated in Navy receivers. For a limiting level range of 20 db, this circuit gives a change in gain below threshold of about 10 db, and a change of 16 db for a limiting level range of 30 db. These comparatively large losses in gain for the lower limiting levels are due to the low minimum limiting level required.

Full-Wave Shunt A-F Output Limiter

Two diodes in a single 6H6 envelope, connected interstage as in Fig. 19, serve as a full-wave shunt type of audio output limiter. One diode shunts plate load R_4 of the interstage a-f amplifier tube for the positive and the other for the negative half-cycles of the audio signal. The diodes are biased in series with a d-c voltage obtained from R_7, which thus controls the threshold level above which they become conductive on audio peaks. The diode impedance when conducting at the usual operating audio voltage levels involved averages only a few thousand ohms (the actual value depending mainly on the resistance of that part of R_7 between the variable contact and ground, plus R_6, and also on the audio voltage values), so that the plate load of the preceding amplifier drops from a value of about 250,000 ohms below limiting threshold to perhaps 5,000 ohms during limiting action.

With a high plate-impedance tube, such a load change will produce about 30 db less amplification above the limiting level than below it. This loss of amplification, combined with normal saturation effects in the preceding amplifier tube, limits the output peak voltage to a value that cannot exceed the d-c limiting bias of R_7 by any considerable amount. This limiting system is considered to be among the best of the audio output limiters for c-w reception. For a limiting level range of about 20 db, the change in gain below limiting threshold is only 2 or 3 db.

Figure 20 shows the resonant overload characteristics of this type of limiter as used in a typical receiver. The change in gain from LIMITER OFF to ON condition is caused by switching out a pad in the a-f amplifier system.

The circuit shown in Fig. 21 was used to investigate the possibility of providing output limiting without serious audio distortion by virtue of exponential nonlinear response, the theory being that a logarithmic increment in output for a linear increment of input would not cause distortion sufficient to destroy intelligibility.

Logarithmic Limiter or Compressor

The arrangement consists of a two-stage a-f amplifier, with degenerative feedback from the plate circuit of the output tube to the cathode of the preceding stage. Two diodes are connected in series with the feedback path, in such a way as to provide a path for both positive and negative half-cycles of the feedback voltage. Potentiometer R_{10} across a battery provides d-c bias to the diodes for setting the limiting level. The diode d-c circuit resistance is kept low to take advantage of low diode internal impedance values varying at an exponential rate with applied voltage. Using the diodes in this manner as feedback impedances is equivalent to varying the feedback percentage from a low value to a maximum as the instantaneous feedback voltage rises, with the reverse effect as the instantaneous feedback voltage falls.

When the instantaneous feedback voltage exceeds the region relative to diode impedance wherein that impedance is effective in determining feedback current, the circuit returns to linear operation. Within the nonlinear portions of the output characteristic, this circuit produces considerable distortion on speech or music but does not destroy intelligibility. Noise interference is reduced substantially,

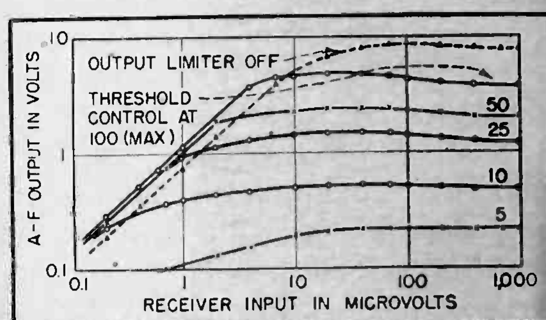


FIG. 20—Resonant overload characteristics of receiver using full-wave shunt a-f output limiter on c-w operation with unmodulated 500-kc input and 1,000-cycle output. Curves continue essentially flat out to 2 volts input

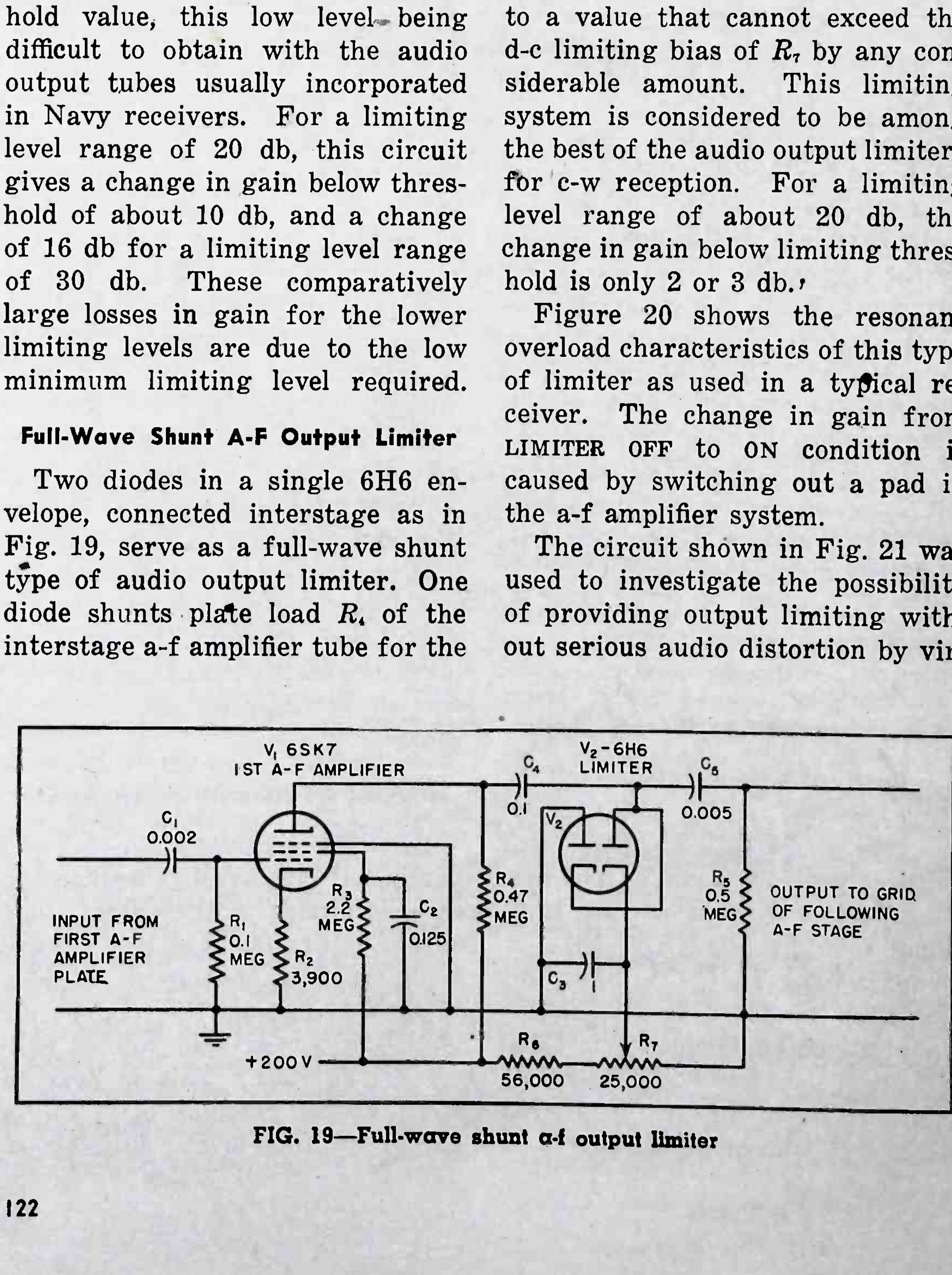


FIG. 19—Full-wave shunt a-f output limiter

and almost as effectively in some cases as with a series noise-peak limiter, if the desired signal is kept within the first linear portion of the output characteristic while noise peaks extend into the compressed region beyond.

Figure 22 shows typical characteristic curves obtained with this limiter arrangement.

Other Limiter Arrangements

If a frequency-modulation receiver employing a discriminator of, perhaps, the Foster-Seeley type is tuned to amplitude-modulated signals, two peaks of maximum response will usually be evident, corresponding to the two points of maximum discriminator current. Since the two halves of the discriminator characteristic are the result of the differential voltage derived from two opposing detectors, the noise output of such a discriminator will be relatively low with no signal input as compared to an ordinary amplitude detector preceded by the same amplifiers. The discriminator provides a somewhat better signal-to-noise ratio on an amplitude-modulated signal tuned to one of the peaks of discriminator response, which is particularly apparent with relatively low modulation frequencies (narrow discriminator characteristic), and especially on keyed c-w signals. It should be noted that the discriminator used in this way reduces the useful bandwidth of the overall selectivity characteristic preceding it to about half of what it would otherwise be with the usual a-m detector.

The discriminator may be followed by a low-pass filter cutting off at about 200 or 300 cps and a d-c amplifier (capable of passing up to these frequencies) which operates a keyer tube controlling a local tone oscillator. Such an arrangement is capable of providing some really startling performance on keyed c-w signals in the presence of noise interference which would make reception with the usual receiving system, even with noise-peak limiters, absolutely hopeless. The use of the local keyer circuit eliminates one of the two peaks of reception, since the discriminator output polarities are opposite for its two maximum response points and the usual keyer tube circuit is arranged to respond to one polarity only. This scheme is subject to various disadvantages when adapted to a conventional a-m receiver, such as complexity and rather critical operating adjustments, but within its limitations has much merit. Figure 23 is typical of such circuits. The similarity of this arrangement to receiving systems for frequency-shift keyed signals is evident.

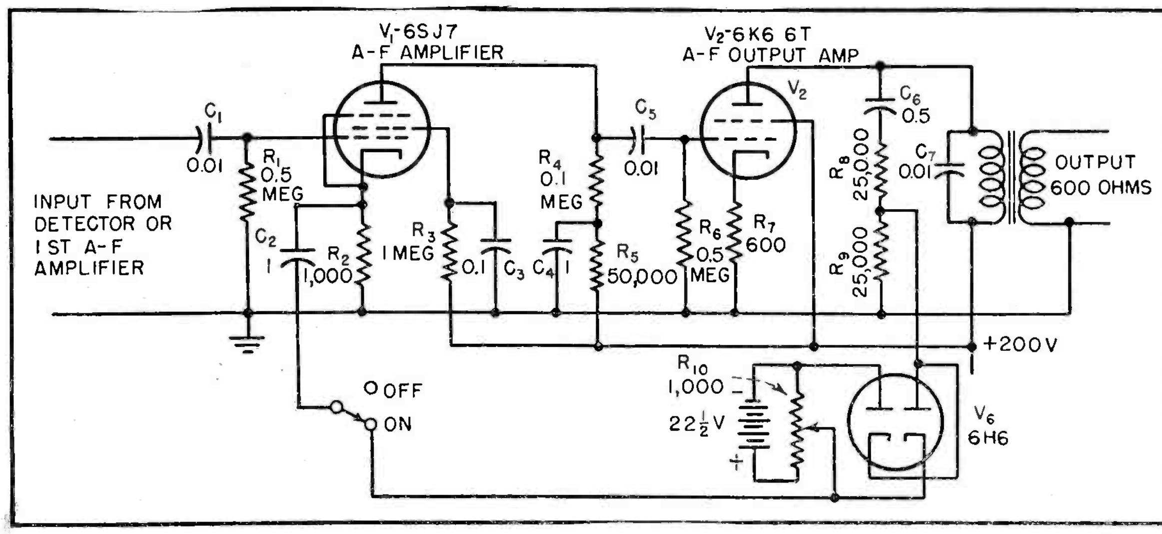


FIG. 21—Logarithmic limiter or compressor, employing two diodes in the degenerative feedback path

Using an f-m discriminator for a-m reception is, of course, a variation on the old proposal of providing two reception channels, one receiving signal plus noise and the other noise only, with the outputs of the two channels appropriately opposed or bucking. This proposal in its usual form does not work satisfactorily, due to the inherent difficulties of balance between such channels and the difference between them in decay time of the noise wave trains. The success (rather limited) of the discriminator version is mainly due to having a very small percentage difference in frequency between discriminator peaks of response as compared to the proposal mentioned, to inherently automatic balance when the discriminator characteristic is symmetrical, and to the single-channel amplifier preceding the discriminator.

Various other modifications of the general scheme of using a discriminator on a-m reception, some in conjunction with noise-peak and other limiters, have been evolved, and preliminary reports have indicated that considerable noise reduction effects have been obtained. The number of circuits and components involved, unfortunately, appears to have resulted in much additional bulk and complexity.

Thermionic Diode Characteristics

A diode of the thermionic type may be considered, for the purposes of this report, as a unidirectional variable resistor in series with an internally generated d-c potential due to cathode emission. For instance, in the 6H6 type of diode, this apparent internal potential appears to be about 1.2 volts and of such polarity as to result in electron flow from cathode to plate within the tube when the external plate-to-cathode path is completed. The effective value of the internal series resistance depends on both the d-c circuit resistance external to the diode and the external applied voltage.

If there is an external d-c circuit resistance of 1 megohm, for example, the internal resistance of each 6H6 diode is in the neighborhood of 600,000 ohms when 1 volt positive external potential is applied to the plate (as by a rising noise-peak), while at 10 volts it is about 35,000 ohms, as shown in Fig. 24. The curve is drawn as an average of quite widely scattered measured values.

Thus the measured shunting effect of the limiter diode is not very appreciable in a circuit like that of Fig. 11 until the noise peak voltage appearing across it approaches 10 volts. With a 1-volt desired signal also appearing across the detector diode load, it would seem to the operator as though the limiter were not functioning. In in the control grid circuit of the output tube reduces a-c loading, and prevents excessively high direct current through the secondary winding of the interstage a-f transformer when rectification occurs in the grid circuit of the output tube. This limiter is useful for c-w reception only. There is some loss in gain below limiting threshold for the lower levels of limiting, amounting to about 5 db for about 21 db of threshold adjustment.

Interstage A-F Output Limiter

The circuit of Fig. 18 obtains its output limiting effect in the a-f stage preceding the output stage, and employs some degenerative feedback to the limiting amplifier from the output amplifier as an aid in maintaining the gain below the limiting threshold as nearly constant as possible.

Limiting is done interstage primarily because of the low limiting level of 60 microwatts required in this case for the minimum threshold value, this low level being difficult to obtain with the audio output tubes usually incorporated in Navy receivers. For a limiting level range of 20 db, this circuit gives a change in gain below threshold of about 10 db, and a change of 16 db for a limiting level range of 30 db. These comparatively large losses in gain for the lower limiting levels are due to the low minimum limiting level required.

Full-Wave Shunt A-F Output Limiter

Two diodes in a single 6H6 envelope, connected interstage as in Fig. 19, serve as a full-wave shunt type of audio output limiter. One diode shunts plate load R_4 of the interstage a-f amplifier tube for the positive and the other for the negative half-cycles of the audio signal. The diodes are biased in series with a d-c voltage obtained from R_7, which thus controls the threshold level above which they become conductive on audio peaks. The diode impedance when conducting at the usual operating audio voltage levels involved averages only a few thousand ohms (the actual value depending mainly on the resistance of that part of R_7 between the variable contact and ground, plus R_6, and also on the audio voltage values), so that the plate load of the preceding amplifier drops from a value of about 250,000 ohms below limiting threshold to perhaps 5,000 ohms during limiting action.

With a high plate-impedance tube, such a load change will produce about 30 db less amplification above the limiting level than below it. This loss of amplification, combined with normal saturation effects in the preceding amplifier tube, limits the output peak voltage to a value that cannot exceed the d-c limiting bias of R_7 by any considerable amount. This limiting system is considered to be among the best of the audio output limiters for c-w reception. For a limiting level range of about 20 db, the change in gain below limiting threshold is only 2 or 3 db.

Figure 20 shows the resonant overload characteristics of this type of limiter as used in a typical receiver. The change in gain from LIMITER OFF to ON condition is caused by switching out a pad in the a-f amplifier system.

The circuit shown in Fig. 21 was used to investigate the possibility of providing output limiting without serious audio distortion by virtue of exponential nonlinear response, the theory being that a logarithmic increment in output for a linear increment of input would not cause distortion sufficient to destroy intelligibility.

Logarithmic Limiter or Compressor

The arrangement consists of a two-stage a-f amplifier, with degenerative feedback from the plate circuit of the output tube to the cathode of the preceding stage. Two diodes are connected in series with the feedback path, in such a way as to provide a path for both positive and negative half-cycles of the feedback voltage. Potentiometer R_{10} across a battery provides d-c bias to the diodes for setting the limiting level. The diode d-c circuit resistance is kept low to take advantage of low diode internal impedance values varying at an exponential rate with applied voltage. Using the diodes in this manner as feedback impedances is equivalent to varying the feedback percentage from a low value to a maximum as the instantaneous feedback voltage rises, with the reverse effect as the instantaneous feedback voltage falls.

When the instantaneous feedback voltage exceeds the region relative to diode impedance wherein that impedance is effective in determining feedback current, the circuit returns to linear operation. Within the nonlinear portions of the output characteristic, this circuit produces considerable distortion on speech or music but does not destroy intelligibility. Noise interference is reduced substantially,

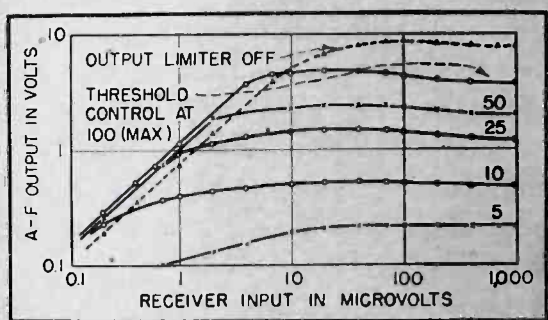


FIG. 20—Resonant overload characteristics of receiver using full-wave shunt a-f output limiter on c-w operation with unmodulated 500-kc input and 1,000-cycle output. Curves continue essentially flat out to 2 volts input

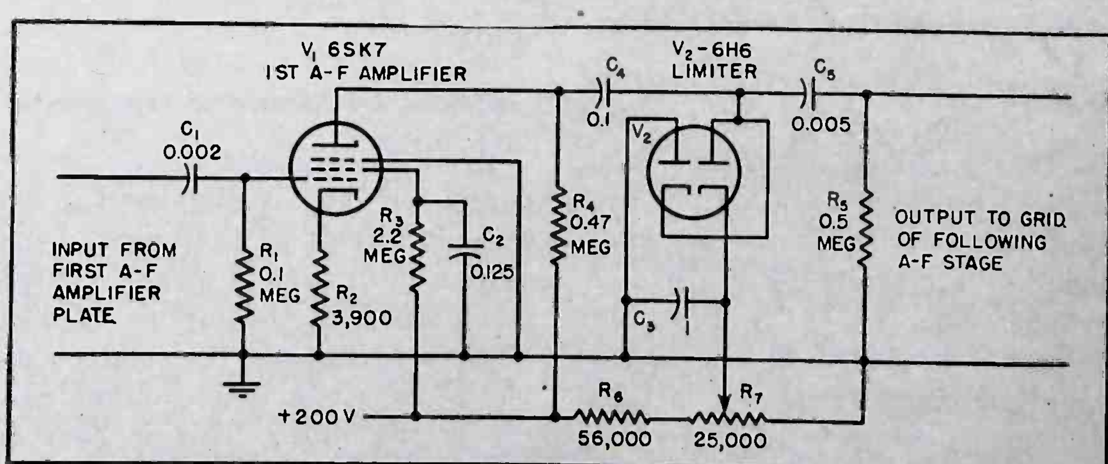


FIG. 19—Full-wave shunt a-f output limiter

and almost as effectively in some cases as with a series noise-peak limiter, if the desired signal is kept within the first linear portion of the output characteristic while noise peaks extend into the compressed region beyond.

Figure 22 shows typical characteristic curves obtained with this limiter arrangement.

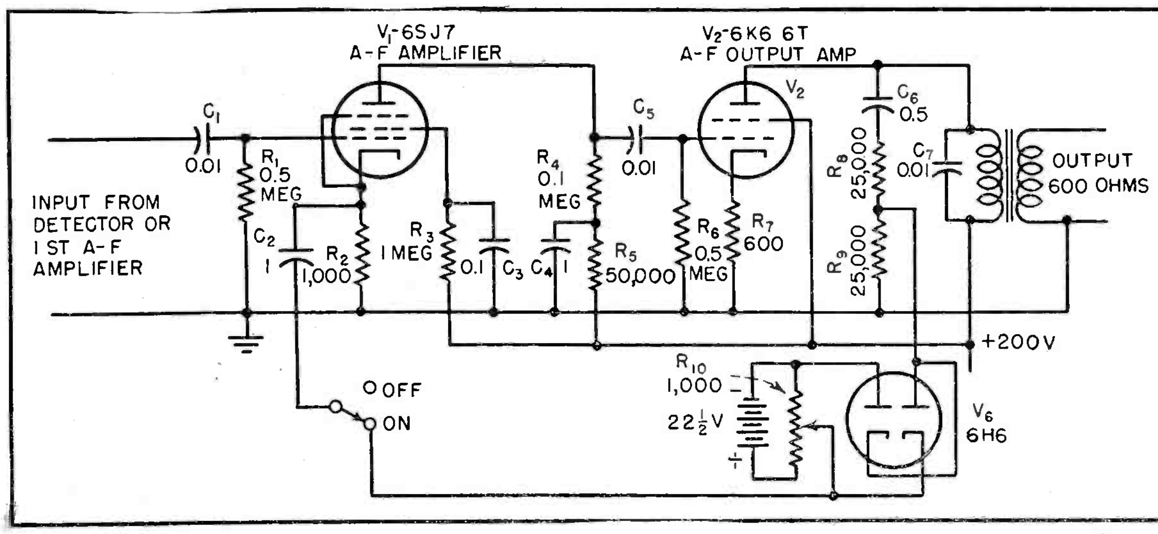


FIG. 21—Logarithmic limiter or compressor, employing two diodes in the degenerative feedback path

Other Limiter Arrangements

If a frequency-modulation receiver employing a discriminator of, perhaps, the Foster-Seeley type is tuned to amplitude-modulated signals, two peaks of maximum response will usually be evident, corresponding to the two points of maximum discriminator current. Since the two halves of the discriminator characteristic are the result of the differential voltage derived from two opposing detectors, the noise output of such a discriminator will be relatively low with no signal input as compared to an ordinary amplitude detector preceded by the same amplifiers. The discriminator provides a somewhat better signal-to-noise ratio on an amplitude-modulated signal tuned to one of the peaks of discriminator response, which is particularly apparent with relatively low modulation frequencies (narrow discriminator characteristic), and especially on keyed c-w signals. It should be noted that the discriminator used in this way reduces the useful bandwidth of the overall selectivity characteristic preceding it to about half of what it would otherwise be with the usual a-m detector.

The discriminator may be followed by a low-pass filter cutting off at about 200 or 300 cps and a d-c amplifier (capable of passing up to these frequencies) which operates a keyer tube controlling a local tone oscillator. Such an arrangement is capable of providing some really startling performance on keyed c-w signals in the presence of noise interference which would make reception with the usual receiving system, even with noise-peak limiters, absolutely hopeless. The use of the local keyer circuit eliminates one of the two peaks of reception, since the discriminator output polarities are opposite for its two maximum response points and the usual keyer tube circuit is arranged to respond to one polarity only. This scheme is subject to various disadvantages when adapted to a conventional a-m receiver, such as complexity and rather critical operating adjustments, but within its limitations has much merit. Figure 23 is typical of such circuits. The similarity of this arrangement to receiving systems for frequency-shift keyed signals is evident.

Using an f-m discriminator for a-m reception is, of course, a variation on the old proposal of providing two reception channels, one receiving signal plus noise and the other noise only, with the outputs of the two channels appropriately opposed or bucking. This proposal in its usual form does not work satisfactorily, due to the inherent difficulties of balance between such channels and the difference between them in decay time of the noise wave trains. The success (rather limited) of the discriminator version is mainly due to having a very small percentage difference in frequency between discriminator peaks of response as compared to the proposal mentioned, to inherently automatic balance when the discriminator characteristic is symmetrical, and to the single-channel amplifier preceding the discriminator.

Various other modifications of the general scheme of using a discriminator on a-m reception, some in conjunction with noise-peak and other limiters, have been evolved, and preliminary reports have indicated that considerable noise reduction effects have been obtained. The number of circuits and components involved, unfortunately, appears to have resulted in much additional bulk and complexity.

Thermionic Diode Characteristics

A diode of the thermionic type may be considered, for the purposes of this report, as a unidirectional variable resistor in series with an internally generated d-c potential due to cathode emission. For instance, in the 6H6 type of diode, this apparent internal potential appears to be about 1.2 volts and of such polarity as to result in electron flow from cathode to plate within the tube when the external plate-to-cathode path is completed. The effective value of the internal series resistance depends on both the d-c circuit resistance external to the diode and the external applied voltage.

If there is an external d-c circuit resistance of 1 megohm, for example, the internal resistance of each 6H6 diode is in the neighborhood of 600,000 ohms when 1 volt positive external potential is applied to the plate (as by a rising noise-peak), while at 10 volts it is about 35,000 ohms, as shown in Fig. 24. The curve is drawn as an average of quite widely scattered measured values.

Thus the measured shunting effect of the limiter diode is not very appreciable in a circuit like that of Fig. 11 until the noise peak voltage appearing across it approaches 10 volts. With a 1-volt desired signal also appearing across the detector diode load, it would seem to the operator as though the limiter were not functioning. In addition, during the period in which the limiter diode internal impedance is low, it provides a path effectively shunting out the resistance in the long time-constant circuit (R_3C_2 in Fig. 11), thereby accelerating the charging-up of C_2. As the voltage across C_2 approaches that appearing between the limiter cathode and ground, limiting ceases. From these considerations, it is apparent that the shunt-diode type of limiter will be peculiarly vulnerable to the modulation envelope set up by the longer wave-trains of interference occurring at the lower frequencies for a given pulse of excitation at the antenna.

Inserting a suitable value of resistor in series with the limiter cathode, as in Fig. 12, will extend the charging time of C_2 when the limiter diode impedance is low, in addition to providing voltage divider action relative to the succeeding a-f amplifier. It is for these reasons that the circuit of Fig. 12 out-performs the simple shunt limiter so greatly, although only approaching the performance of the simple series limiter.

The series type limiter operates to open the circuit to the a-f amplifier. Once the internal potential of the limiter diode itself plus the external no-signal potential applied to this diode by the associated detector diode has been overcome (as it may be by a relatively weak signal or even by inherent receiver noise), further negative biasing of the limiter diode by a noise peak will open it, so that it becomes, in effect, an extremely high resistance, resulting in practically no signal being transmitted to the succeeding a-f amplifier. Precautions should be taken to avoid shunting the limiter diode by the stray capacitance of wiring, switches, etc. Since the diode is open on noise peaks, it will not shunt the resistance of the long time-constant circuit (R_1C_2 in Fig. 1) and so will not abrogate the functioning of that part of the limiter. This characteristic makes it of great value even in receivers designed for as low as 15-kc carriers.

Where it is of importance, the diode internal potentials which may delay functioning of the series limiter in the presence of very weak signals may be bucked-out by, for instance, a suitable battery in series with the limiter cathode resistor. It should be noted that shunting this cathode resistance with any substantial value of capacitance in an attempt to obtain a capacitance voltage-divider for the open condition of the limiter diode should be avoided, as it generally results in increased distortion of the desired signal.

On weak signals, the insertion loss of the series limiter is perhaps 3 db, while on strong signals there is practically no such loss. By insertion loss is meant the change in desired-signal gain of the receiver when switching from LIMITER OFF to ON condition, as measured with signal modulation percentage below the threshold of limiting. In the absence of noise peaks exceeding the preset threshold of limiter action, the limiter diode is biased to closed condition

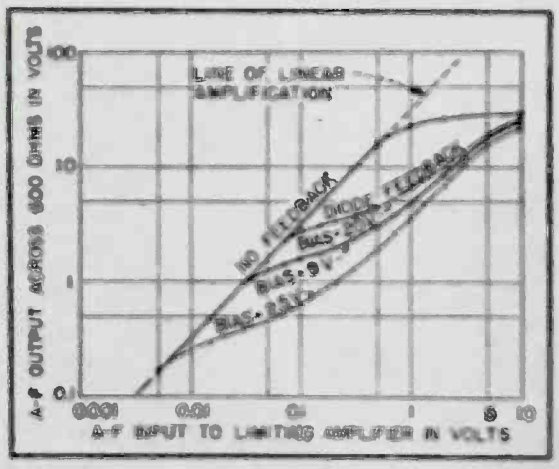


FIG. 22—Typical characteristic curves for receiver using logarithmic limiter, with 1,000-cycle a-f input

by a relatively low external voltage when a weak signal is present, resulting in a high value of internal resistance in this diode, with attenuation of input to the succeeding amplifier by voltage divider action. On a strong desired signal, however, the external diode biasing voltage is much higher, with much lower diode internal resistance, and the insertion loss is minimized.

Crystal Diodes

Diodes of the crystal type may be utilized in place of the thermionic type in the various limiter circuits designed for diode use. For such purposes, the crystal must be capable of operation without damage at relatively high impressed voltages and fairly large instantaneous currents. Crystals of the silicon and similar varieties are therefore unsuitable, due to their inadequate voltage and current handling capabilities, but germanium crystals may be considered for such service. It should be remembered, however, that the various crystal diodes have relatively low back resistance compared with thermionic diodes, and also that their inverse current characteristics have peculiarities of slope that cannot be neglected in some applications. Further, since the back-resistance is relatively unaffected by the d-c load resistance with which the crystal is used, while the forward resistance increases with increased load resistance, the actual values of resistance incorporated in limiter circuits using crystal diodes become of prime importance in determining limiter effectiveness. The temperature-sensitivity of crystal diodes will also have to be seriously considered for some applications.

Limiter Input Levels

In general, it is desirable to have control of the a-f gain following instantaneous limiters of any type. This, of course, is normal for AVC ON operation, but should also be true for AVC OFF or c-w operation. The shunt limiters operate better with low a-f gain following, and with a high r-f input level at the associated detector. The series diode limiters are usually inoperative, as regards limiting, until their internal diode potentials are exceeded, something also most readily accomplished with the highest possible signal input to the detector.

Progressive Limiting in Amplifiers

All amplifiers are, of course, limiters as their maximum output capabilities are approached. Advantage can be taken of this characteristic to prevent blocking, or a decrease of signal output from a receiver with increasing input during AVC OFF operation. The average r-f pentode of the semiremote or remote cutoff type will withstand an r-f input of about 10 times the value required to just initiate appreciable overload before its maximum output begins to drop. Fo example, by appropriate choice of plate load, it is possible even with normal d-c electrode potentials to have the i-f amplifier preceding a last i-f stage begin to overload before the last i-f stage begins to block, to have the amplifier preceding the next-to-last begin to overload in its turn, etc.

With five properly designed i-f or r-f stages preceding the final detector, for instance, it is possible to provide satisfactory protection against blocking in this way over a range of about five orders, or 100,000 times the input which initiates overloads of the last i-f stage. While of maximum utility on c-w operation, such a characteristic will also be of use on mcw operation with avc off, since even though distortion of voice signals is very high, their presence will nevertheless be evident. This means can also be very useful in protecting detectors and audio limiters against excessive overdrives which tend to abrogate their characteristics.

Linear Detection

Linear detection is to be preferred for the final detector stage, not only for the reasons of low distortion and discrimination against weak undesired signals in the presence of relatively stronger desired ones, but also because of behavior with regard to noise. In the linear region of detection, increase in the signal input level to the detector will not be accompanied by substantial increase in the noise output due to internal noise modulation of the carrier within the receiver, a highly desirable condition.

Desirable A-F Amplifier Characteristics

The frequency response of the a-f amplifier following the detector should be restricted to a range not exceeding the requirements for satisfactory voice reproduction, or the fidelity permitted by the selectivity preceding the final detector, whichever is the lesser. The high-frequency cut-off for good voice intelligibility is, however, about 3,500 cps, and the selectivity preceding the detector should not, in general, abrogate this requirement.

Audio systems which have poor transient reproduction characteristics may tend to magnify the effects of noise pulses. The tendency toward damped oscillations or hangover on sharp peaks of input in such systems may be reduced by the use of low-impedance output tubes (triodes) or by a sufficient degree of degenerative feedback from the output, and also by the provision of properly designed output transformers, properly loaded.

Circuit Diagrams

The circuit diagrams in this report have been prepared with the intent of showing, as clearly as possible, the circuit configurations in their most readily comprehensible form. It has been the author's experience that this is absolutely essential for an understanding of limiter circuits particularly, and seemingly novel circuit arrangements have often revealed their similarity to or identity with one of those covered in this report upon redrawing.

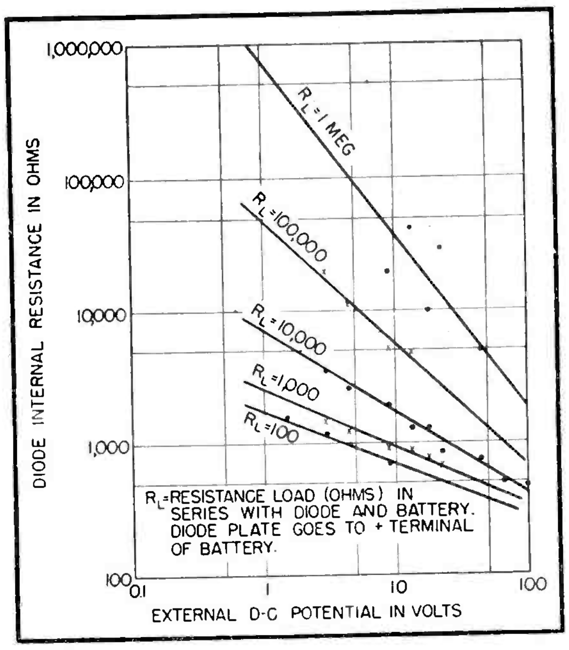


FIG. 24—Diode internal resistance at various external load resistances and applied d-c potentials, for a 6H6 diode element. Values are derived on basis of 1.2 volts diode apparent internal potential

Conclusions

From the overall viewpoint of simplicity, effectiveness, and low distortion, the series-type noise-peak limiter appears to be the best choice for mcw operation, while from the standpoint of effective limiting, minimum change of gain below limiting threshold over a wide threshold range, and relative simplicity, the full-wave a-f shunt output limiter appears best for c-w operation. The former may be combined with the latter for even more effective operation on c-w signals.

It should be remembered that no limiter is a cureall. When noise-peaks do not substantially exceed the desired carrier peak values and occur so frequently that they fill in the modulation, only some of the very elaborate limiter arrangements, such as, for instance, the discriminator-keyer combination types for c-w reception, will afford any considerable degree of relief. Within their inherent limitations, however, those limiters recommended above can be very useful additions to the communication receiver, and also to the broadcast receiver which must work under conditions of high ambient static or similar disturbances.

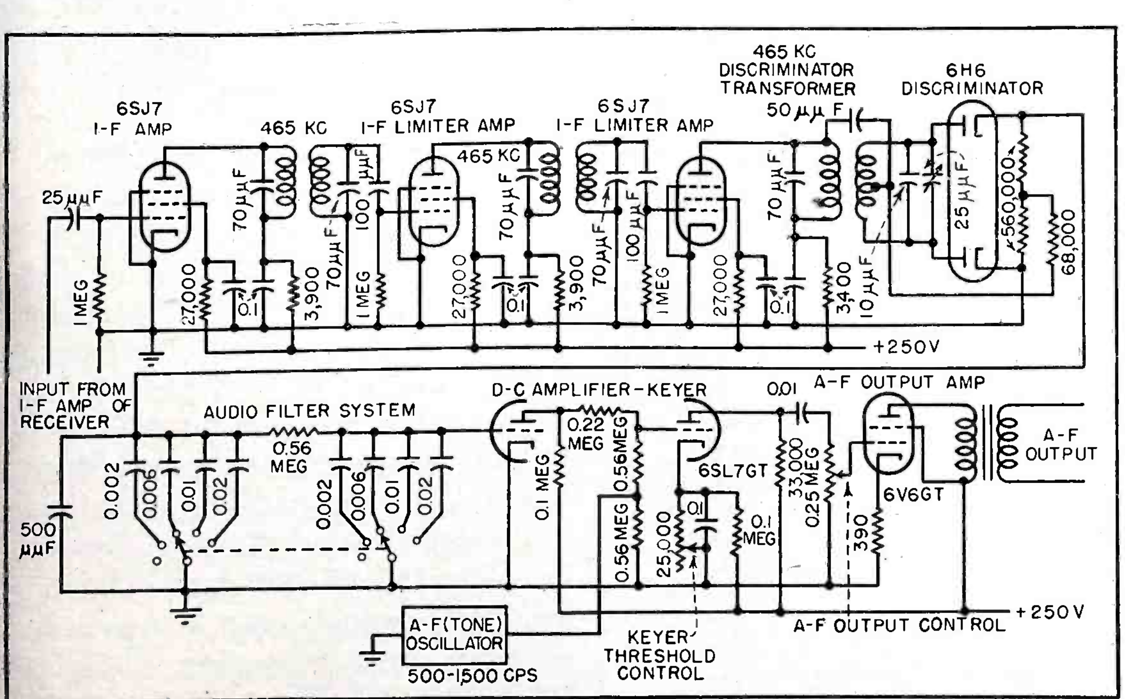


FIG. 23—Discriminator-keyer circuit arrangement for c-w operation

A PROBLEM in

Vancouver radio stations, a British Columbia engineering firm, and the RCAF pooled their technical resources to provide audio facilities for the city's 60th anniversary celebration. Placement of microphones to cover a 520 by 125-foot stage and arrangement of speakers to blanket a 525 by 200-foot audience area is discussed

By A. B. ELLIS and JAMES P. GILMORE
Regional Engineer, *Senior Broadcast Operator, CBR*
Canadian Broadcasting Corp., Vancouver, B. C.

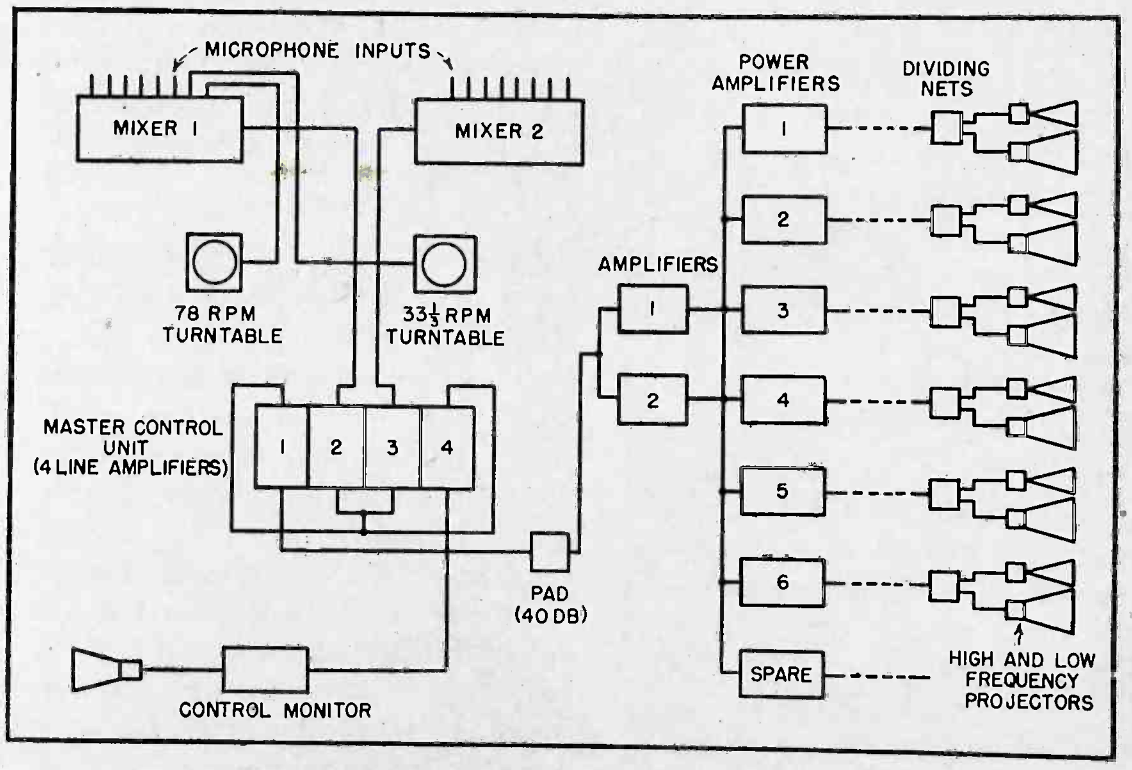


FIG. 1—Block diagram of the complete sound equipment installation

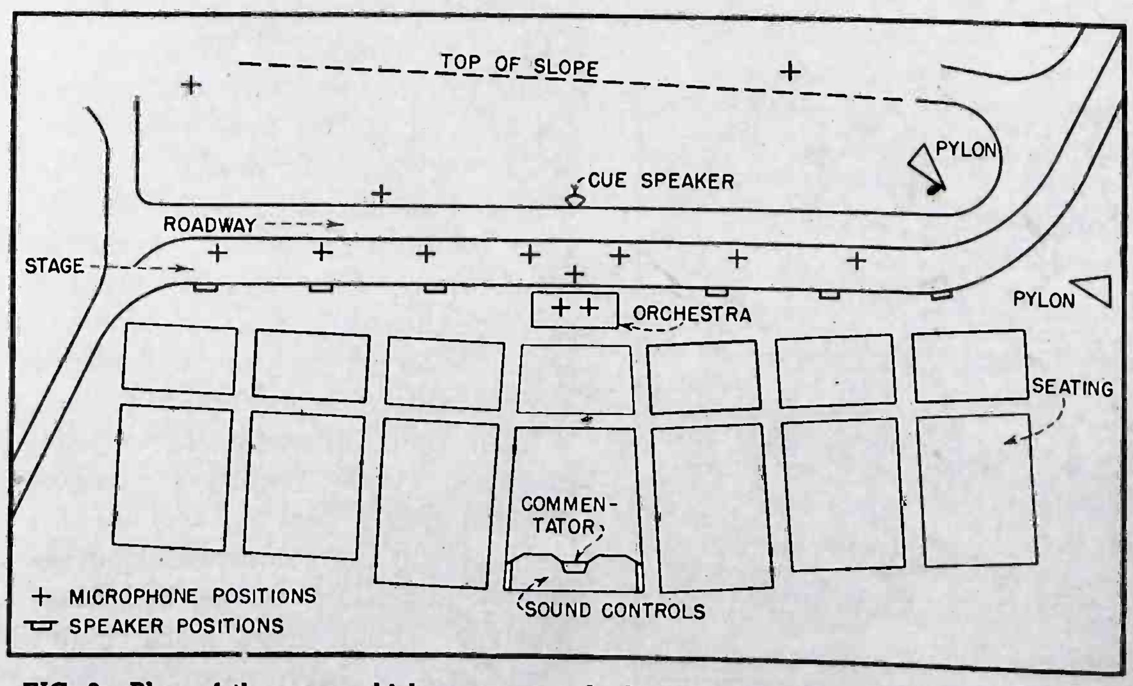


FIG. 2—Plan of the area which was covered, showing the placement of microphones, speakers, and the control tower

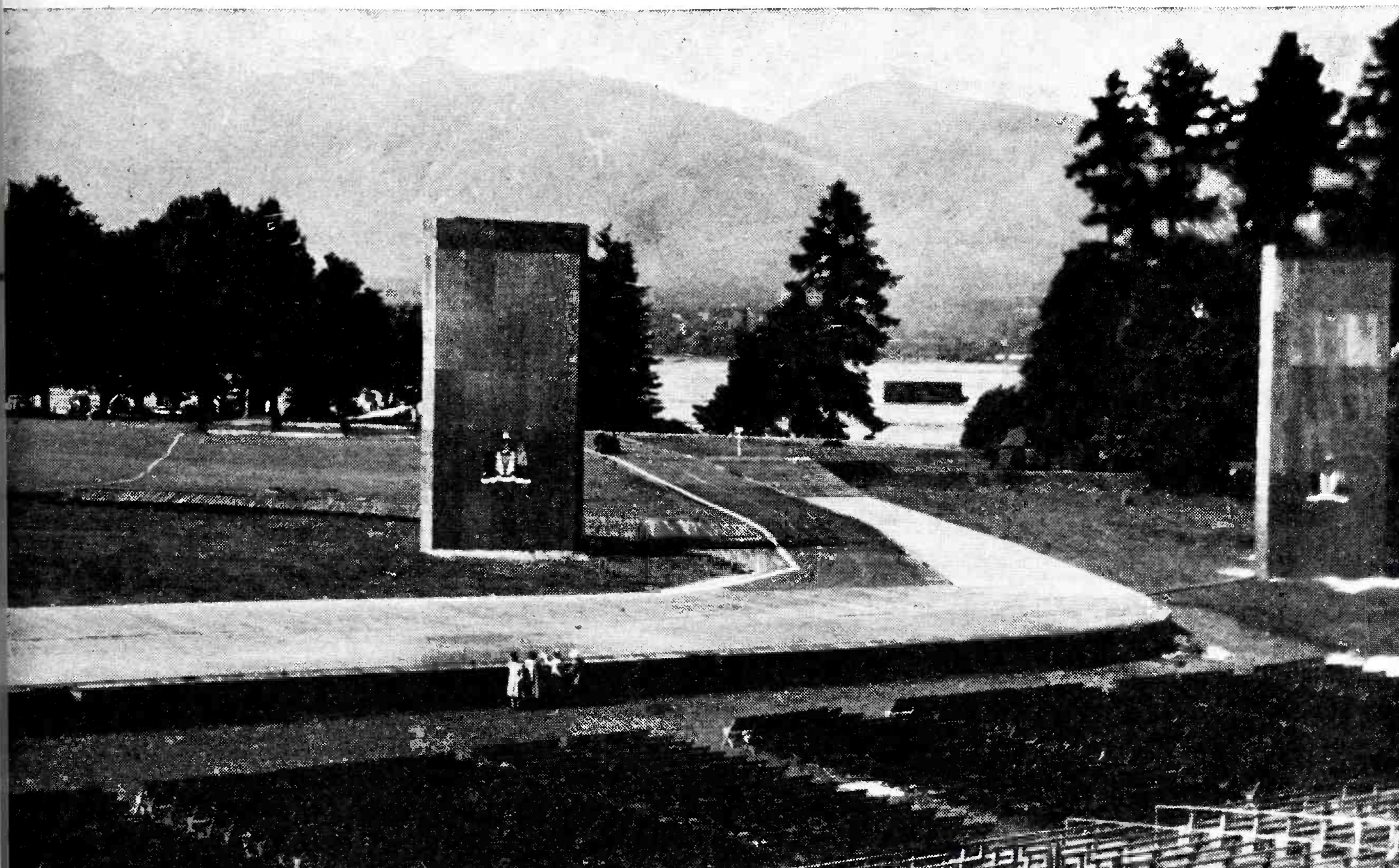
DURING the summer of 1946, Vancouver celebrated the 60th anniversary of its incorporation. Among many events planned by the citizens' Diamond Jubilee Committee was one which presented a number of interesting technical problems to a group of radio and sound men in the city. This was the Jubilee Show, a presentation of pageantry, which due to its magnitude could only be staged out of doors and yet required treatment similar to that given radio productions in a studio.

It will be the aim of this paper to outline the operations undertaken and to present some of the problems encountered and the solutions evolved, in the hope that it may act as a guide for future enterprises of this type.

Requirements

Study of the blueprints for an outdoor theatre to be constructed at Brockton Point in Stanley Park revealed the unusual extent of the technical facilities which would be required. Microphone coverage would have to be provided for a stage with a frontage of 520 feet. This would include coverage of an upstage area extending along a grass slope behind the stage proper to a depth of 125 feet. Sound projection would have to cover an audience area extending along a 525-foot front to a depth of 200 feet, seating 12,700 persons. The

OUTDOOR SOUND



ne corner of the giant outdoor stage, as seen from the roof of the the control tower, and showing the integral road over which heavy equipment taking part in the pageant was moved on and off stage. Figure 2 shows the entire area

equirements clearly indicated that the desired results were to be tained, the equipment employed ould have to maintain broadcast uality throughout.

The plans were considered by the adio stations of Vancouver with he view of obtaining experienced roadcast technicians to handle the ob. The Canadian Broadcasting orporation's studios arranged to an one of its experienced program echnicians, some sound mixing quipment, and a sound effects multiple turntable unit. Also, through s network operations office, the BC provided the remainder of the ound mixing equipment and miscellaneous parts.

At this point it was apparent that dditional outside help would be equired and that someone, giving is full time to the work, would ave to be placed in charge of all echnical arrangements to coordinate and expedite them. The Royal anadian Air Force supplied this man in the person of Wing Commander Kenneth Cameron, who was formerly chief engineer of CKRC Winnipeg.

Although sound mixing equipment was available, no adequate sound projection equipment was obtainable in the city. A contract was awarded the Dominion Sound Company when it was found that they could import a sufficient number of large theater projection units with the necessary amplifiers, in addition to 15 microphones.

Equipment

A functional description of the entire system now will be undertaken and the reader is referred to Fig. 1.

Thirteen stage microphones, one commentator's microphone and two turntable units were connected to the inputs of two CBC portable mixers. These provide approximately 90-db gain. The outputs of the two mixer units were fed separately into two of the four line amplifiers in a CBC portable master control unit. The outputs of the two amplifiers receiving feeds from the mixers were coupled together. The other two amplifiers in the control unit were bridged on these to give two isolated, separately controllable feeds of the complete program. One of these feeds was supplied to the sound projection amplifiers and the other was used to feed the monitor system in the control rooms.

Sound projection was accomplished by the use of two Northern Electric R4079A amplifiers feeding seven R4080A power amplifiers. The output of each power amplifier was terminated in a high-frequency dividing network to feed an Altec Lansing type H210 low-frequency horn and a type 288 high-frequency unit. Six of these double projectors were used, leaving one power amplifier as a spare. The sound projectors themselves were set in the apron of the stage at regular intervals on each side of center stage. The separation of the two center units was increased slightly to allow for placement of pit microphones.

All the microphones used were Western Electric type 639A cardioids. These were used in the cardioid setting on all occasions except one. The extreme up-stage left microphone located on the top of the grass slope was subject to considerable wind sweeping in from the harbor entrance. This microphone was set on the dynamic condition with optimum results.

Turntables were used for sound effects reproduction of domestic and transcribed sequences. One Presto K8 turntable recorder was utilized for 78-rpm reproduction, and one NE 5A unit was used for 16-inch transcriptions at 33⅓-rpm.

Installation

The heaviest job in installation was the laying of microphone and speaker cable. All the mixing equipment was mounted in trunks with removable fronts and backs and could be quickly set up and terminated. The sound projection amplifiers were rack mounted and required a minimum of labor after initial connections had been completed. However, the cable-laying process was another matter.

The blueprints revealed that lines for microphone positions would have to be laid for a total of 5,430 feet in lengths varying from 550 feet to 215 feet. This is illustrated in Fig. 2. The work was accomplished by three men, a jeep and some walkie-talkie equipment. The latter provided invaluable assistance in checking the cables from one location to another over distances which were too great for the voice to carry. The lines were first laid out, cut and labeled. Then the jeep was utilized to haul them to the front of the seating area and into position. Microphone lines then were brought to their labeled positions individually and terminated in junction boxes. Three spare lines were pulled in and terminated at center stage. Due to later production changes and additional facilities required, all of the spares were used.

The final phase of the installation was the laying up to the control tower of the microphone lines and the speaker cables. This was done along a five-foot wide duct. The low-level lines were cabled roughly and kept to one side of the duct, while speaker lines occupied the opposite side. No trouble in isolation was experienced.

The ground system required very careful attention. Rain was a continuous problem throughout both installation and early production periods, making open conductor ends subject to considerable moisture with consequent tendencies towards transmission to ground at audio frequencies. The ultimate success of the system required two of the longer lines used on input positions to be individually ground-staked. In addition, all control room equipment was brought to two ground stakes, two feet apart.

The lighting of an outdoor area of this size from 200 feet, which was the distance from control tower to stage, was rather a large project. About 600 kilowatts was under control, resulting in considerable voltage drop in the power circuits when full lighting load was applied so that voltage regulators were necessary on all audio facilities.

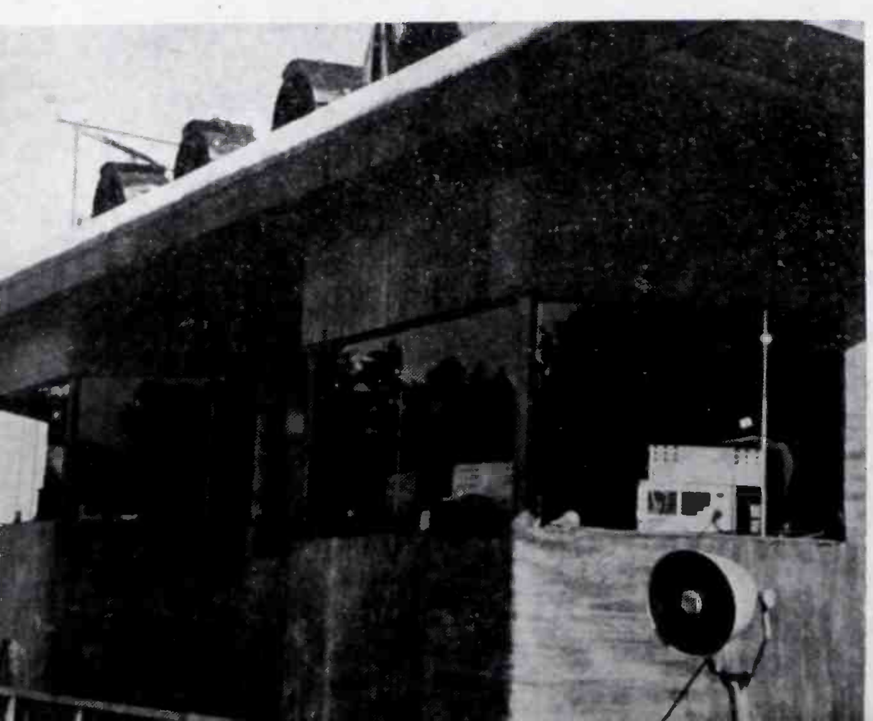
Facilities

Final plans for the control tower provided for two 15 x 27-ft. control rooms, pictured in Fig. 3. One was to be occupied by the director general and his staff, the lighting control and communications center. The second housed the sound system with the mixers located forward on a shelving along the entire front of the plate glass windows, affording the control operator a view of the entire area. High-level amplifiers were located towards the back of the room to the left of the control position. The recorded sound equipment occupied the right-hand postion of the shelving so that its operator was conveniently close to the program control operator at all times.

A commentator's cubicle, glass fronted, was constructed between the double-bay fronts of the two control rooms. This gave the commentator a wide view of the stage area and direct communication with both director and program operator.

The sound control room was

FIG. 3—(Left) Exterior of the Vancouver Diamond Jubilee show control tower. The far windows enclose the director's room, the near windows are those of the sound control room, and the cubicle between the two rooms was used by a commentator. The speaker (not part of the main sound system) was used to convey directions to the stage. (Right) Interior of the sound control room showing left to right, one corner of the power amplifier bays, master control unit, the two mixers, and the two turntables



acoustically treated with four inches of rock wool lining, giving excellent dampening and isolation. The monitor speaker was mounted above the control position, giving a good indication to the program and recorded sound effects operators, for balance and cueing purposes.

Operation

The production of the show itself presented a number of interesting situations not envisioned in the original planning. Forty-three hundred persons were involved in the various sequences, opening with the colorful portrayal on stage and across the horizon of the coming of the early explorers and their meeting with the Indians, and continuing through to the parades of civic apparatus and industrial machinery. In these latter scenes considerable trouble was anticipated in the transmission of heavy vibration along the microphone stands.

The roadway along which fifteen-ton log carriers, earth movers and heavy pieces of fire apparatus moved was constructed upstage (see photograph and Fig. 2) and was physically a part of the stage itself. Eighteen-inch square plyboard bases were bolted to the bases of the microphone stands as shown in Fig 4. Two-inch square kelder pads were glued to the four corners of the plywood sub-base, providing sufficient shock absorption to cut the vibration effects to a point where no trouble was experienced.

Another technique illustrated in the figure is the method employed to keep the microphone cable off the stage area, where it would interfere with motor vehicles and dancers moving through the various scenes in the show. Three-inch holes were drilled through the stage and the microphone cable dropped through to the junction boxes directly beneath each position. All cable was thus concealed.

Mention of the dancers brings up one of the most critical of the production problems encountered. This was the inability of the several ballet groups in scenes of the cavalcade of Vancouver's history to hear their orchestral accompaniment. The light intensity, as a result of spotting, was such that the conductor in the pit was almost invisible. The orchestra pit had been constructed directly in front of center stage, but notwithstanding this fact, the open-air absorption prevented the artists hearing the music directly. Also, the highly directional characteristics of the sound projectors made it impracticable to use them as a cueing source.

The ultimate solution of this problem was found in the installation of a horn upstage in the sand packing for the stage roadway. As this road ran parallel to the stage, the horn could be placed at the center stage point and faced upstage. A program feed was provided and a point in level adjustment finally was reached where both artists and technical personnel were satisfied with the results. This was aided by the limited frequency response of the horn, which helped to eliminate feedback.

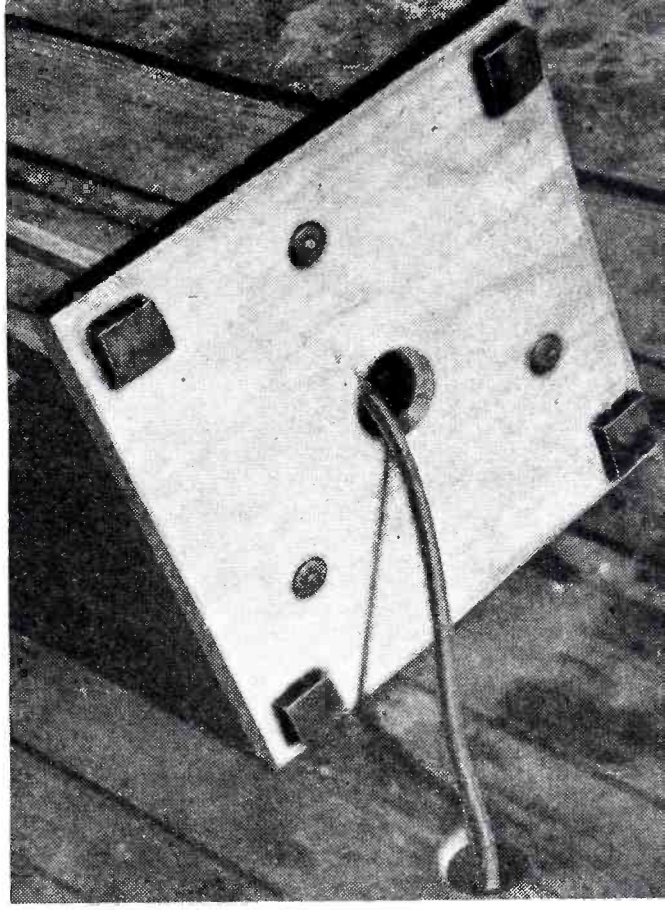


FIG. 4—Closeup of microphone stand base, tilted to show how this wooden base was bolted to the stand itself and shock-insulated, and how cables were carried through the stage floor

The orchestral and choral setups, which looked somewhat difficult at first glance, became simplified greatly as the result of a plan which was worked out to yield a minimum of complication. The orchestra was arranged in a conventional layout in the left half of the 50 x 20-foot pit. A choir of sixty voices was set up in the right section facing the orchestra. This permitted the placement of two microphones, on cardioid position, back to back. Maximum isolation coupled with good definition was attained. The changing personnel of the choral group eliminated the possibility of a standard vocal placement. The final arrangement split the group into two sections, male and female, on either side of a narrow aisle. The choral microphone was placed about 15 feet in front of the center of the front line of the choir, and artists always were instructed to project their voices at a point well in front of this location. Again the results were very favorable.

Personnel

It is appropriate to mention and give credit to a group from the Royal Canadian Corps of Signals, who installed and operated a complete seventy-line switchboard to provide telephone communication to all keypoints in the several square miles of production and marshalling area. During the production, a party line setup was worked out whereby the communications director acted as talker to all points in relaying production and technical instructions. The operators in the field spoke only when placing a call or when individually called.

Wing Commander Cameron, Flight Lieutenant Lowman, and James Gilmore set up all sound mixing and control equipment as well as laying the cables and wiring required from microphone to projection amplifier racks. The projection system was installed by Leo Sigurdson, Art Jackson and Ray Winstone. Lieutenant Ralph Hind, Royal Canadian Navy, was in charge of power and lighting equipment, and the operation of stage lighting controls, while Lieutenant Stan Stebban, Royal Canadian Corps of Signals, supervised a group who installed and operated the telephone system.

In program operations, James Gilmore was at the sound mixing controls, with Warrant Officer Rex Thompson, RCCS, assisting with sound effects.

Electrometer

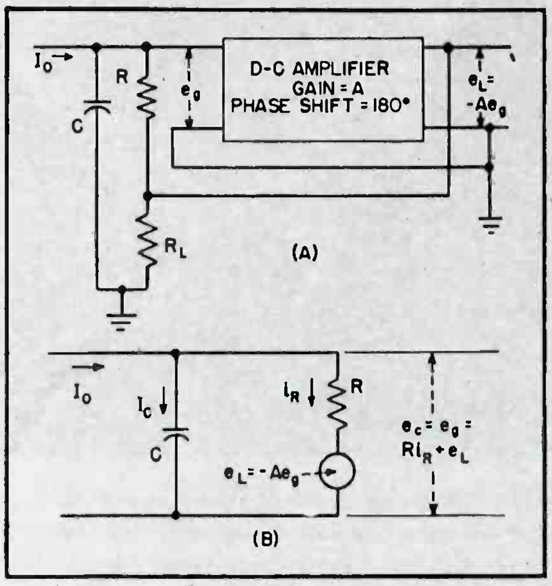


FIG. 1—(A) Basic circuit of high input impedance amplifier, and (B) equivalent circuit

Application of negative feedback to high impedance input circuits of direct-current amplifiers reduces the time constant, thereby increasing the rapidity of response. One such circuit is analyzed, curves are presented, and a typical amplifier is described

By HAROLD A. THOMAS*

Electrical Engineering Department
Agricultural and Mechanical College of Texas
College Station, Texas

WHEN A DIRECT-CURRENT AMPLIFIER is used to amplify extremely small currents, the high input resistance in conjunction with the inherent input capacitance introduces a large time constant that will not allow the amplifier to respond to rapid changes.

In typical electrometer vacuum tube circuits such as are used to measure ion current in a mass spectrometer tube or an ionization chamber, the input resistor usually is of the order of magnitude of 10^{11} ohms. With an input capacitance of only twenty micromicrofarads this resistance would produce a time constant of two seconds. Hence any rapid variations in ion current would not appear at the output of the amplifier.

Transient Response

The effect of the large time constant can be reduced by using a high gain direct-current amplifier and feeding all of the output voltage back into the input circuit. Partial negative feedback has been used extensively for improving the response of a-c amplifiers. Negative feedback has even greater advantages in the d-c electrometer amplifier. While voltage gain is reduced to unity if the voltage feedback is 100 percent, current gain, linearity, stability, and speed of response are greatly increased. Full negative feedback has the additional advantage, as pointed out by Hipple and Grove[1], of reducing grid swing on the input stage, thus allowing the use of a higher value of input resistor because the grid current can then be held closer to zero.

Consider the feedback amplifier circuit shown in Fig. 1A: C represents the inherent capacitance of the input circuit, R the input resistor, A the gain of the amplifier without feedback, and R_L the resistance of the amplifier output circuit including the load. The voltage e_g actually applied to the amplifier is equal to the difference between the voltage developed across R and the output voltage e_L. Because R_L is usually very small compared to R, a simple equivalent circuit shown in Fig. 1B may be drawn.

If the input current changes abruptly from zero to some value I_0, then the output voltage will rise exponentially to a value

$$e_L = -RI_0 \frac{A}{1+A} \cong RI_0$$

if $A >> 1$

A transient solution of the equivalent circuit shown in Fig. 1B for an abruptly applied current I_0 gives

$$e_L = -RI_0\left(\frac{A}{1+A}\right)\left(1 - \epsilon^{-\frac{1+A}{RC}t}\right) \quad (1)$$

If $A >> 1$ this equation reduces to

$$\epsilon_L = -RI_0\left(1 - \epsilon^{-\frac{At}{RC}}\right) \quad (2)$$

which shows that the output voltage rises exponentially to the value RI_0. Furthermore, if a time $t = RC/A$ be chosen as the new time constant, designated as T_f, then substituting this value of time in

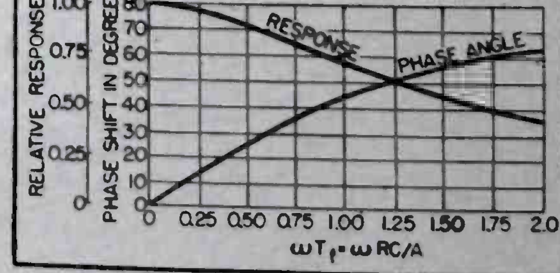


FIG. 2—Normalized transfer characteristic of input circuit

*The investigation on which this paper is based was made while the author was on leave of absence from A. and M. College of Texas to the Westinghouse Research Laboratories.

Input Circuits

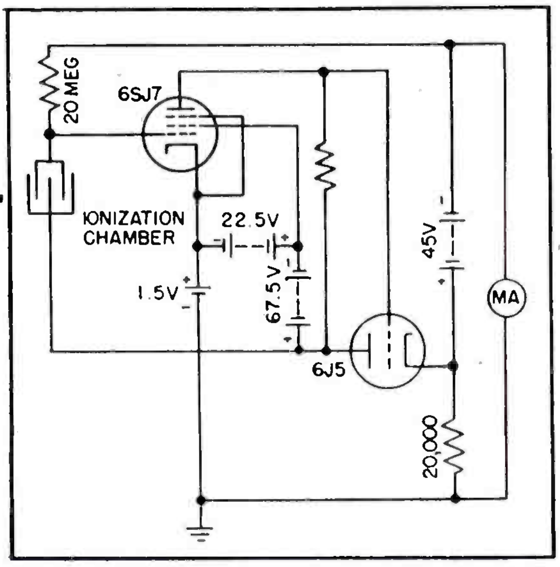


FIG. 3—Essentials of typical electrometer amplifier, illustrating methods of applying negative feedback

Eq. 2 shows that the output voltage e_L will rise to 63.2 percent of its final value in a length of time T_f seconds. Because this percent of rise is the basis for the time constant of a circuit without feedback, then evidently 100 percent negative feedback reduces the time constant of the input circuit by the factor $1/A$.

Frequency Response

It is desirable to determine the frequency response of an electrometer amplifier to an input current that is varying sinusoidally. The input current I_0 may be replaced by the effective value I of a current wave expressed by $i_0 = I_{MAX} \sin \omega t$ and the other currents and voltages shown may also be replaced by effective values: I_C, I_R, E_g, E_C, and E_L. A vector treatment of the equivalent circuit will then give the solution

$$E_L = -IR\left(\frac{1 - j\omega\,(RC/A)}{1 + \omega^2 (RC/A)^2}\right) \quad (3)$$

Letting $(RC/A) = T_f$, the time constant of the input circuit with 100 percent negative feedback, and expressing the complex expression of Eq. 3 in terms of its magnitude and phase angle there results

$$|E_L| = IR\,\frac{\sqrt{1 + \omega^2 T_f^2}}{1 + \omega^2 T_f^2} \quad (4)$$

and the phase angle of E_L is $\phi = \tan^{-1}\omega T_f$. The relative response is

$$\frac{E_L}{IR} = \frac{\sqrt{1 + \omega^2 T_f^2}}{1 + \omega^2 T_f^2} \quad (5)$$

If the relative response and the phase angle are plotted as functions of ωT_f, the resulting response curves are universal curves and can be used to determine the response and phase shift for any given set of circuit constants with very little calculation involved. Such a set of response curves are shown in Fig. 2. Note that for the value of $\omega T_f = 1$ the response is down to 0.707 of its zero frequency value and the phase shift is 45 degrees.

Practical Application

In the development of the above equations it was assumed that the d-c amplifier itself had reasonably high gain and that its phase-shift (other than the 180 degrees required for negative feedback) was negligible compared to that of the high-resistance input circuit. Furthermore, the distributed capacitance of the input resistor was neglected. These conditions are not difficult to attain in actual practice but it should be kept in mind that at some higher frequency the total phase-shift around the circuit may produce positive feedback and consequent oscillations.[2] Theory and practice both indicate that this undesirable condition can be eliminated by putting a low-pass filter across one of the stages of the amplifier. Simply connecting a capacitor of the proper value from the plate of one of the stages to ground will usually accomplish the desired result.

It is also desirable to design the complete amplifier so that high gain is realized in one of the early stages, preferably, the first. This design makes the feedback more effective for reducing drift. Where the input resistance is of the order of 10^8 to 10^{11} ohms, the input stage must necessarily be of the electrometer type which usually has a voltage gain of less than one, but satisfactory results have been obtained by making the following stage of very high gain.

In Fig. 3 is shown a typical electrometer amplifier circuit using the above principles. This very simple amplifier was used to amplify the ion current from a multiple-plate ionization chamber which had an inherent capacitance of approximately 0.01 microfarad. Without feedback the time constant of the input circuit was 0.2 seconds, which gives a response that drops off to 0.707 at a frequency of $f = 1/2\pi T = 0.8$ cps. In this amplifier the first stage had a gain of 75 and the cathode-follower output stage had nearly unity gain, so that with feedback the time constant became $T_f = RC/A = 0.2/75 = 0.00267$ second, and the reduction of response to 0.707 takes place at about 60 cps. Experimental response curves taken on this amplifier verified the above results. The output cathode follower stage serves not only as a low-impedance source for driving a recorder or meter but also reduces the bucking potential required to bring the output back to ground level[3].

REFERENCES

(1) Private communication.
(2) Peterson, E., Kreer, J. G. and Ware, L. A., Regeneration Theory and Experiment, *Proc. I.R.E.*, p 1191, October 1934.
(3) Hipple, J. A., Grove, D. J. and Hickam, D. J., Mass Spectrometer, *Electrical Engineering*, p 141, April 1945.

APERTURES in CAVITIES

Size and placement of apertures and slots in walls of resonators affect loading, internal field distortion, and efficiency of energy transfer from cavity to load. Experimental results indicate effects of opening size for wanted and unwanted radiation

By J. H. OWEN HARRIES
Harries Thermionics, Ltd., 11 Waterloo Place London, England

Electromagnetic energy, when generated in a cavity by a beam of electrons, has to be guided out of the cavity and into a load. To extract energy a loop can be coupled to the internal magnetic field. Another method is to project the end of either a tuned or terminated transmission line into the internal electric field. But probably the neatest way, and the one which is perhaps the most likely to be used for most engineering purposes, is that of cutting an aperture in the wall of the resonant cavity at an appropriate place. Energy will travel out through such an aperture to a greater or lesser degree, and with differing radiation patterns according to position, size, and shape of the aperture in relation to the mode of oscillation within the cavity.

Slots and Apertures

Typical experimental results indicate the operation of this latter method. A rectangular resonator shown in Fig. 1A and having the dimensions $x = z = 59.8$ cm, and $y = 15.0$ cm was set into oscillation at its lowest frequency (H_{011} mode; subscripts here indicate the number of standing waves in each of the three cavity dimensions). Under this condition the electric field was wholly in the y direction. The current antinode was around the vertical sides of the box; the voltage antinode was in the center of the x-z sides. The measured resonant wavelength was 81.8 cm.

A slot a-b was cut as shown so that dimension b was normal to the lines of current flow. Dimension a was 1.5 cm. The slot dimension b was varied from zero (no slot) to 20 cm. The Q of the cavity varied with b in the manner shown in Fig. 2A. Wavelength remained almost constant, increasing only to 82.3 cm as b was increased to 20 cm. The electric field shape within the resonator is very little affected over this range of dimension b.

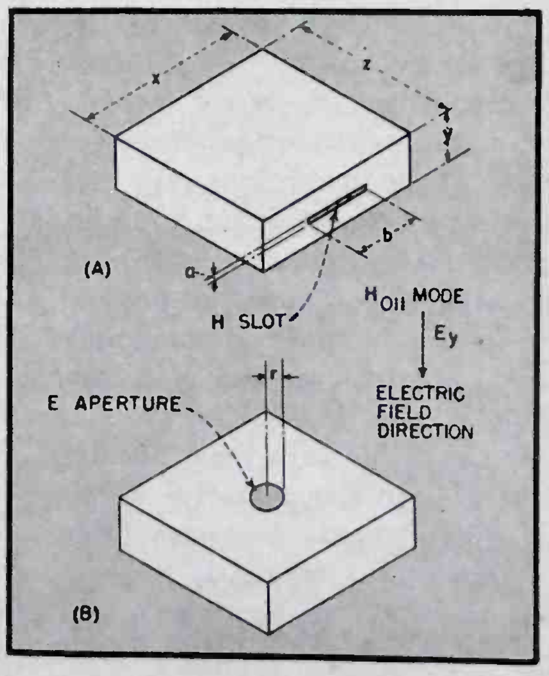


FIG. 1—Openings in cavity serve to extract electromagnetic energy

A slot at the current antinode operates by virtue of disturbing the magnetic field at the wall of the resonator, and is therefore referred to an H slot.

Instead of using an H slot at the current antinode, electromagnetic energy can be withdrawn through an aperture positioned at the electric antinode. This hole in the cavity wall is called an E aperture. Such an arrangement is illustrated in Fig. 1B.

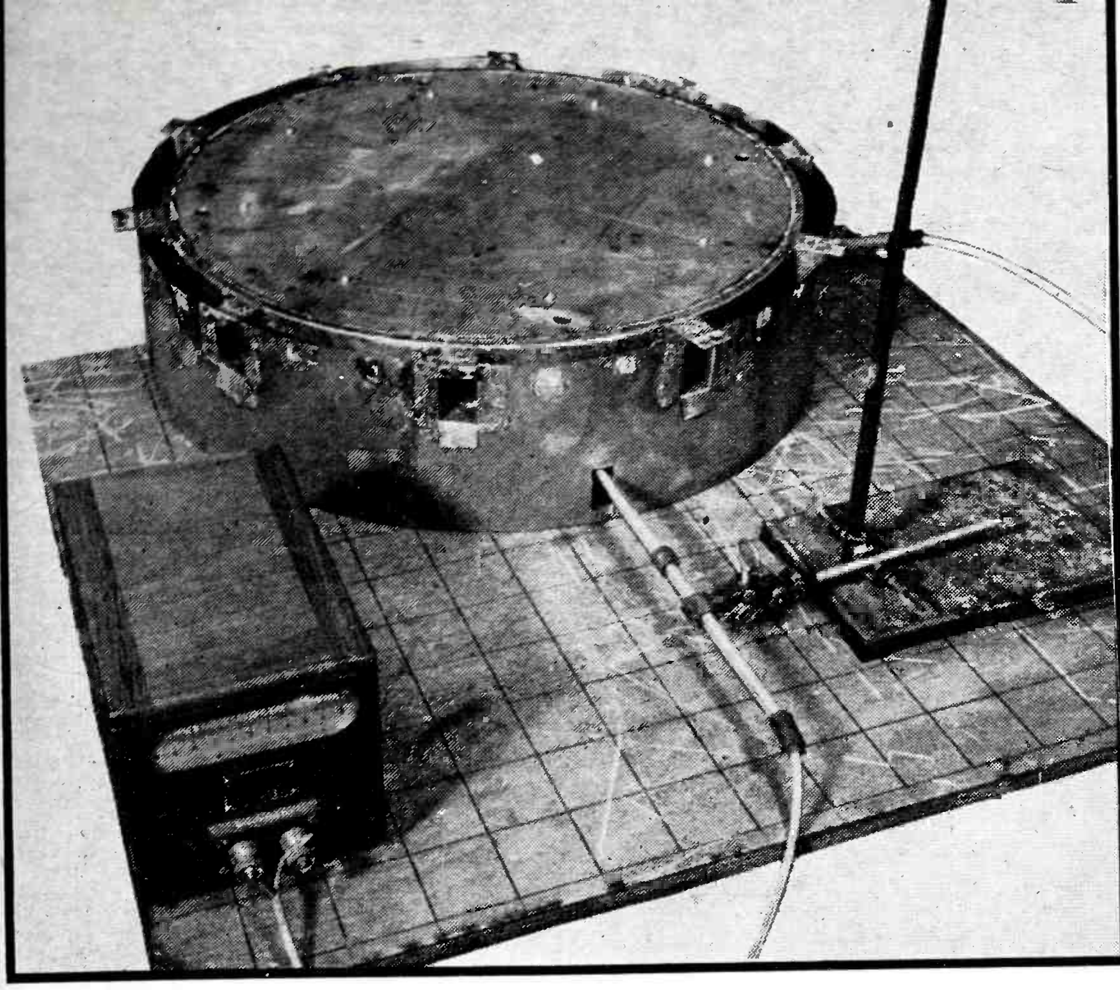
An experimental curve of the Q of the same resonator as used with the H slot, but with an E aperture used instead, is also plotted in Fig. 2A. It was found that if the diameter of this aperture was increased much beyond three or four centimeters the electric field was severely distorted.

In most resonators used in conjunction with electron beams, the electrons are injected at the electric antinode and it is necessary, as far as possible, to preserve a fairly even distribution of electric field in that neighborhood. Moreover, it is generally convenient to separate the point at which the electron beam enters the resonator and the place where the electromagnetic energy is withdrawn. Therefore the H slot is generally the more useful of the two methods of loading the cavity. For this reason the plot of E aperture in Fig. 2A has not been carried to larger diameters.

Loading Factors

In any resonator the maximum instantaneous value of the energy stored in the field is given in mks units by

$$W_r = \frac{\epsilon_0}{2} \int E^2 dv \tag{1}$$



Laboratory measurement of loading of cylindrical resonator with circumferential openings intermediate between slots and apertures

where ϵ_0 is the specific inductance-capacitance of free space, E is the maximum instantaneous value of electric field in the cavity, and v is the volume of the resonator. The selectivity factor of the resonator is:

$$Q = \frac{\omega W_F}{P_R} \qquad (2)$$

where $\omega = 2\pi C/\lambda$, C being the velocity of the electromagnetic wave and λ the electromagnetic wavelength, and P_R is the power lost in the internal surface of the resonator.

If a load is added in which power P_L is dissipated, the selectivity factor becomes

$$Q_L = \frac{\omega W_F}{P_R + P_L} \qquad (3)$$

which can be rewritten as

$$\frac{1}{Q_L} = \frac{P_R}{\omega W_F} + \frac{P_L}{\omega W_F} \qquad (4)$$

or

$$\frac{1}{Q_L} = \frac{1}{Q} + K_1 \qquad (5)$$

where K_1 may be referred to as the aperture loading factor.

From the measurements presented in Fig. 2A we see that the Q of the unloaded cavity is 13,700. The load Q when loaded can be obtained from these curves. Using Eq. 5 the respective loading factors can be plotted for the H slot or the E aperture used in this resonator at the H_{011} mode. Aperture loading is plotted in Fig. 2B for both cases. Further studies show that dimension a of the slot has comparatively little effect upon the loading.

Coupling to a Resonant Load

The loading factor K_1 applies only when the aperture is radiating into free space. If instead the slot is arranged to couple the resonator to another tuned element, the phenomenon will be modified in a more or less complicated way depending upon the relative damping of the two resonators and the coefficient of coupling. If, as will be described later, a dipole aerial, which is tuned to the resonant wavelength, is arranged with its current point near the H slot or one of its voltage points in the E aperture, the loading factor will increase very much more rapidly with either b or r than is indicated in Fig. 2B. This phenomenon enables much smaller

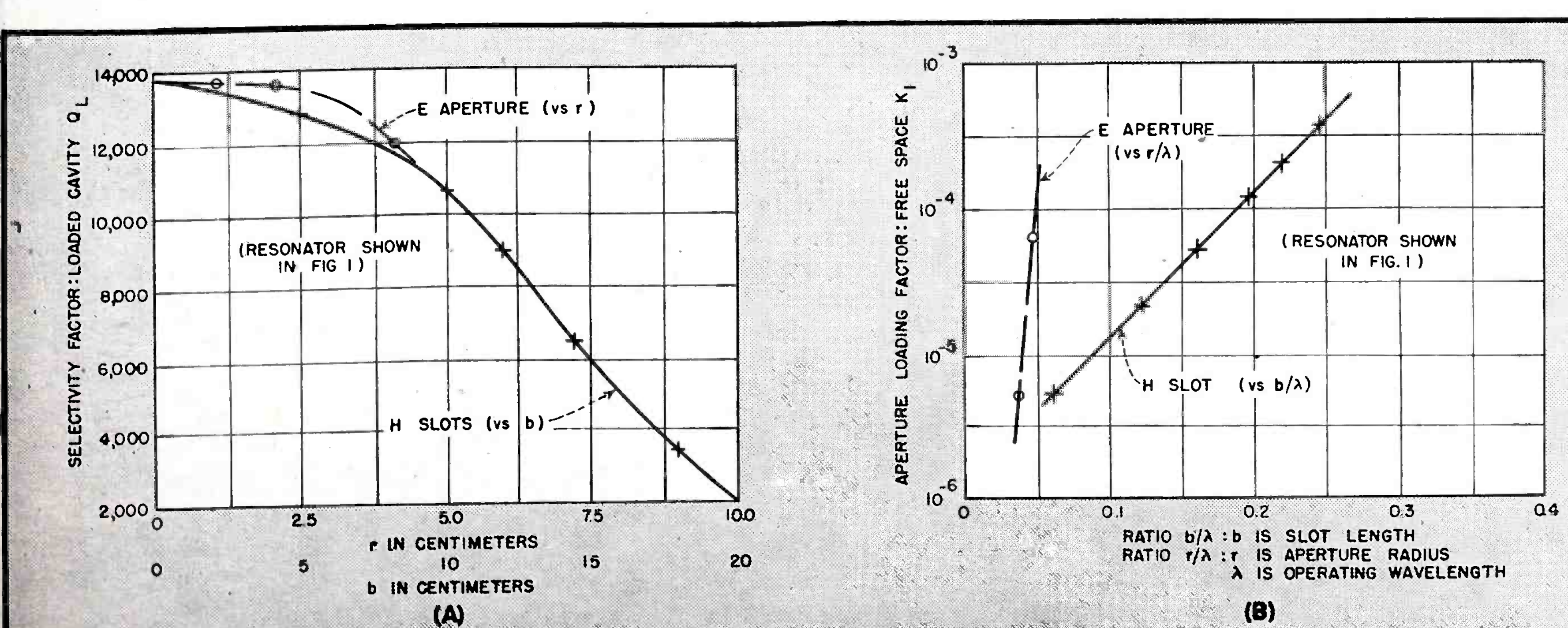


FIG. 2—Loading is affected by size of opening in resonator

values of b or r to be used for a given loading, and correspondingly less disturbance of the internal field shapes within the resonator is produced.

It can be shown that the efficiency of a resonator and load in combination is given by

$$\eta = \frac{P_L}{P_L + P_R} = 1 - \frac{Q_L}{Q} \qquad (6)$$

from which it follows that Q_L/Q should be roughly not more than one-tenth.

Unintentional energy leakage through apertures must also be considered. It is often necessary not only so to arrange an aperture that considerable energy is guided from the cavity, but in addition to arrange other apertures through which electrons may be injected into or removed from the cavity, so that they do not allow appreciable energy to leak out.

If we indicate by K_2 the loading factor of a slot through which energy must not be appreciably radiated from the cavity, we can write for the reciprocal of the selectivity factor

$$\frac{1}{Q_X} = \frac{1}{Q_L} + K_2 \qquad (7)$$

where, as before, Q_L is the selectivity factor of the loaded cavity, and Q_X is the selectivity factor of the cavity losing energy both to a load and by leakage.

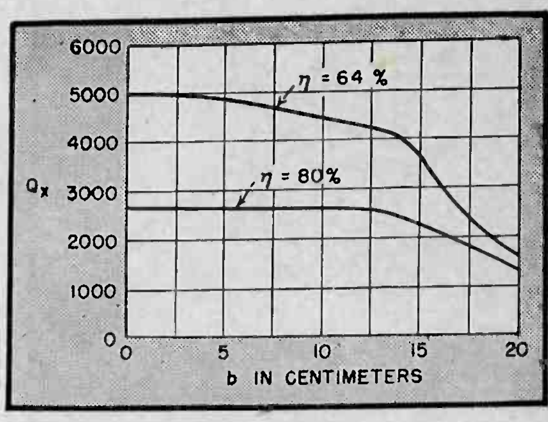


FIG. 3—Size of opening affects unwanted leakage lost through it

To avoid leakage of energy, the value of either b or r must be such that Q_X tends to equal Q_L, so that K_2 is small compared to $1/Q_L$. It will be observed in Fig. 2B that this condition can be met quite readily in practice. However the accidental presence of an external resonant structure might easily upset these conditions.

Figure 3 shows the variation of Q_X with the slot dimension b in the resonator of Fig. 1A. Two cases are shown, one when the resonator is so loaded that $\eta = 64\%$, the other when $\eta = 80\%$. In the latter case an H slot length of 10 cm can be used, for example, to inject electrons without permitting appreciable radiation loss.

Tuned Loads

Consider again the design of an aperture for withdrawing wave energy from a resonator. One of the factors that has to be taken into account is whether the distortion of the internal electric field caused by the aperture in the cavity wall is sufficiently small to be tolerable. The following experimental results illustrate this point.

A roughly cylindrical resonator was arranged to operate in the H_{111} mode on about a 78 cm wavelength. An H slot was cut in one of the flat ends, and Q and Q_L as functions of b were measured. The ratio between electric field magnitudes at two points, each near one of the two flat ends of the resonator, was also measured as a function of b as an indication of the disturbance of the field by the slot.

Utilizing Eq. 5, the resonator load efficiency was plotted together with a curve of the internal field ratio as shown in Fig. 4A. It will be observed that the field became severely distorted when the slot was made suf-

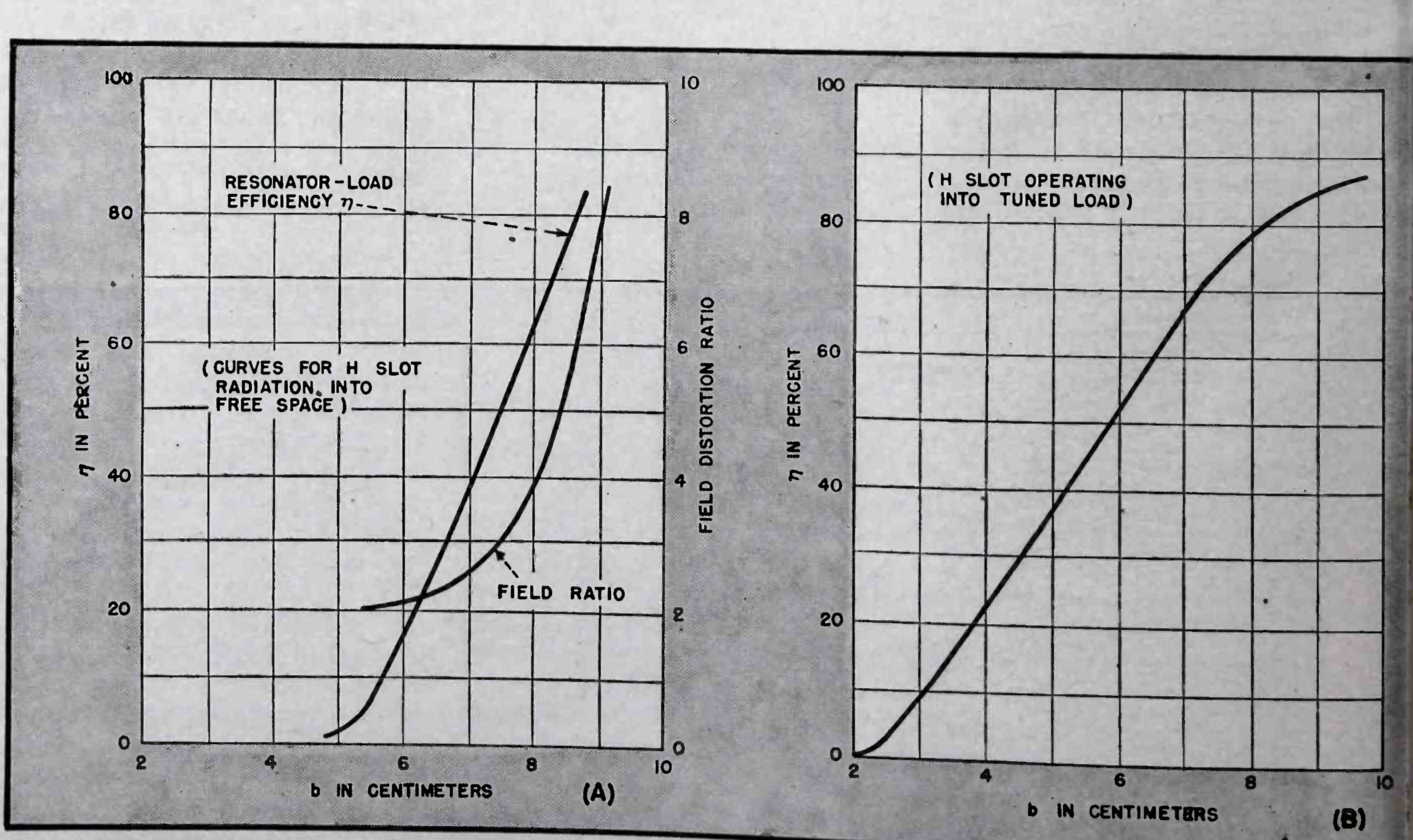


FIG. 4—Energy transfer to the load varies with size of opening

ficiently large to give reasonable efficiency. This trend is largely because the unloaded Q was only 2,000. Had it been higher, a lesser value of b would have sufficed to give a good efficiency.

In this experiment the walls of the resonator consisted of copper foil about 0.01 inch thick. The wall near the slot was next thickened to about six inches, whereupon no appreciable radiation from the resonator to free space was observed even with b at its maximum of ten inches.

The current antinode of a dipole that was tuned to the operating wavelength was next placed near the slot. Adequate energy could then be withdrawn to give good values of resonator-load efficiency, and negligible distortion of the internal field of the resonator was observed. The graph of resonator-load efficiency against b under these circumstances is given in Fig. 4B.

The tip of a tuned dipole was exposed to the field immediately outside an E aperture of such a resonator as that illustrated in Fig. 1B operating in the H_{011} mode. Very small loading was produced unless the aperture was made so large as to distort the field of the cavity. It is in general necessary to insert the dipole or tuned rod a considerable distance into the resonator, or even to connect it to the internal wall opposite the aperture to obtain reasonable resonator-load efficiency.

Hybrid Slots

Some slots are intermediate between the E aperture and the H slot. An example of the use of such a hybrid slot is of interest. It is placed between points of magnetic and electric antinodes of the resonator.

A cylindrical resonator that is depicted elsewhere in this article and whose dimensions are given in Fig. 5 was operated in the E_{010} mode—that is, with the electric field in the axial direction. A circumferential slot was arranged as shown, and bridges were provided to join the center of the flat upper side to the vertical sides of the cylinder. The flat side was 2.5 cm thick.

With 20 bridges, Q_L closely approached Q, the unloaded Q value, which equaled 1,000. With only ten bridges, as illustrated, Q_L dropped to 630. With only two bridges, which

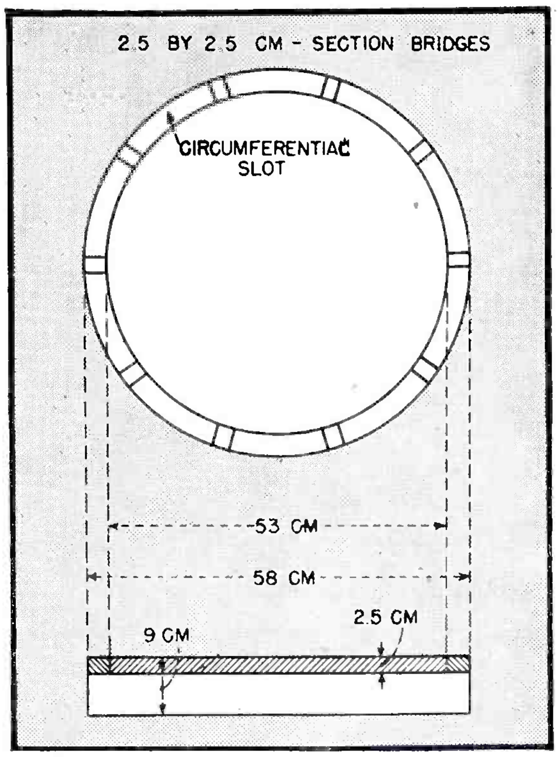


FIG. 5—Cavity used to study coupling to cylindrical resonators

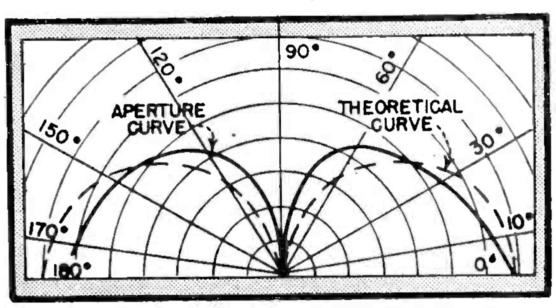


FIG. 6—Neyman compared the patterns of an aperture and a theoretical dipole

were positioned at opposite ends of a diameter, Q_L was reduced to 200. With ten bridges, the thickness of the top was increased from 2.5 to 5.0 cm, and the height of the sides and the thickness of the bridges increased the same amount. However Q_L was unchanged, within the accuracy of measurement, from the previous 630. These results are applicable to the problem of coupling a circular wave guide to a cylindrical resonator.

Because a resonator designed for practical engineering applications seldom leads to analytically tractable shapes, the design of apertures seems to be performed best by experiment, and usually on model resonators the results of which can be scaled down to apply to the operative wavelength. Once the general phenomenon is understood, it is easy to produce desired degrees of loading by trial, with little error.

There does not seem to be an adequate published mathematical analysis of the properties of apertures, although an interesting paper by Neyman has been published in Russian (*Izvestiya Elektroprom. Slab. Toka,* 1940, No. 6, pp 1-16) which provides an admittedly approximate theory and quotes some experimental results.

Aperture Theory

It is not within the scope of this paper to deal with mathematical theory of apertures, but the following comments on Neyman's paper may be of interest.

Neyman points out that a rigorous solution of the problem presents mathematical difficulties. He therefore presents an approximate solution for the E aperture, for which he gives experimental confirmation.

He concludes that the radiation resistance into free space of an E aperture situated at the electric antinode and having a radius r, small compared to the wavelength, is approximately $10^6(r/\lambda)^6$. This radiation resistance is referred to the maximum current in a cylindrical resonator operating in the E_{010} mode.

He also states that performance of an H aperture can be represented by a system of equivalent dipoles for which he derives formulas, but there does not seem to be experimental confirmation of these results nor of the statement that, for b equal r, the radiation from an E aperture is thousands of times greater than that from an H slot. He also presents an expression for power radiated by an H slot which varies as b^6 and a^2. This result does not seem to be confirmed by this reviewer's experiments.

Neyman points out that loading can be increased by external tuned elements such as the dipole, or by resonance of the external surroundings of the resonator or of its own external contours. He also points out that radiation patterns can be produced that are the resultant of the fields from several slots.

The radiation pattern from an E aperture at the electric antinode is similar to that of a dipole. Neyman has shown this to be the case experimentally by the plot shown in Fig. 6.

The present author expresses his thanks to Rediffusion Ltd., at whose Electronics Department the experiments were performed, for permission to publish this paper.

Linear Sweep Circuits

Eight methods of correcting nonlinearity in sawtooth sweep-generating circuits for cathode-ray tubes are presented and analyzed, with 60-cycle circuits as examples

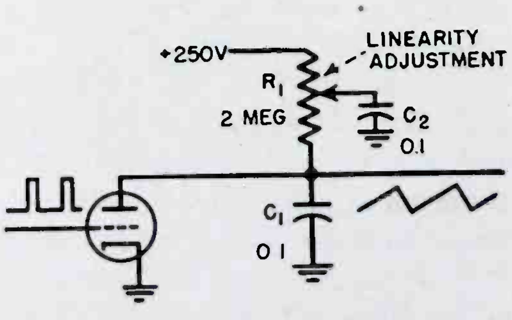
By ROBERT P. OWEN

Graduate Hall
California Institute of Technology
Pasadena, California

THE CONTINUING REFINEMENT of cathode-ray equipment, particularly for television, has made necessary the generation of almost perfectly linear sweeps. These are most easily obtained by the application of some form of linearity correction to the more or less exponential output of a conventional sweep circuit. Several of the more practicable and effective methods of correcting nonlinearity have been selected for description here, although there are many others that may be equally valuable in a particular application.

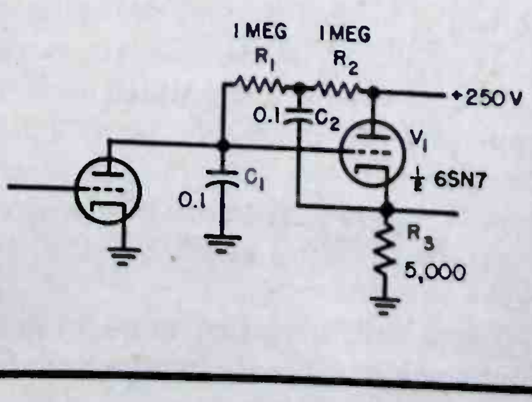
The sawtooth waveform of both electrostatic and low-frequency electromagnetic sweeps is almost invariably derived from the charging or discharging of a capacitance through a resistance. The resistance may be that of a simple fixed or variable resistor, or the plate resistance of a so-called constant-current pentode. In either case the rise or fall of voltage will be exponential, for the plate current of an uncompensated constant-current tube is never absolutely independent of the plate voltage. In the case of a variable-frequency circuit the sweep range is determined by the size of charging capacitor, and a fine adjustment of frequency is provided by variation of the charging resistor or of the grid or screen potential of a constant-current pentode.

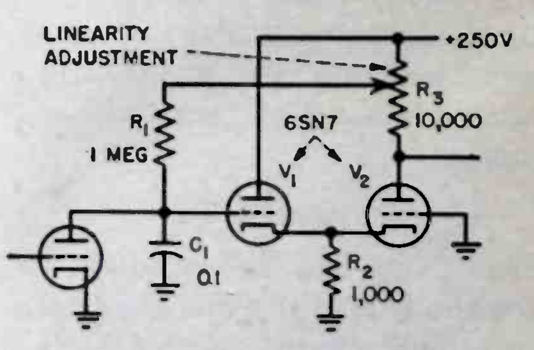
Discharge of the capacitor after



METHOD 1—The simplest means of attaining linearity correction in a fixed frequency sweep is to bypass part of the charging resistor with a capacitor. This gives two *RC* circuits in cascade, which, if it were not for the loading effect of the second upon the first, would result in a perfectly linear output when the two time-constants are equal. In practice, linearity can be definitely improved. The best value of C_2 should be determined experimentally. Input and output waveforms shown here apply to all methods covered

METHOD 2—This circuit, sometimes known as a bootstrap circuit, has been widely used. The sawtooth is fed back through a cathode-follower, which has a gain of approximately one and does not reverse the phase, to the top of charging resistor R_1. In this way a constant voltage is maintained across R_1 and a constant current into C_1. The isolating resistor R_2 may be replaced by a diode, but this is usually of little advantage. As a cathode-follower output is often required after a sweep generator, use of this circuit does not necessarily mean the inclusion of an extra tube. The circuit is especially suitable for use with high-speed sweeps. R_1 and C_1 may be varied without affecting linearity. Almost perfect linearity may often be obtained, although over-compensation is not possible except where constants are such that the combination of R_2 and C_2 acts as in Method 1





METHOD 3—As in the preceding method, correction is accomplished here by feeding back without phase reversal to the top of the charging resistor. Output is linear when the gain around the feedback loop (from lower end to upper end of R_1) is one, and over-compensation will result as the arm of the linearity adjustment potentiometer is advanced toward the plate of V_2. It should be noted that if a load resistor equal to R_3 is added in the plate circuit of V_1 these two tubes can function as a balanced output amplifier. This method is one of the best available for compensating low and medium-frequency sweeps, either fixed or variable

Cinch IS THE STANDARD

The new Cinch sub-miniature tube sockets are the standard because:

1. Insure positive electrical contact
2. Hold tubes securely in place
3. Permit easy maintenance and replacement of tubes
4. Maximum insulation resistance
5. Minimum high frequency loss
6. Adaptable to various chassis mounting requirements
7. In production and available on order

UB-MINIATURE SOCKETS

CINCH MANUFACTURING CORPORATION 2335 WEST VAN BUREN STREET, CHICAGO 12, ILLINOIS
Subsidiary of UNITED-CARR FASTENER CORPORATION, Cambridge 42, Massachusetts

LINEAR SWEEP CIRCUITS

it has charged (or recharge after it has discharged) is accomplished by means of a thyratron or, in more modern circuits, by an ordinary triode, the grid of which is periodically pulsed from cutoff to near zero bias.

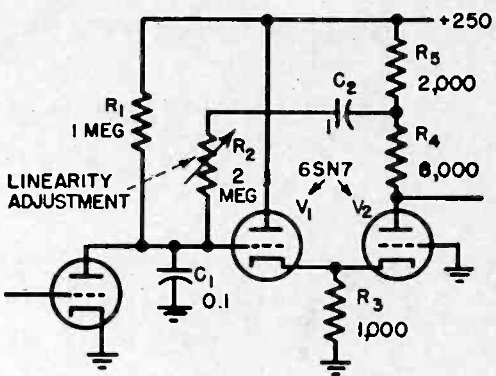
In the data given here the charging resistor and capacitor will be designated R_1 and C_1, respectively, and the discharge (or recharge) will be assumed taken care of by an externally controlled triode. All the methods mentioned are applicable to single or driven sweeps as well as to continuous sweeps. The circuits are shown in their most elementary form, and approximate component values for a 60-cycle sweep are given. Many modifications of each are possible. Adaptation to the particular sweep circuit in use will be necessary.

Most of the circuits discussed here are in actual use, and are covered by U. S. or British patents. Methods 4 and 7 were developed by the writer while a member of the staff of Allen B. DuMont Laboratories, Inc.

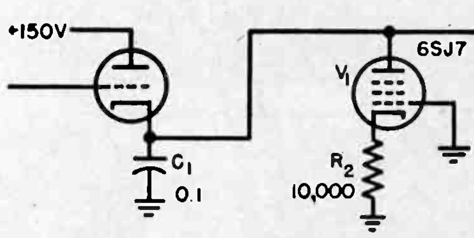
References

(1) Puckle, O. S., "Time Bases", John Wiley & Sons, Inc., New York, 1943.

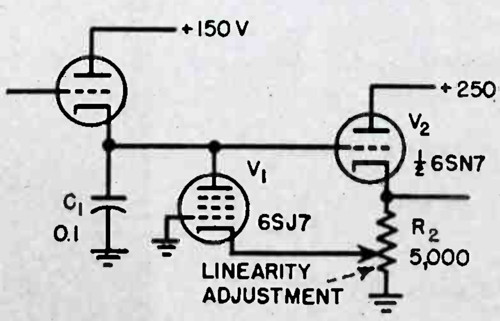
(2) Clarke, A. C., Linearity Circuits, *Wireless Engineer,* June, 1944. (The analysis of Method 6 in this reference is incorrect, as it disregards the fact that the signal fed back to the pentode cathode appears between cathode and control grid.)



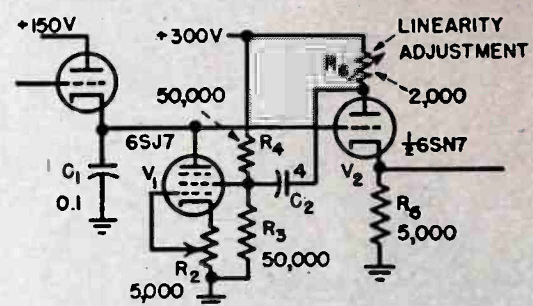
METHOD 4—This circuit is a modification of Method 3 which is useful under certain conditions. Although slightly more complicated, it has the advantage that the linearity-adjusting potentiometer is not the load resistor of V_2. Perfect linearity will result when the ratio of R_2 to R_1 is equal to $A-1$, where A is the gain around the feedback loop



METHOD 5—The output of almost any type of sweep generator can be improved by replacing the charging resistor with a constant-current pentode, but this is easily done only where the capacitor discharges, rather than charges, through the resistor. A pentode having a high plate resistance should be used, and the tube should be operated well out on the flat portion of the characteristic. The screen potential must of course be held constant, as by a fairly heavy bleeder between the positive supply and ground. Constancy of plate current will be much improved by a large cathode resistor, the effective plate resistance being increased by a factor of $1-G_mR_2$

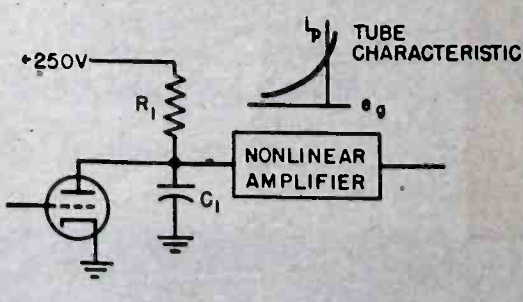


METHOD 6—The use of a constant-current tube may improve linearity though it will never make possible a perfect sawtooth, but by the additional application of feedback even strong overcorrection can be attained. This method utilizes the cathode-follower which often follows such circuits to feed a small part of the output voltage back to the cathode of the constant-current pentode. The circuit is useful both for high-speed sweeps and, because it is direct-coupled, for those of extremely low frequency



METHOD 7—The preceding method can not easily be applied to some sweep circuits because of their use of cathode degeneration for frequency control. In this case feedback can be to the pentode screen, with equally good results. A variable resistor, R_6, can be inserted in the plate circuit of the cathode-follower with little effect on the output, if it is small compared with the plate resistance of the tube. The screen supply bleeder R_4 and R_3 may be omitted and the screen connected directly to the plate of the cathode-follower instead of through C_2 if operating voltages permit

METHOD 8—Vacuum tubes are not linear devices, in that their e_g-i_p characteristics are seldom straight lines. With careful design, advantage can be taken of this curvature to counteract imperfections of the sawtooth. This is done in many magnetic sweep circuits, with a bias control on the output stage as the linearity adjustment. At present, ordinary tubes are capable of giving definite improvement. In the future, special types designed especially for this purpose may be available



... and here's why

Because Mallory's position as the largest producer of vibrators in the world has given Mallory more experience than any other manufacturer.

Because Mallory research has resulted in more than 50 important vibrator patents, issued or pending—has introduced many vibrator "firsts."

Because Mallory's adherence to the strictest standards of workmanship and materials is unsurpassed in its field.

These are a few of the reasons why four out of every five automobile radios today carry Mallory vibrators as original equipment—*why more Mallory vibrators are sold than all other makes combined.* It's natural to buy your vibrator power supplies from Mallory—natural, too, to bring your vibrator problems here.

CHECK THESE FEATURES OF THE MALLORY VIBRATOR

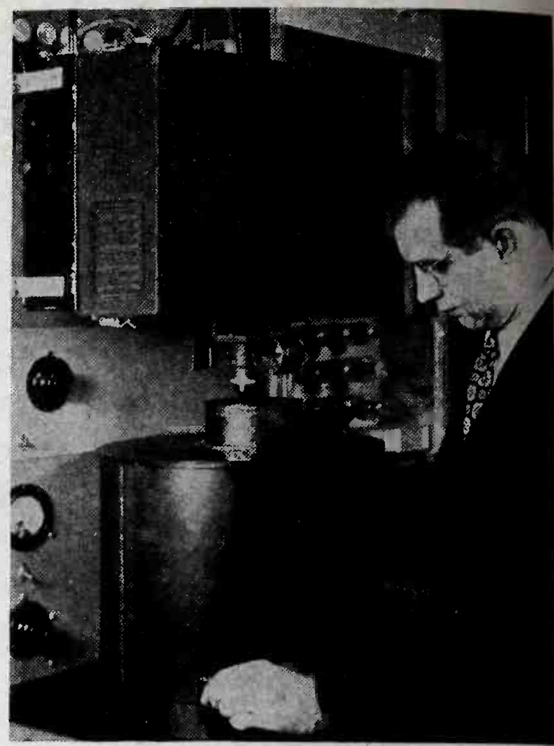
- ✓ Heavy frame holds springs in permanent alignment.
- ✓ Extra heavy cans insure better sound deadening.
- ✓ Special reed design and rigid material specifications eliminate reed breakage.
- ✓ Precision measurements in increments of .0001" assure stable operation.
- ✓ 105-strand wire defies vibration—connections stay intact.
- ✓ Optical adjustment methods insure accuracy not obtainable with the unaided eye.
- ✓ Especially selected Mallory made contacts assure longest vibrator life.

P. R. MALLORY & CO Inc.
MALLORY APPROVED PRECISION PRODUCTS

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

TUBES AT WORK

Edited by VIN ZELUFF



Color slide television camera that uses a 30-kv cathode-ray tube as the light source. Ray D. Kell, head of television research at RCA Laboratories, checks the tube by looking through a glass window in the top of the case

All-Electronic Color Television

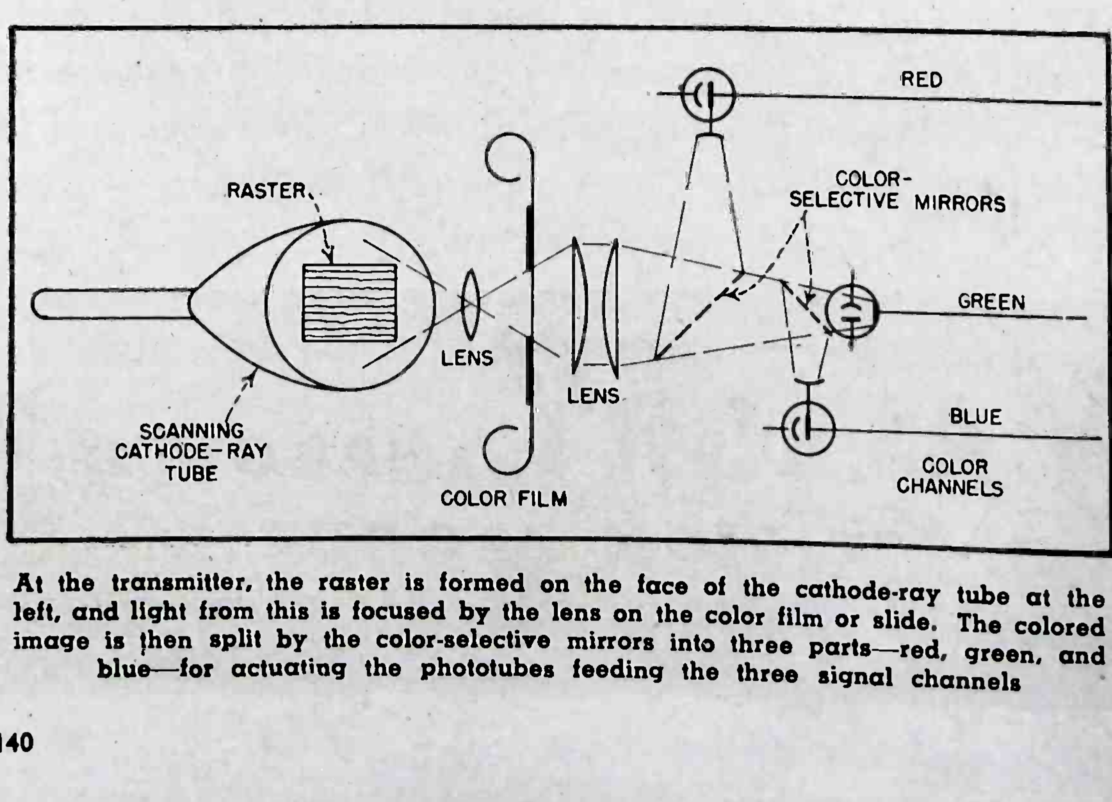
LONG AWAITED by radio engineers, an electronic color television system has been demonstrated publicly by RCA Laboratories. Color slides and a color movie cartoon were transmitted over coaxial cable and were shown on two laboratory receivers and, in black and white, on a current production television receiver.

The electronic system makes use of simultaneous color transmission instead of sequential color-by-color transmission used in the mechanical systems. In the simultaneous system, a cathode-ray tube is used as the light source for illuminating the color film or slide. On the face of this tube the scanning beam forms a conventional 525-line raster.

Light from the raster shines through the film and is focused into a color-selective mirror arrangement that splits the image into three parts, red, green and blue. Two half-mirrors allow the green image to proceed to a phototube where it is converted into a signal for the green image channel. At the same time, they deflect the red and blue images into their respective phototubes that feed two other signal channels.

The color transmission was made over three coaxial cables, one for each image, from a transmitter in the Laboratory building.

The color receiver is equipped with three 3-inch projection-type cathode-ray tubes which are separately actuated by the signals from the red, blue, and green signal channels. The trio of kinescopes is called a Trinoscope. The three color images from the tubes are optically projected into a composite picture on a 15 x 20-inch screen to form the full-color picture.



At the transmitter, the raster is formed on the face of the cathode-ray tube at the left, and light from this is focused by the lens on the color film or slide. The colored image is then split by the color-selective mirrors into three parts—red, green, and blue—for actuating the phototubes feeding the three signal channels

The electrical characteristics of the green-image signal, including the synchronizing pulses, are identical to those of the present black-and-white standards so that broadcasts from color stations using the electronic simultaneous system can be received on a current production black-and-white receiver by addition of a radio-frequency converter that tunes from 480 to 920 mc, the range now allotted to experimental television broadcasts, including color. The simultaneous transmission of the three color channels requires a bandwidth of 16 to 18 megacycles.

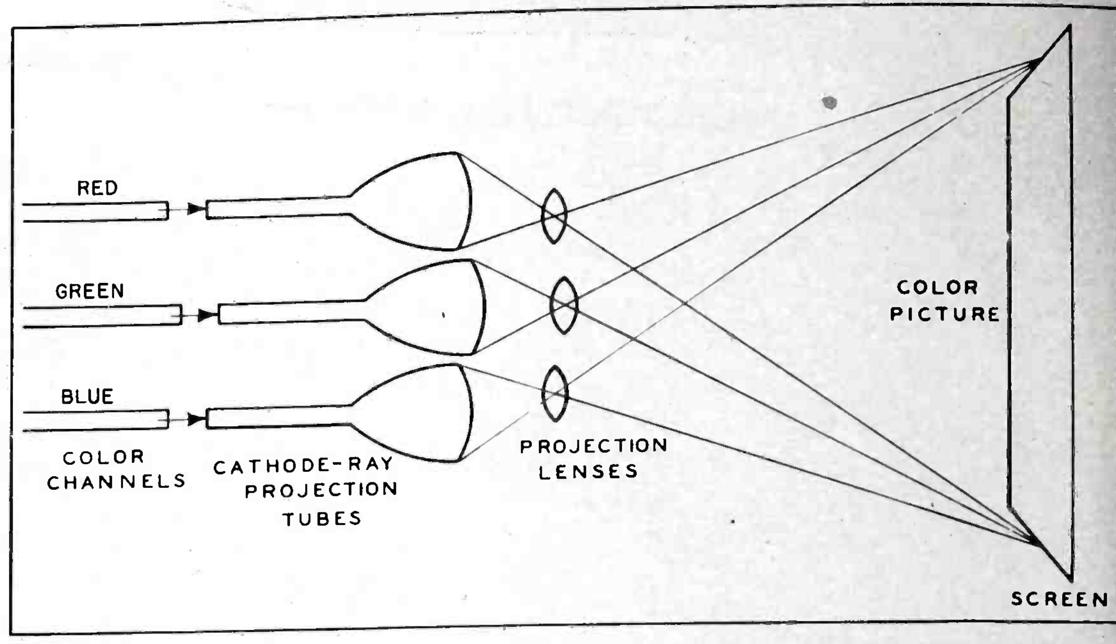
With the converter, present-day television sets could receive color programs and reproduce them in black and white by using the green-image signal. Thus, existing receivers would not be made obsolete by the introduction of color at some future date. Even a prewar television receiver could be adapted to tune to the electronic color transmission and use the green-image signal to show pictures in black and white.

Conversely, it will be possible for electronic color television sets to receive the broadcasts of black-and-white stations. This was demonstrated by showing a black-and-white broadcast from New York, 45 miles away, on all three receiv-

ers. The program televised appeared in normal black and white on the production receiver and in green on the two color models, since the green-image channel of these was being supplied with the signal.

As officials of RCA pointed out, a station owner can operate a monochrome transmitter on a low frequency and also an electronic color transmitter on an ultrahigh frequency, using the signal of the color camera to operate both transmitters.

In commenting on the new electronic color system, Dr. C. B. Jolliffe, executive vice president in charge of RCA Laboratories declared, "The problem is no longer how to transmit and receive color pictures by an all-electronic method, because the basic principles have now been solved. The problem that still challenges is how to operate television broadcasting as a steady and regular service to the public on the higher frequencies, whether in black and white or in color. To open the high-frequency spectrum and to make it commercially useful will require propagation studies under broadcasting conditions, development of new circuits, new tubes and new cameras, all of which must be field-tested before commercial standards can be recommended by the industry for approval by the FCC.



In the receiver, the signal from each color channel feeds a separate cathode-ray projection-type tube. By superimposing the three images on the screen, the final color picture is obtained

"What we have done today is to demonstrate the realization of the principle of simultaneous electronic color television. The apparatus used in the demonstration is purely experimental as developed in the Laboratories. It is not commercial equipment."

Dr. Jolliffe disclosed that the remaining stages in the timetable of laboratory demonstrations of electronic color television are as follows: Motion picture films within 3 months, live-action studio scenes by the middle of 1947, outdoor action scenes by the latter part of 1947, and large-screen theatre-size pictures in 1948.

The Trinoscope consists of three cathode-ray tubes that project the colors upward to the screen in the top of the cabinet. Karl Wendt, research engineer, holds the triple lens assembly used to focus the beams

New Uses for Pentagrids

By A. H. Taylor
Sound Division
Naval Research Laboratory
Washington, D. C.

In 1937, while experimenting with the German type AH-1 hexode, a mixer similar to the 6L7 but lacking a suppressor grid, the author noticed that when grid 3 bias was changed the screen current to grids 2 and 4 varied in an opposite sense to the plate current.

These simultaneous positive and negative mutual conductances suggested possibilities as a phase in-

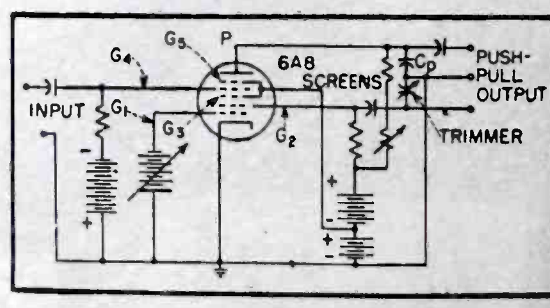


FIG. 1—Basic inverter circuit for a pentagrid tube

verter and indeed Schäfer used the similar RENS 1224 with grid 4 as a control grid and grid 3 and plate as output anodes.

For video work an inverter is desirable in which the input grid is shielded with respect to both out-

SHORT DELIVERY CYCLE!

IRC PRECISION WIRE WOUND RESISTORS

1. Accuracy. IRC offers standard tolerance of ± 1% . . . tolerances as low as .5, .25 and .10% available on special order.

2. Wide Selection Ranges and Types. Select whatever range, size or type you need to suit your design. IRC Precision Wire Wound Resistors are available in ranges from 0.1 ohm to 2.5 megohms. IRC also offers a wide selection of sizes and terminal types.

3. Non-Inductive. The largest possible special alloy enamelled wire, wound on winding forms without a break in insulation, with adjacent sections in opposite directions, allows windings of low residual inductance. The frequency characteristics of IRC Precision Wire Wound Resistors suit them for use at audio and carrier frequencies up to 50 KC.

4. Low Noise Level. Specify IRC Precision Wire Wound Resistors for instruments that require lowest possible noise level.

5. Protection Against Atmospheric Conditions. Non-hygroscopic ceramic winding forms are specially impregnated for additional moisture protection and to prevent abrasion of enamelled-wire windings. Windings are impregnated with special varnish, which improves insulation, eliminates breakdowns and shorted turns. This impregnating compound hardens with high temperatures instead of softening as is the case with wax impregnation found in some wire wound resistors. Baked impregnation of windings secures wires rigidly in place and gives effective protection from high humidity. For further protection, extra insulation coatings are applied before and after labeling.

6. Terminals. To insure positive terminal connections, IRC molded contacts are used on Precision Wire Wound Resistors.

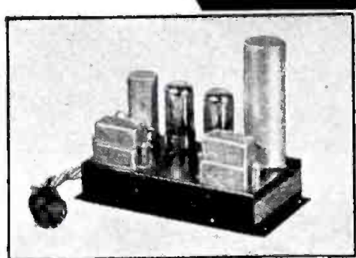
Your IRC Sales Engineer can quote you definite delivery schedules, or address inquiries to Dept. 1-L.

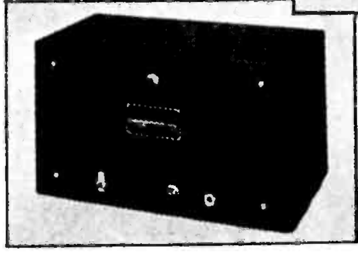
PREFERRED FOR PERFORMANCE
IRC
FIXED & VARIABLE RESISTORS

INTERNATIONAL RESISTANCE CO.

401 N. BROAD ST., PHILADELPHIA 8, PA.

In Canada: International Resistance Co., Ltd., Toronto, Licensee





TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

American Time Products, Inc.

580 Fifth Ave. **New York, N. Y.**

Dist. of Western Electric & Watch Master Watch-rate Recorders

puts. The pentagrid converter types such as the 6A8 seem ideally suited to this purpose when connected as shown in Fig. 1. As the experimental curves of Fig. 2 show, the current to grid 2, the oscillator anode in a conventional converter operation, varies in almost perfect symmetry to the plate current, when G_1 bias and G_3 and G_5 screen voltage are kept constant and G_4 is used as the control grid.

These curves merely change their slopes without losing symmetry seriously, when G_1 bias is varied as a means of expansion or compression or remote volume control. Figure 2 shows that the inverter should

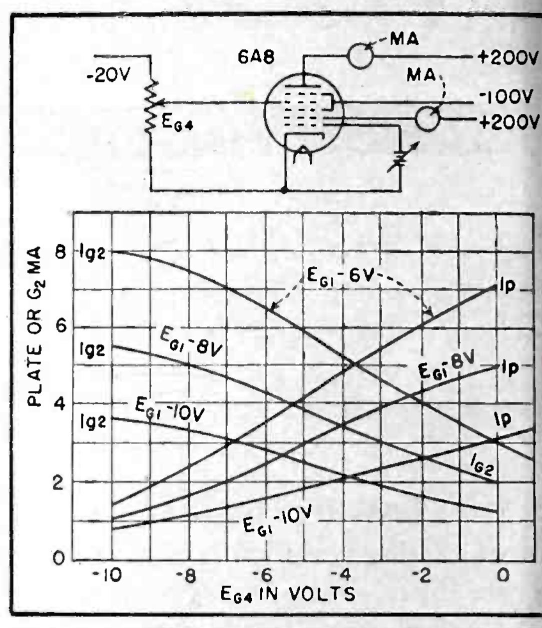


FIG. 2—Static characteristics of the 6A8 for phase inversion

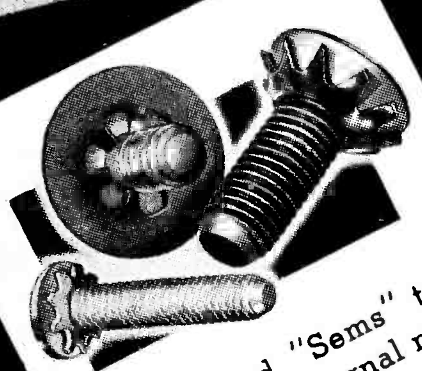
be operated with G_4 biased at — volts, with 100 volts on the screen and with 200 volts at G_2 and plate, G_1 bias being varied to control the gain. More conservative operation with less dissipation would follow similar characteristics at lower voltages.

Application

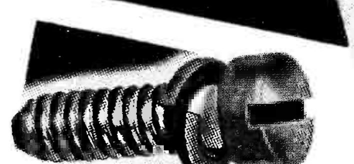
The outputs can be adjusted for symmetry either by juggling the voltages of G_4 and the screens, or by making one load impedance variable, both in magnitude and phase angle, and testing with a square wave.

Such a circuit is not a phase inverter in the strictest sense of the word, but an amplifier stage producing greater-than-unity gain to two oppositely phased outputs. It is used by the author in the amplifier limiter of the sweep synchronizer in a wideband cathode-ray oscillograph. Switching to either of the

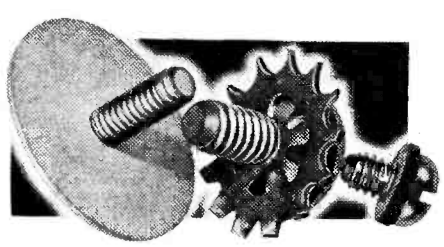
WE'RE TAKING ORDERS FOR SCOVILL SEMS WASHER ASSEMBLED SCREWS!



1 Standard "Sems" type internal or external multi-toothed washers.



2 Standard split type lock washers.



3 Special SCOVILL engineered adaptations of multi-toothed washers, and variations of fibre or metal, plain or spring, standard washers. Here SCOVILL ingenuity enables you to fit the right type of fastening to the exact requirements of your job.

SPEED UP ASSEMBLY! GET BETTER WORK!

Take time to take a look at your fastenings! Are they the best type for the job—or are you losing time—and money?

Sems washer assembled screws offer important advantages. The washer's permanently fastened—yet free to rotate. Easier, faster driving. No fumbled, lost, or forgotten washers. Matching finish on both parts. Easier ordering. Balanced inventories.

If you use fastenings in mass production—see what Scovill can do for you. And if you use special fastenings in large quantities, contact Scovill. Fill out the coupon below and mail it—now!

SCOVILL MANUFACTURING COMPANY
WATERVILLE SCREW PRODUCTS DIVISION
WATERVILLE 48, CONN. EB

Please have your sales engineer call with more information on:

- ☐ SEMS Washer Screw Assemblies
- ☐ PHILLIPS Recessed Head Screws
- ☐ CLUTCH HEAD Screws
- ☐ Special Cold-forged Fastenings

NAME____________________

COMPANY____________________

ADDRESS____________________

SCOVILL MANUFACTURING COMPANY
WATERVILLE SCREW PRODUCTS DIVISION
WATERVILLE 48, CONN. TEL. WATERBURY 3-3151

NEW YORK, Chrysler Building • DETROIT, 6460 Kercheval Avenue • CHICAGO, 135 South LaSalle Street • LOS ANGELES, 2627 South Soto Street • SYRACUSE, Syracuse-Kemper Insurance Building • CLEVELAND, Terminal Tower Building • SAN FRANCISCO, 434 Brannan Street

Speer Graphite Anodes

ADD BIG FEATURES

To UNITED Tubes

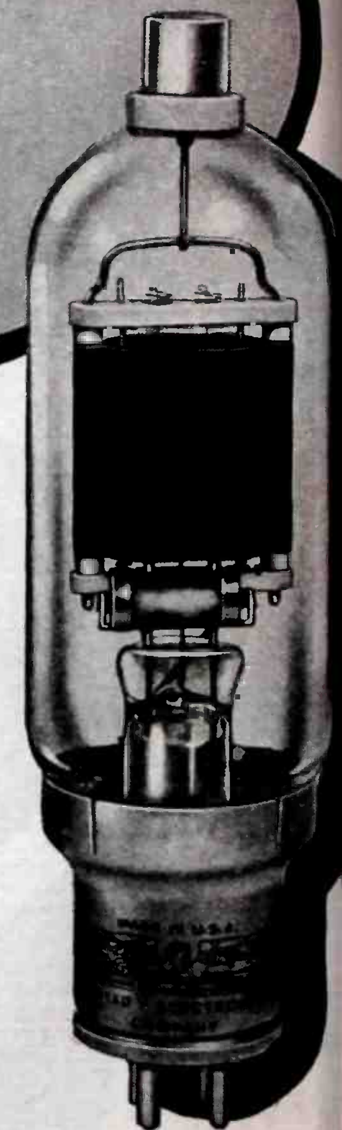
Almost Unbelievable!

Only 8 Watts Drive for

1/2 K.W. Phone Input with

NEW UNITED GRAPHITE TRIODES

(says United Electronics Company)



POWER like this is only one of the reasons why tube users are getting more and more enthusiastic about graphite anode transmitting tubes. This and other equally remarkable advantages are constantly winning new friends and convincing old ones for United Electronics Company. Using Speer Graphite Anodes, United puts these big advantages in every tube:

LONGER LIFE—Graphite anode tubes last longer than metallic anode tubes even under continued severe usage, because they operate at lower temperatures. Cooler operation means less heating of associated tube parts—reduced grid emission.

GREATER STABILITY AT HIGH INPUTS—From 200 to 300% more input power than metal anode tubes of the same plate area is the capacity of tubes with Speer Graphite Anodes. High radiation emissivity and conductivity of graphite make these higher ratings possible.

LOW FREQUENCY-DRIFT—Cool-operating, non-warping graphite anodes maintain their characteristics—assure stability of tube inter-electrode capacitances—inhibit warping in other tube elements. The result: high stability of frequency.

Look for graphite anodes when you're looking for better tubes.

CHICAGO • CLEVELAND • DETROIT
MILWAUKEE • NEW YORK • PITTSBURGH

SPEER

SPEER
CARBON COMPANY
ST. MARYS, PA.

744

outputs from G_2 and plate affords choice of positive or negative synchronization, a necessity in studying some wave forms.

An additional advantage of the pentagrid arrangement illustrated in Fig. 1 is the high d-c resistance that can be tolerated in the circuit of G_4. A 6A8G, used in the first stage of a multistage amplifier for small piezoelectric pressure gages was perfectly stable with 80 megohms, and remained stable for some time, even with G_4 entirely floating. The amplification from G_4 to plate or G_2 is of course not high, but it i greater than unity except for ver low load impedances.

Single-Coil Oscillator

The possibility of a very simpl single-coil oscillator, having a tan circuit in G_2 and feedback to G_4, illustrated in Fig. 3 and Fig. 4.

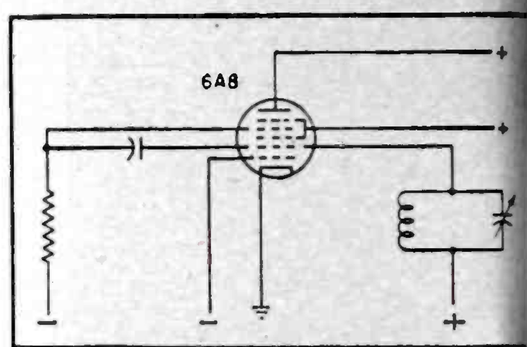


FIG. 3—Basic two-terminal oscillator circ

would seem to have the advanta over dynatrons and transitrons th the electrode arrangements are n abnormal; the various d-c potenti are applied substantially as in t tube manual. Longer or at lea more predictable tube life should the result.

If G_4 bias and the feedback G_4 from the plate or G_2, as the ca may be, are adjusted carefully a amplitude limitation is provided an avc circuit biasing G_1, a ve stable oscillator having zero gr current and extremely low harmon content is possible.

Using the AH-1 tube, the auth set up such an oscillator. Its oper tion was determined by test to confined to the linear portion of t mutual characteristic. Its frequen was wholly independent of any jected signal however close in f quency and however large in amp tude, even to the point of what v called "Totmachen ohne Mitnahm the increasing amplitude of injec

There is a High Sensitivity

RAULAND VISITRON

for every photo tube application

The *Rauland VISITRON* family of Phototubes includes the widest selection of versatile types for practical application in the field of light-sensitive devices. (Representative *VISITRONS* are described here briefly.) Whatever the application . . . for industrial electronic control, sound-on-film, or research and development, there is a dependable, high sensitivity *Rauland VISITRON* available to do the job perfectly. *Rauland* phototube engineers are ready to consult with you on your special phototube requirements.

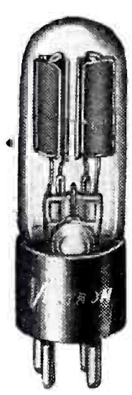
To be sure . . . specify VISITRON!

R-58 SERIES

Exceptionally dependable for use in electronic control equipment (for counting, sorting, burglar and smoke alarms, etc.) A preferred type for use in 16 MM sound-on-film equipment.

R-59 SERIES

Widely employed in theater sound projection equipment. Popularly used in 35 MM semi-portable systems. Rugged design makes it unusually adaptable to industrial electronic equipment. One of several series of *Rauland VISITRONS* also available for blue and ultra-violet applications.



R-60 SERIES

A dual-type phototube designed primarily for dual sound track systems; ideal wherever dual tube operation is required and space is at a premium.

R-64 SERIES

This rugged phototube in a short glass envelope is recommended for industrial light-operated relay and measurement applications where space is a limiting factor.

R-71 SERIES

One of the most widely used *VISITRONS*. Ideal for sound-on-film applications. Used extensively in electronic control devices for weighing, conveying; illumination controls; safety devices; flame contro work; smoke and turbidity measurement controls.

Send for this Descriptive Catalog

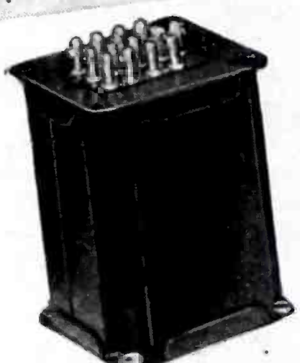
This valuable new *Rauland* VISITRON Catalog is yours for the asking. It's packed with informative data on phototube theory, characteristics and circuit applications. You will want this important treatise for your engineering reference library.

ALSO MANUFACTURERS OF DIRECT-VIEWING AND PROJECTION TYPE CATHODE RAY TUBES

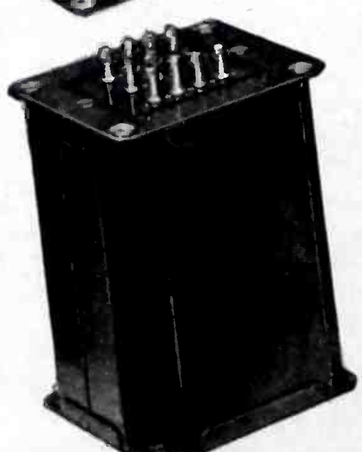
RADIO • RADAR • SOUND • **Rauland** COMMUNICATIONS • TELEVISION

Electroneering is our business

THE RAULAND CORPORATION • CHICAGO 41, ILLINOIS



"Imitation" is the sincerest form of flattery—so, being human, we're "flattered" that our "out front" T-LINE is the most copied-of-all transformer housings! Competitors were quick to see the superiority of T-LINE over the "horse and buggy," unpotted open-type transformers—and adopt this improved design principle..



More power to them! But, meanwhile Kenyon Designers are still ahead with these—

KENYON T-LINE ADVANTAGES

- UNIVERSAL MOUNTINGS—die-punched in a single, simultaneous operation, so that they ALWAYS REMAIN EXACT!
- Electrically and Mechanically FOOL-PROOF LUGS—DEPENDABLE under EVERY CLIMATIC CONDITION!
- UNIFORMITY and BEAUTY of APPEARANCE assured in finely designed ONE STYLE CASE in durable, black dull satin finish enamel!
- PROVED-THROUGH-SERVICE EXCELLENCE of electrical and mechanical design that today is being produced from AVAILABLE MATERIALS at LOW COST!

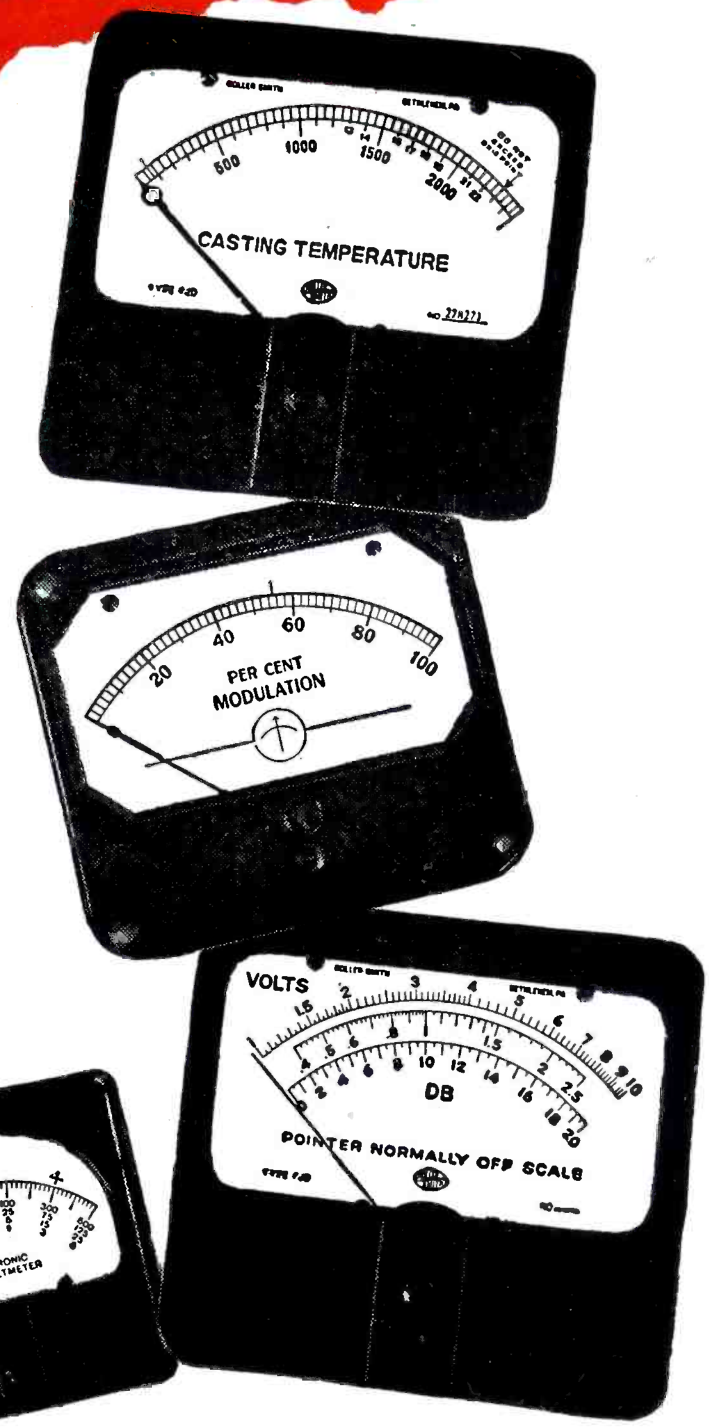
TRANSFORMER TROUBLE? CONSULT KENYON!

You are cordially invited to present your transformer problems to Kenyon Engineers. Pioneers in transformer development and design, we SPECIALIZE in "SPECIAL UNITS" for the electronics field and other commercial and industrial users. Our seasoned advice is, of course, yours—entirely without obligation.

KENYON TRANSFORMER CO., Inc.

840 BARRY STREET
NEW YORK, U. S. A.

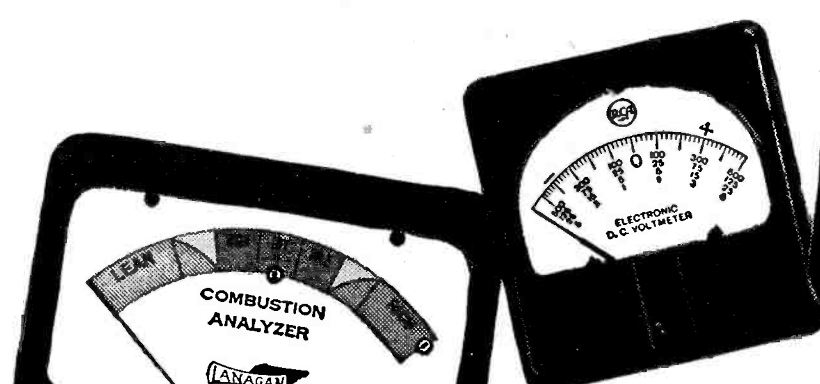
HOW to get a LOW COST answer to the problem of "Special Instruments"

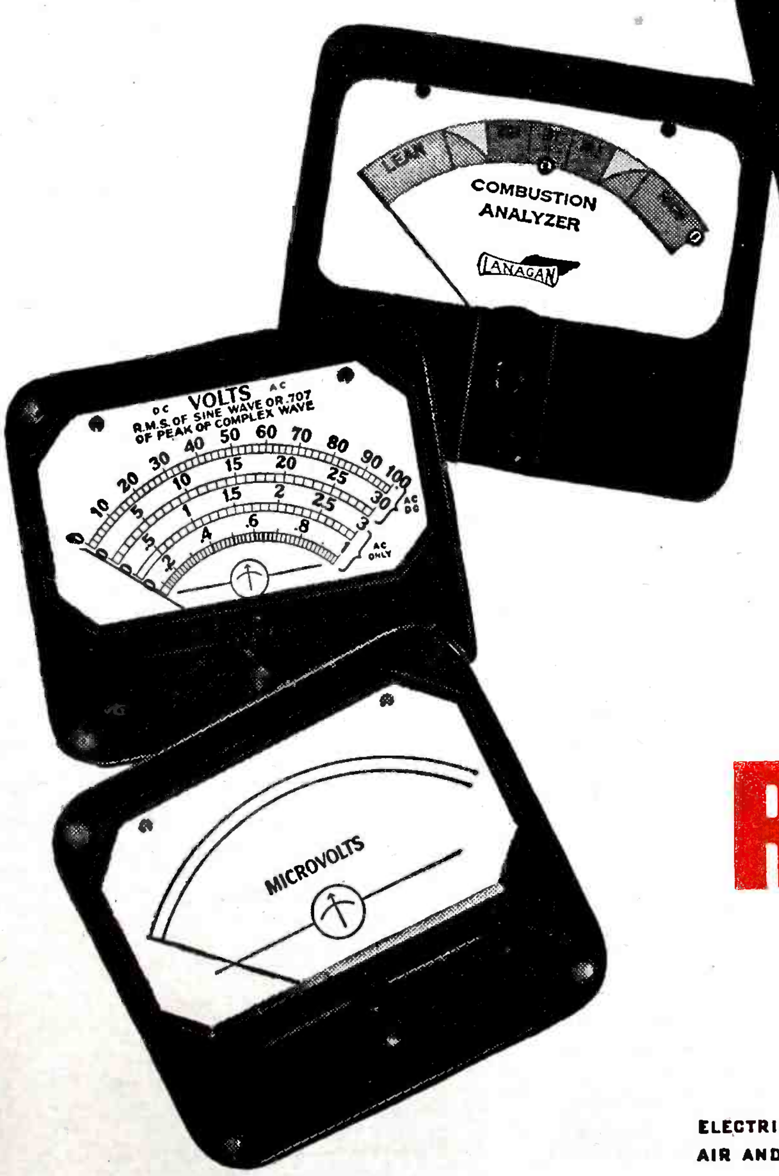


Are you troubled with the high cost of a special instrument for your product?

Our engineers know how to solve your instrument problems by modifying a standard Roller-Smith Instrument movement. The rugged construction, accuracy and long life of the instruments have been amply demonstrated for over 40 years. You get the regular high quality of standard Roller-Smith Instruments, application engineered to your measurement problem.

You save special tooling costs, get assured quality and speedier delivery when you solve your "special instrument" problem with a standard Roller-Smith Instrument movement. Write us in detail for help with your instrument, or see your R-S representative.





Typical Instrument Problems Solved with Standard Roller-Smith Movements

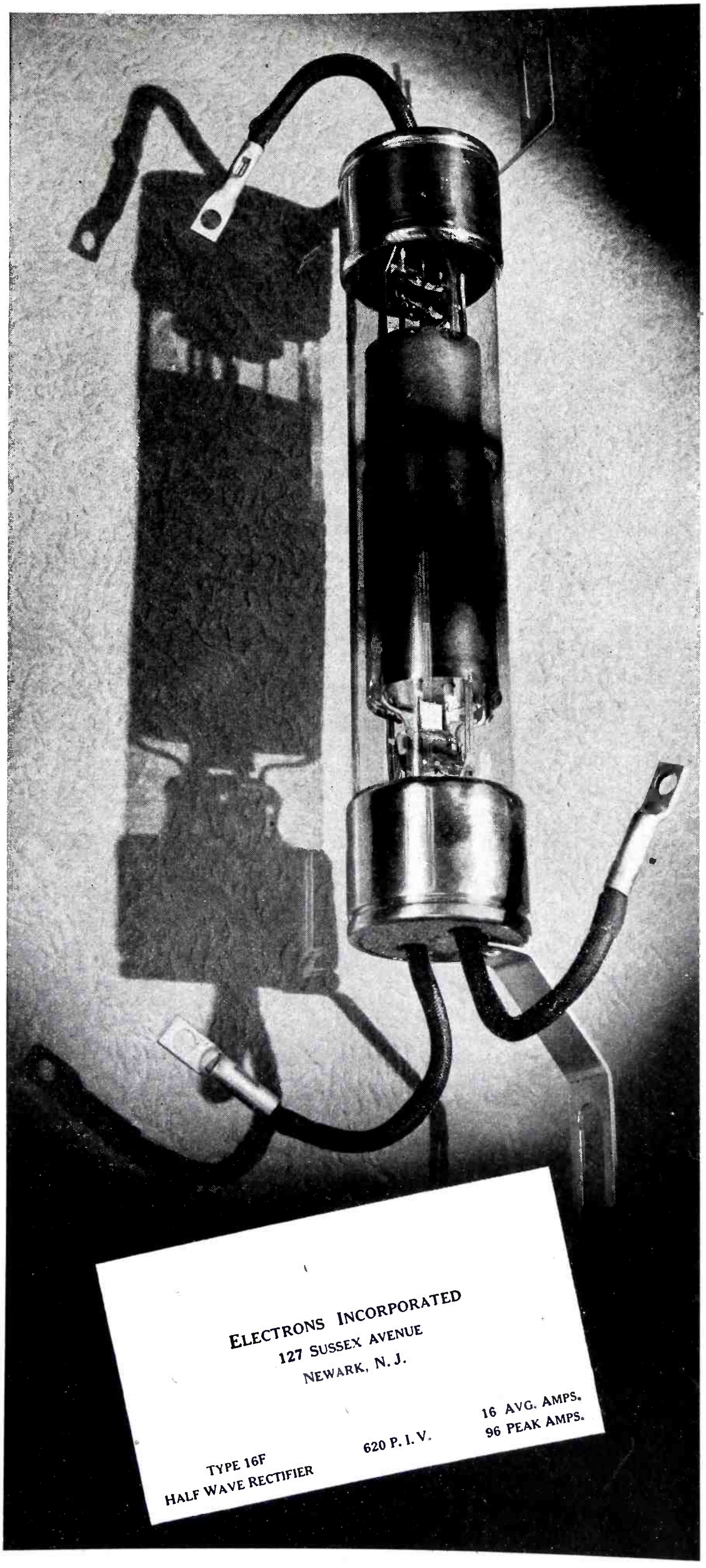
Measurement of: Temperature, Percent Modulation, Noise Level, Vacuum Tube Circuits, Combustion Analysis, Radio Frequency Circuits.

ROLLER SMITH

ROLLER-SMITH *Instruments*

1752 WEST MARKET STREET
BETHLEHEM • PENNSYLVANIA
In Canada: Roller-Smith Marsland, Ltd., Kitchener, Ontario

ELECTRICAL INDICATING INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR
AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES



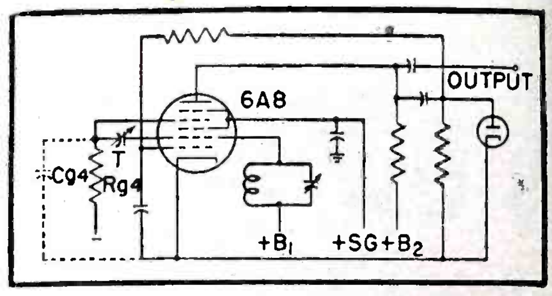


FIG. 4—High stability with compression is a feature of this circuit

signal gradually replaced the self oscillation until the latter disappeared altogether, without ever having had its frequency influenced.

This process could be observed very vividly with a cathode-ray oscilloscope; first the pure local oscillation was present, then a ripple crept slowly across the screen as the injected signal differing in frequency by a cycle or so was brought up; this ripple increased to a maximum as the two signals beat at equal amplitudes, and faded away again to leave only a sine wave after the injected signal had overwhelmed and stopped the self oscillations. This behavior is in accordance with the accepted theory that "Mitnahme" or locking depends on nonlinearity.

A pentagrid compressor crystal oscillator might be of advantage in a primary frequency standard because of freedom from grid current loading or influence by external causes. A proposed variable oscillator to replace the electron-coupled oscillators now used in variable-frequency transmitters is shown in Fig. 4. The value of R_{g4} is very high and trimmer capacitor T is adjusted to give the proper feedback through the capacitance potentiometer which it forms with C_{g4}.

Constant output amplitude over a tuning band can be obtained by using a suitably adjusted impedance potentiometer here instead of a capacitance potentiometer. The maximum permissible time constant of the filter circuit biasing G_1 is critically related to the decrement of the oscillatory system; if it is too long, blocking will result.

Direct-Coupled R-F Amplifier

By EARLE TRAVIS

Chief Engineer, Station KVEC
San Luis Obispo, California

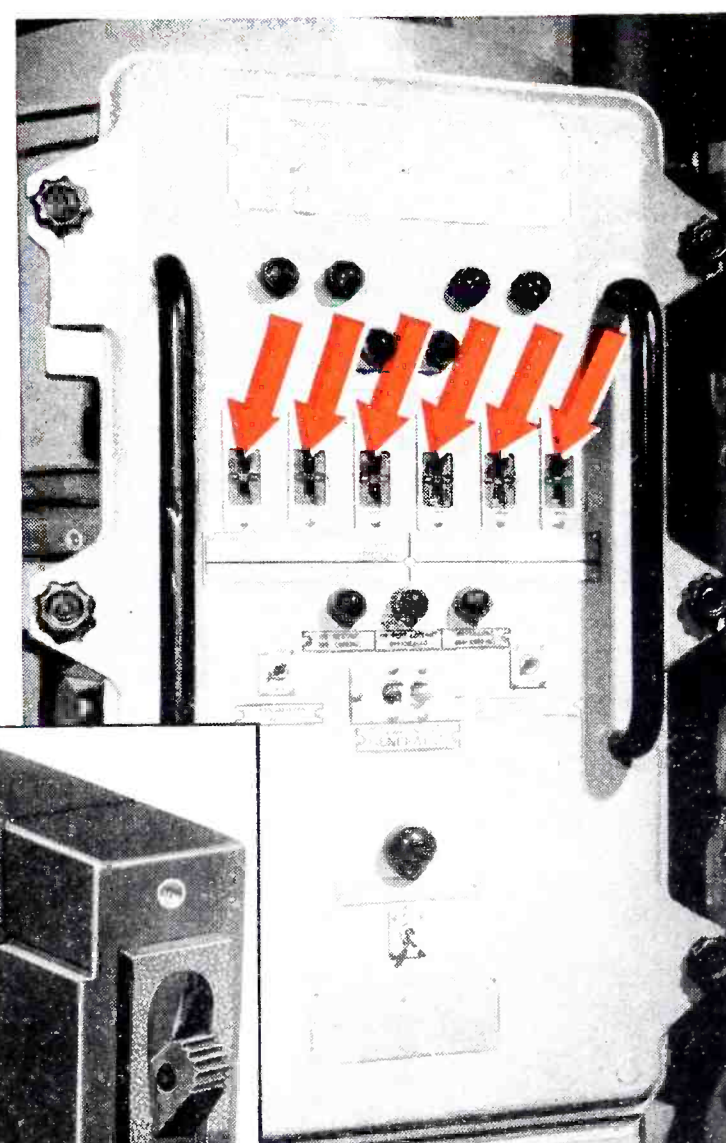
ANYONE who has ever used a bridge for measuring antenna resistance knows that a strong signal genera-

SPERRY USES

HEINEMANN

MAGNETIC CIRCUIT BREAKERS

For the Protection of Their Microwave Instrument Landing System Transmitters



THE SPERRY GYROSCOPE CO., INC. of Great Neck, Long Island, N. Y., realizing the need for flexible yet unfailing protection of the many critical parts of their landing system transmitters, selected HEINEMANN MAGNETIC CIRCUIT BREAKERS as best suited for the job. The complete landing system consists of two mobile ground station transmitters mounted in trailers, and receiving equipment in airplanes equipped to use the system.

On this equipment all circuit breakers are manually closed, and open automatically on circuit overload. They operate independently of each other. Being *entirely magnetic*, they are instantaneous in action on sudden, excessive overload or short circuit, but hydraulic time-delay mechanism allows passage of slight, temporary overload or starting surge. If this overload continues beyond the time-delay limit, the breaker interrupts the current. Magnetic blowout provides high and fast interrupting capacity.

Your equipment can be equally well protected by the installation of

HEINEMANN MAGNETIC CIRCUIT BREAKERS

EST. HECO 1888

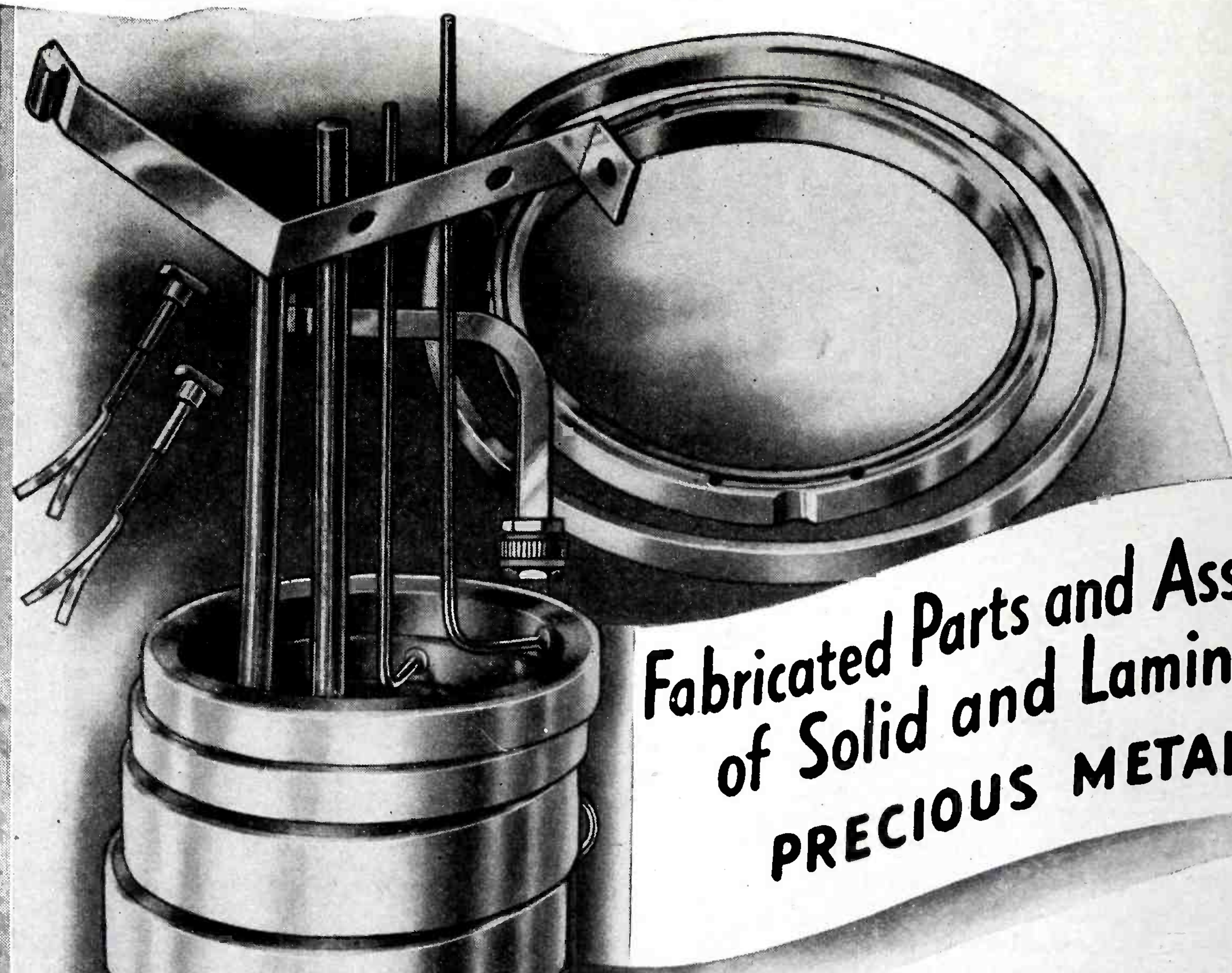
Red Arrows above show the location of six HEINEMANN Circuit Breakers in the Sperry Transmitter.

Left: — Close-up of the breaker.

HEINEMANN ELECTRIC COMPANY

ESTABLISHED 1888

97 PLUM STREET **TRENTON, N. J.**



Fabricated Parts and Assemblies of Solid and Laminated PRECIOUS METALS

In addition to the sheet, wire and tubing which we fabricate, we offer full facilities for the manufacture of various types of contact rings, fabricated parts and assemblies. These facilities include punch press and deep drawing work, milling, turning, grinding and drill press operations. In addition, we have facilities for silver soldering, silver furnace brazing and fine polishing.

To assist you in the application of our products to your products, we maintain a staff of thoroughly experienced metallurgists, chemists, designers and consultants . . . an up-to-date research and testing laboratory . . . and a splendidly equipped tool room. These are all at your service to cooperate with your own staff to the full extent of our facilities.

Your inquiries are cordially invited. Ask, too, for a copy of our descriptive folders on laminated metals or silver solders.

START RIGHT with *Makepeace* PRODUCTS

SHEETS · WIRE · TUBING · SOLDERS · FABRICATED PARTS AND ASSEMBLIES

D. E. MAKEPEACE COMPANY

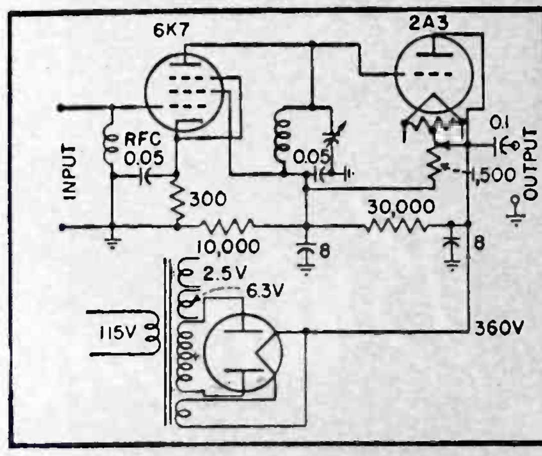
Main Office and Plant, Attleboro, Massachusetts

NEW YORK OFFICE, 30 CHURCH ST. CHICAGO OFFICE, 55 EAST WASHINGTON ST.


Bringing YOUR BIRDS HOME TO ROOST
Dependable communication between planes and airports is yours with Wilcox radio equipment. Its high performance is but one of many virtues. Economy, convenience, easy maintenance, and protection against frequency obsolescence are provided through extensive research, careful assembly, and thorough testing. Check the features of the Wilcox Type 99A Transmitter and see what they mean to you.
★ Four transmitting channels, in the following frequency ranges:
125-525 Kc. Low Frequency
2-20 Mc. High Frequency
100-160 Mc. Very High Frequency
Other frequencies by special order
★ Simultaneous channel operation, in following maximum combinations:
3 Channels telegraph
2 Channels telephone
1 Channel telephone, 2 Channels telegraph
★ Complete remote control by a single telephone pair per operator
★ 400 Watts plus carrier power
★ REMOVABLE R.F. HEADS are protection against frequency obsolescence. All connections to the transmitter are by means of plugs and receptacles. Instant removability means quick and easy maintenance.
WRITE FOR COMPLETE INFORMATION
WILCOX ELECTRIC COMPANY, INC.
KANSAS CITY, MISSOURI

tor is essential. Otherwise the null is buried under noise and the signal of any transmitter on that frequency. As the average signal generator has a rather low output, an amplifier for it is a decided advantage.

An amplifier for this purpose should be completely shielded and nonoscillating. It is an advantage to have a low-impedance output to match the low-impedance cables furnished with the bridge. The circuit shown in the diagram meets all



Circuit of high-gain direct-coupled amplifier for use with a signal generator

these specifications. The reason for making it direct coupled is that this does away with all untuned circuits between the 6K7 and the 2A3, allowing the 6K7 to produce a relatively high gain.

If it is desirable to have a constant output impedance, the output voltage of the amplifier may be varied by detuning the tuned circuit. No values are shown in the diagram for the tuned circuit as its values depend on the frequencies over which the amplifier will be used.

Multiple Thyratron Circuits

By IRVING SAGER
Thermionics Branch
Evans Signal Laboratory
Belmar, N. J.

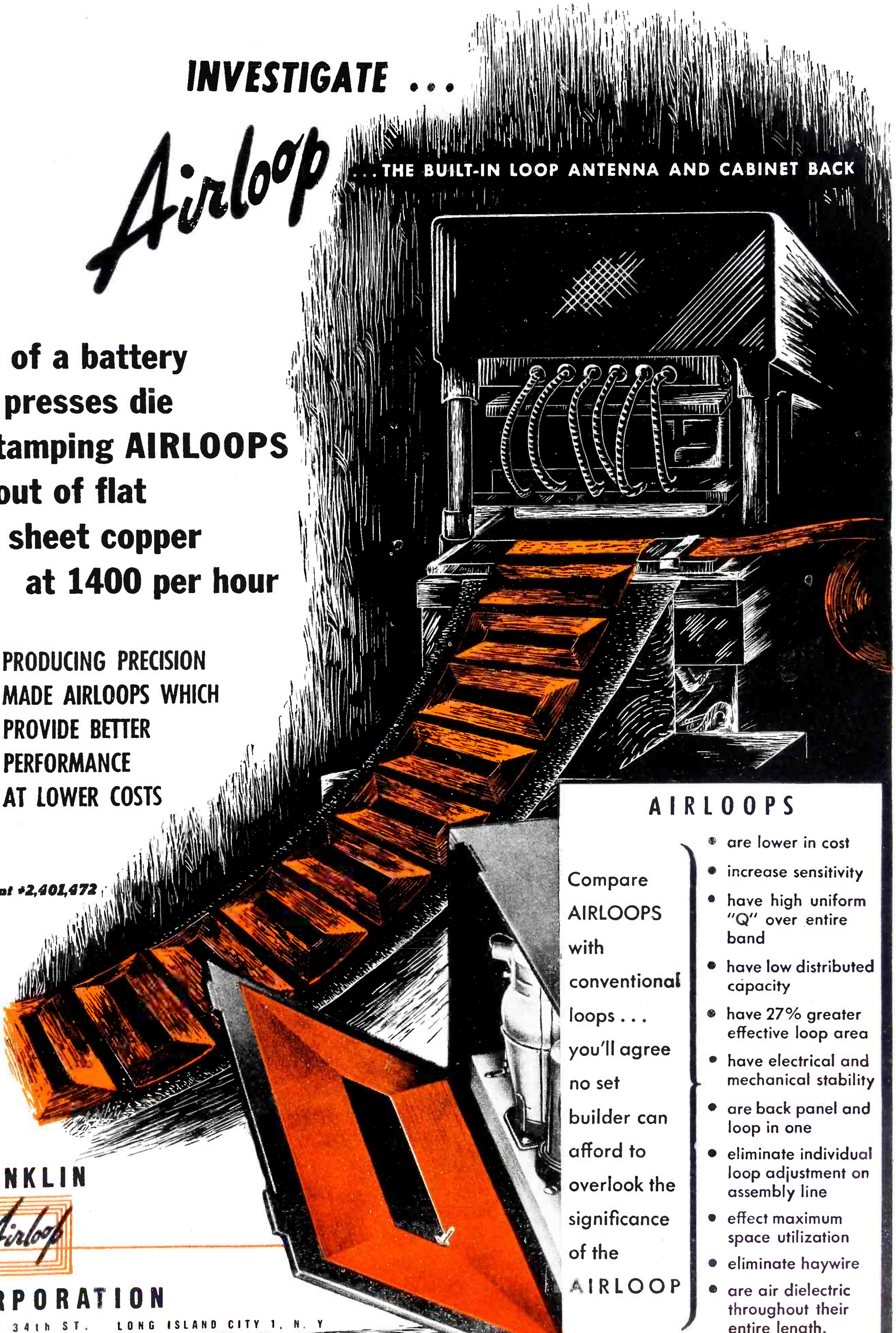
ENGINEERS THAT work with thyratrons are occasionally limited by the power-handling capacity of the tubes. Doubling or quadrupling the power capabilities can be achieved by operating thyratrons in series, parallel, or series-parallel as has been done with thyratron line-type modulators for pulsed radar sets.

The conventional line-type modu-

INVESTIGATE ...

Airloop

...THE BUILT-IN LOOP ANTENNA AND CABINET BACK



one of a battery of presses die stamping AIRLOOPS out of flat sheet copper at 1400 per hour

PRODUCING PRECISION MADE AIRLOOPS WHICH PROVIDE BETTER PERFORMANCE AT LOWER COSTS

patent #2,401,472

AIRLOOPS

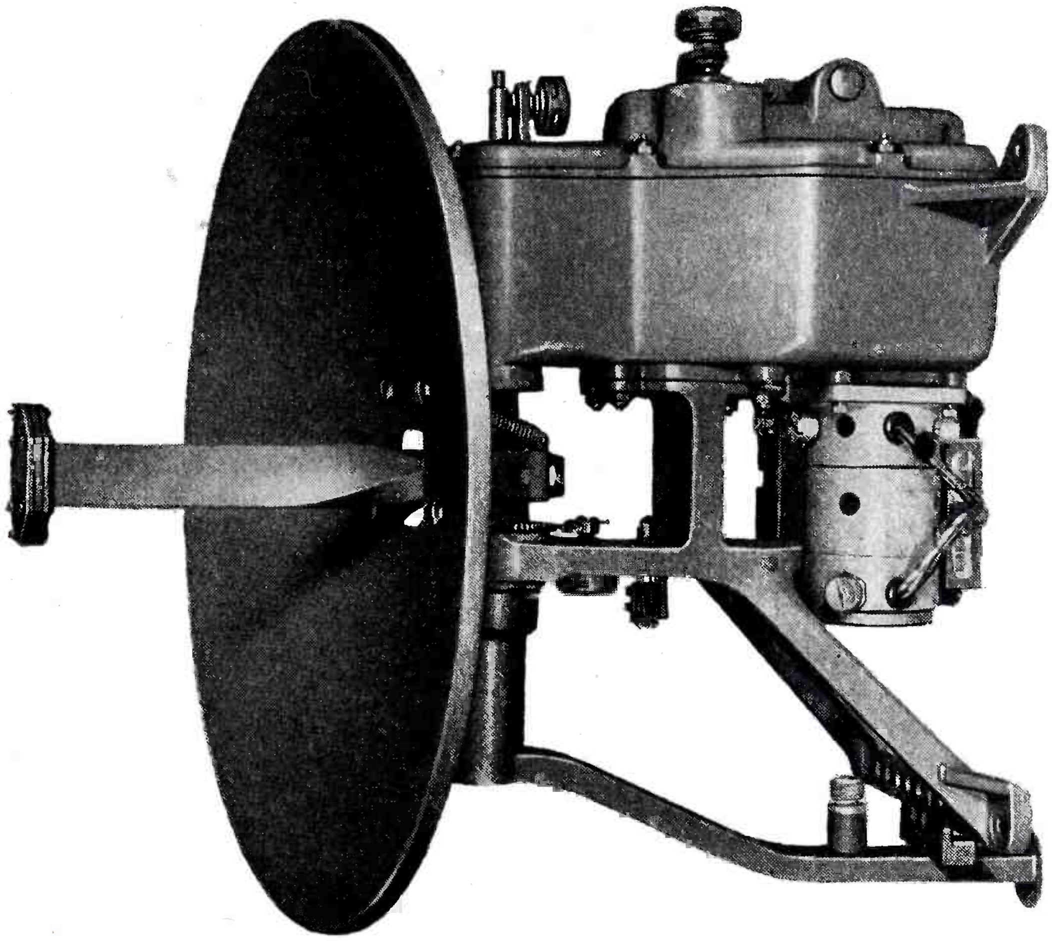
Compare AIRLOOPS with conventional loops . . . you'll agree no set builder can afford to overlook the significance of the AIRLOOP

- are lower in cost
- increase sensitivity
- have high uniform "Q" over entire band
- have low distributed capacity
- have 27% greater effective loop area
- have electrical and mechanical stability
- are back panel and loop in one
- eliminate individual loop adjustment on assembly line
- effect maximum space utilization
- eliminate haywire
- are air dielectric throughout their entire length.

FRANKLIN *Airloop* CORPORATION

43-20 34th ST. LONG ISLAND CITY 1, N. Y

AIRBORNE RADAR ANTENNA TYPE AN/APS-4



LIGHT WEIGHT SIMPLICITY LONG LIFE!

These are the features which distinguish the success of the DALMO VICTOR -designed and -developed AN/APS-4 Airborne Radar Antenna.

•

Typical of component parts combining these features are the Main Gear Drive and Gear Housing illustrated here.

MAIN GEAR HOUSING

Light Weight!

The AN/APS-4 Antenna weighs less than 13 pounds! Quantity production was accomplished through good basic design, incorporating magnesium castings, aluminum reflectors, and snap retaining rings.

MAIN GEAR DRIVE

Simplicity!

Simplicity is the keynote in all DALMO VICTOR airborne radar antenna designs. In the AN/APS-4 Antenna, simple direct drives and gearing with a minimum of moving parts were used.

•

Long Life!

The AN/APS-4 Antenna, built for the U.S. Navy, has an operating life of 2000 hours before major repairs—the equivalent of approximately 600,000 scheduled miles of "Constellation" flying.

During the war air search operations for the location of surface vessels, and for mapping, were of paramount importance in attaining victory. The need was successfully met by the development of the AN/APS-4 Airborne Radar Antenna, which was used on our bombers, land-based planes and carrier-based fighters.

DALMO VICTOR'S superior design of the AN/APS-4 Antenna was among the foremost contributions in the outstanding performance of this equipment.

DALMO VICTOR is developing and producing micro-wave equipment to be applied to peace-time uses. We solicit inquiries from electronic engineers, aircraft companies—from all who may be interested.

DALMO VICTOR

Manufacturers

SAN CARLOS, CALIFORNIA

current is called time delay. It is necessary to insure that each tube starts conducting anode pulse current at the same instant. If one tube starts conducting appreciably before the second tube, the output waveform will be distorted.

Series Circuit

The operation of thyratrons in series automatically insures that both tubes will conduct anode current during the same period of time and hence the output pulse shape will not suffer. It also insures that the tubes will conduct equal currents. By means of a resistance voltage divider, the circuit voltages may be adjusted so that each tube is subjected to half of the peak network voltage.

The series arrangement is shown in Fig. 2. When the trigger pulse is applied to tube 1, the tube fires and the voltage at point X drops to practically zero. As a result of this, the potential across tube 2 will start to increase very rapidly and will reach a value equal in magnitude to the voltage that appeared across tube 1 when the trigger was applied. The distribution of voltage within the tube to this steep wave front will be determined by the interelectrode capacitances. In the case of the 5C22 hydrogen thyratron, the grid-anode capacitance is approximately equal to the grid-cathode capacitance and about one-half of the steep pulse voltage will be applied to the grid of tube 2, making it unnecessary to supply any other trigger. Although the voltage applied to the tubes by the charging operation can be split by means of the voltage divider, the actual voltage on tube 2 at the instant of breakdown is higher than the desired value.

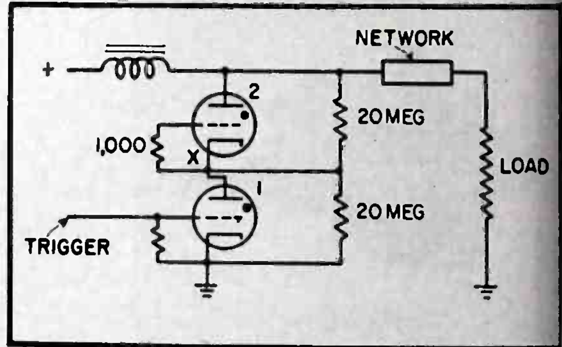


FIG. 2—In the series circuit, use is made of the tube interelectrode capacitances to supply the trigger to tube 2

Tests made on the series circuit

THE NEW FM SIGNAL GENERATOR

Model 202-B

FREQUENCY RANGE 54 to 216 MEGACYCLES

The design of this FM Signal Generator has been completed after many months of painstaking research on the part of Boonton Radio Corporation to develop a precision instrument meeting the rigid requirements set forth by leading FM and television engineers throughout the country.

Frequency coverage from 54 to 216 megacycles is provided by two ranges, 54 to 108 megacycles and 108 to 216 megacycles. A front panel modulation meter having two deviation scales, 0-80 kilocycles and 0-240 kilocycles, permits accurate modulation settings to be made.

Although fundamentally an FM instrument, amplitude modulation from zero to 50%, with meter calibrations at 30% and 50%, has been incorporated. This AM feature offers increased versatility and provides a means by which simultaneous frequency and amplitude modulation may be obtained through the use of an external audio oscillator.

The internal AF oscillator has eight modulation frequencies ranging from 50 cycles to 15 kilocycles, any one of which may be conveniently selected by a rotary type switch for either amplitude or frequency modulation.

The calibrated piston type attenuator has a voltage range of from 0.1 microvolts to 0.2 volts and is standardized by means of a front panel output monitor meter.

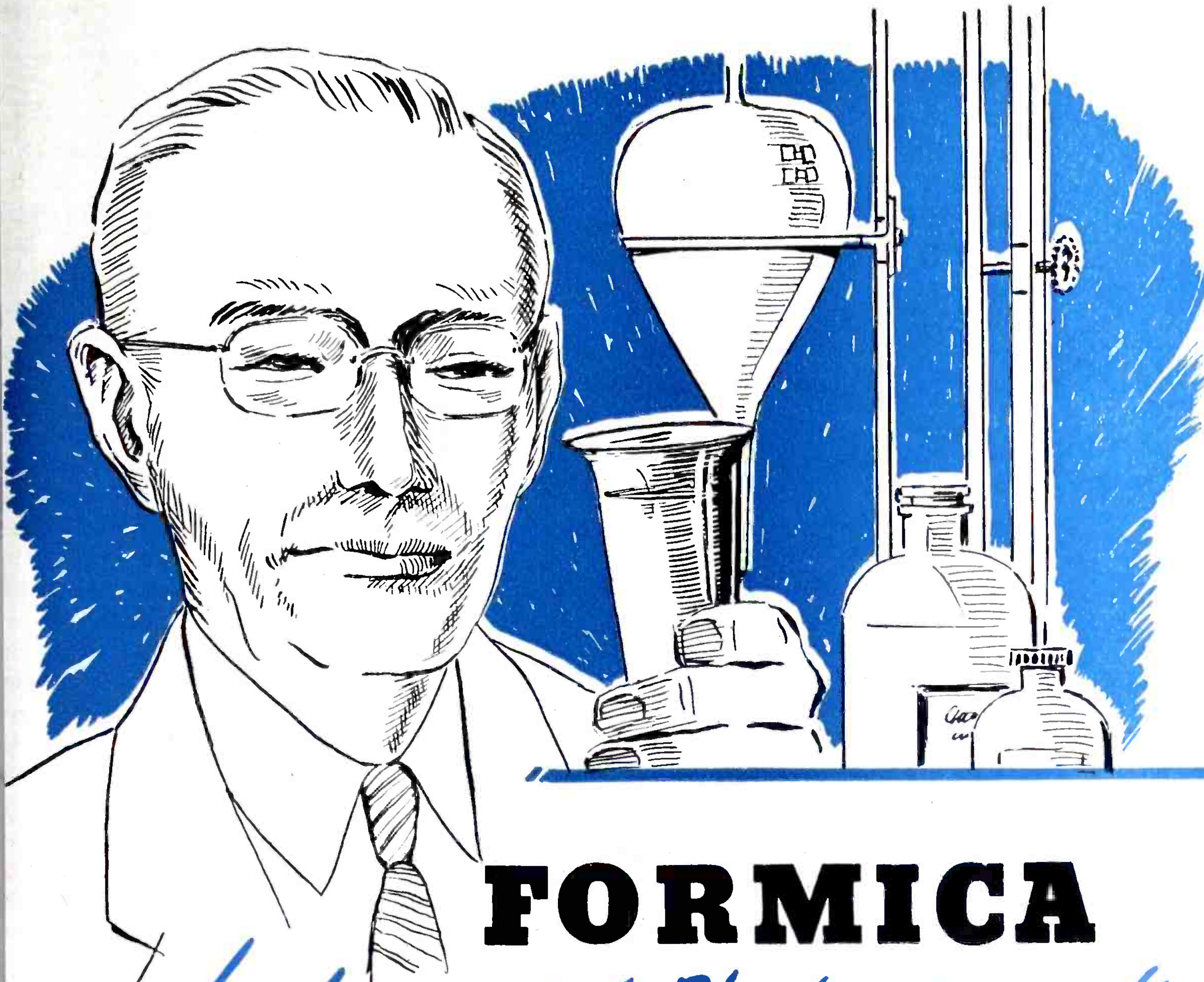
The output impedance of the instrument, at the terminals of the R.F. output cable, is 26.5 ohms.

Careful consideration has been given to the positioning of the main frequency dial and various controls, with modulation and output monitor meters located at eyelevel for maximum readability. Dimensions have been chosen to permit greatest economy of laboratory space. For complete details write for Catalog "D".

The design of this instrument was described on pages 96-101 of the November issue of ELECTRONICS. Reprints of this article are available upon request.

BOONTON RADIO *Corporation*
BOONTON·N·J·U·S·A·

DESIGNERS AND MANUFACTURERS OF THE Q METER • QX CHECKER
FREQUENCY MODULATED SIGNAL GENERATOR • BEAT FREQUENCY GENERATOR AND OTHER DIRECT READING INSTRUMENTS



FORMICA

for Laminated Plastic Specialties!

Formica has an extensive research and engineering staff which devotes itself to the development of special products for special purposes.

This development organization has many important "firsts" to its credit, and produces regularly a long list of products that are not available elsewhere.

The organization is exceptionally well equipped to see that you get the right material for your requirements in the right form to give you maximum service and satisfaction.

Formica also has an unusual quantity and variety of modern fabricating equipment and can turn out parts of exacting specifications for a very wide variety of purposes.

Bring your problems involving laminated engineering to the Formica organization.

The Formica Insulation Company, 4661 Spring Grove Avenue, Cincinnati 32, Ohio

FORMICA
TRADE MARK REG. U.S. PAT. OFF.

used a voltage divider consisting of two 20-megohm resistors. A low-capacitance filament transformer was used to heat the filament of tube 2. The capacitance of this transformer will disturb the charging-voltage distribution at high repetition rates and hence should be kept small.

Shunt Circuits

Parallel operation of thyratrons may be achieved simply by using separate pulse networks for each tube, provided that the variation in firing time normally encountered does not adversely affect the output pulse shape. On very wide pulses, the effect of one tube starting conduction a fraction of a microsecond before the other is not a serious disadvantage. However, on narrow pulses (about 5 microseconds), the variation in firing time of a few tenths of a microsecond must be considered. Under these conditions it is necessary to provide some method of preventing power pulse current from flowing until both tubes have been ionized.

Figure 3 shows a parallel thyratron circuit with a single pulse network. The grid of tube 1 is fired by a conventional thyratron trigger. Point X on the circuit drops to practically ground potential. For a small period of time (0.1 to 0.25 μsec for 5C22 tubes), tube 1 is ionized and is capable of passing the power pulse. However, the secondary of transformer T sees an open circuit (because tube 2 has not fired) and hence prevents the power pulse from flowing through tube 1. Transformer T is a 1:1 phase-reversing pulse transformer.

A negative pulse appears at terminals XZ of the transformer because of the firing of tube 1. This negative pulse is reversed by

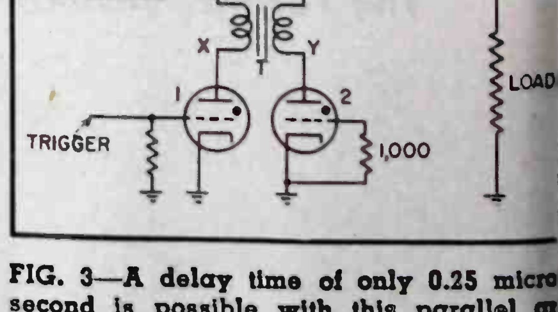


FIG. 3—A delay time of only 0.25 microsecond is possible with this parallel arrangement

MICA CERAMIC INSULATION

Molded TO YOUR SPECIFICATIONS

Holds to Tolerances up to ±.001"

In part after part, and in any quantity, Mykroy molds and *holds* to critical tolerances. In this, the only ceramic which can be molded under heat and pressure to such close tolerances, are combined many other highly desirable properties that distinguish Mykroy from all other types of insulating materials.

Unique in the class of glass-bonded mica ceramics, Mykroy possesses *electrical characteristics of the highest order* which do not shift under any conditions short of actual destruction of the material itself. Furthermore it will not warp—is impervious to gas, oil and water—withstands heat up to 1000° F and will not char or carbonize.

Its mechanical strength is comparable to cast iron and because it bonds firmly to metals it is particularly suited to molding parts with metal inserts. Even where price is a factor it competes with many standard insulating materials of lower electrical properties.

For improved performance and better quality in your new products investigate the many advantages of Mykroy. Write for samples and full information.

10th ANNIVERSARY 1935 MYKROY 1945 ELECTRONIC MECHANICS, INC.

MADE EXCLUSIVELY BY

ELECTRONIC MECHANICS INC.

70 CLIFTON BLVD., CLIFTON, N. J.

CHICAGO 47; 1917 N. Springfield Ave., Tel. Albany 4310

EXPORT OFFICE: 89 Broad Street, New York 4, New York

The New EDISON Thermal Relay...

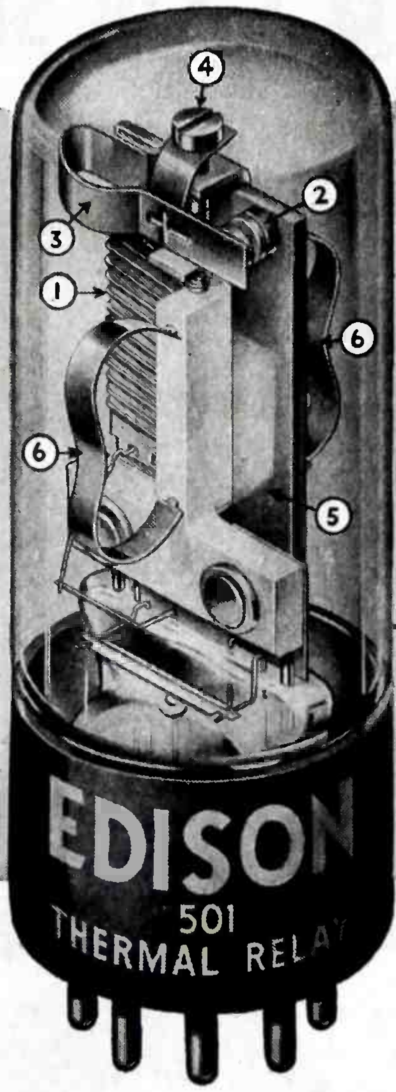
Here's how it works

❶ ELECTRICAL HEATER
(5 watts nominal up to 150 volts AC/DC) deflects bi-metal to actuate contacts.

❷ CONTACTS
are rated at 6 amperes at 250 volts AC or 450 volts DC; under some conditions, s.p.s.t. normally open or closed.

❸ MOVING CONTACT ARM
carried by heated bi-metal is a preloaded spring, which applies full contact pressure immediately after making. Action absolutely noiseless.

❹ FACTORY-ADJUSTED SCREW
sets contact spacing for desired operating time—5 seconds to 8 minutes.



❺ COMPENSATING BI-METAL
maintains pre-set contact spacing and relay timing, regardless of ambient temperature.

❻ "E" SPRINGS
braced between sturdy ceramic support and glass tube make assembly shock proof.

- **HERMETICALLY SEALED**
in glass envelope, relay is tamper-proof, fully protected from dust, dirt, corrosion, or contact with outside air, with operation independent of altitude.
- **ARC-QUENCHING ATMOSPHERE**
guarantees absolute minimum of contact fouling, pitting, or transfer; permits equal AC and DC ratings.
- **STANDARD RADIO TUBE BASE**
4-pin or octal.

What can this new thermal relay do for you?

It protects vacuum tubes by delaying plate voltage until cathodes are hot. But delay or timing is only one of its many uses. For instance, it indicates or controls over- and under-current or voltage. The EDISON Thermal Relay carries relatively heavy AC or DC loads and prevents chatter when actuated by delicate controls. It can do dozens of other jobs better and more cheaply than any other type of relay.

AN
EDISON
CONTROL

The services of Edison engineers
are available to assist you in working out your particular problems. A letter giving as much data as possible on the proposed use will receive prompt attention. Instrument Division, Thomas A. Edison, Incorporated, 22 Lakeside Avenue, West Orange, New Jersey.

AMERICAN AIRLINES PHOTO

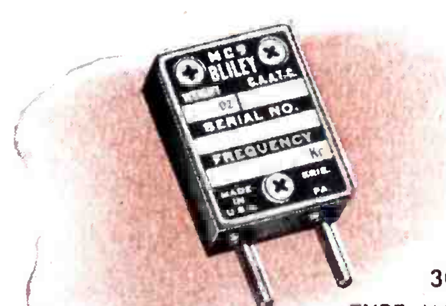
ı air carrier aircraft the seal of airworthiness is CAATC
). Civil Aeronautics Administration Type Certification.
he Bliley crystal units, shown on this page, are avail-
ɔle with CAATC when specified.

The prime requisite for airworthiness is reliability.
ach Bliley crystal, whether standard or CAATC, is
gidly tested for reliable performance. Frequency stabil-
y, precision and activity are proven for all conditions
f temperature, moisture and vibration covered by the
ɔecifications that govern.

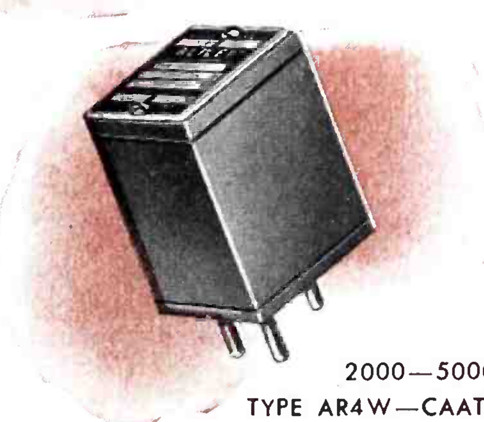
Engineers everywhere rely on Bliley "techniquality"
r the answer to their frequency control problems.
/hen you specify Bliley crystals you automatically
clude the creative engineering and production talent
ıat has pioneered in frequency control for over fifteen
ears.

Write for Bulletin 27

2000—11000KC
TYPE SR5—CAATC No. 363



3000—11000KC
TYPE MC9—CAATC NO. 362



2000—5000KC
TYPE AR4W—CAATC NO. 360
TYPE AR5W—CAATC NO. 361

Bliley CRYSTALS

LILEY ELECTRIC COMPANY • UNION STATION BUILDING, ERIE, PENNSYLVANIA the transformer, and the anode potential of tube 2 starts increasing.

The increase in anode potential of tube 2 causes its grid to become positive because of the grid-anode capacitance and firing of tube 2 is accomplished in a manner similar to the firing of tube 2 in the series arrangement.

When both tubes are conductive, the transformer equalizes the currents in the tubes by virtue of the unity turns ratio. The impedance it offers to the main pulse energy is presented only by its leakage inductance. The actual added circuit inductance is equal to one-fourth the sum of the primary and secondary leakage.

Measurements on Sylvania 5C22 tubes showed that in the parallel circuit the maximum delay time (time between the instants of firing of the two tubes) for tube 2 was 0.25 microsecond. The transformer used for the tests consisted of two coils of 15 turns wound on a 0.002-inch Hipersil core of three square inches area. This transformer satisfactorily passed main anode pulses of 1.5 μsec and 5 μsec at 16 ohms impedance.

Because of the extremely rapid rate of rise of voltage applied to the grid of tube 2 in both the series and parallel circuits the increase in jitter introduced by the addition of the second tube is reduced to a minimum. Measured values of jitter in two-tube circuits were always less than 0.04 μsec.

Combination Circuit

Combining the series and parallel circuits permits operation at extremely high power levels. The circuit used for accomplishing this is shown in Fig. 4. It is only neces-

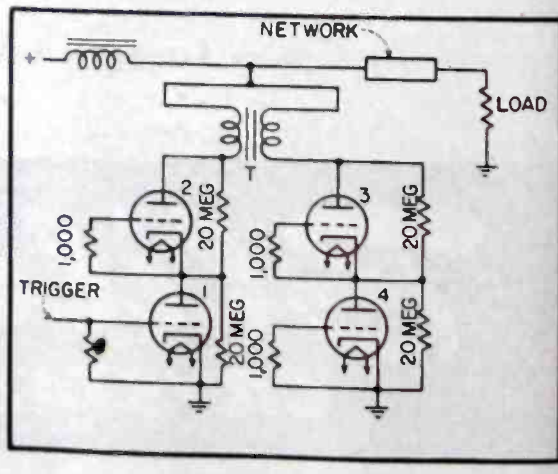
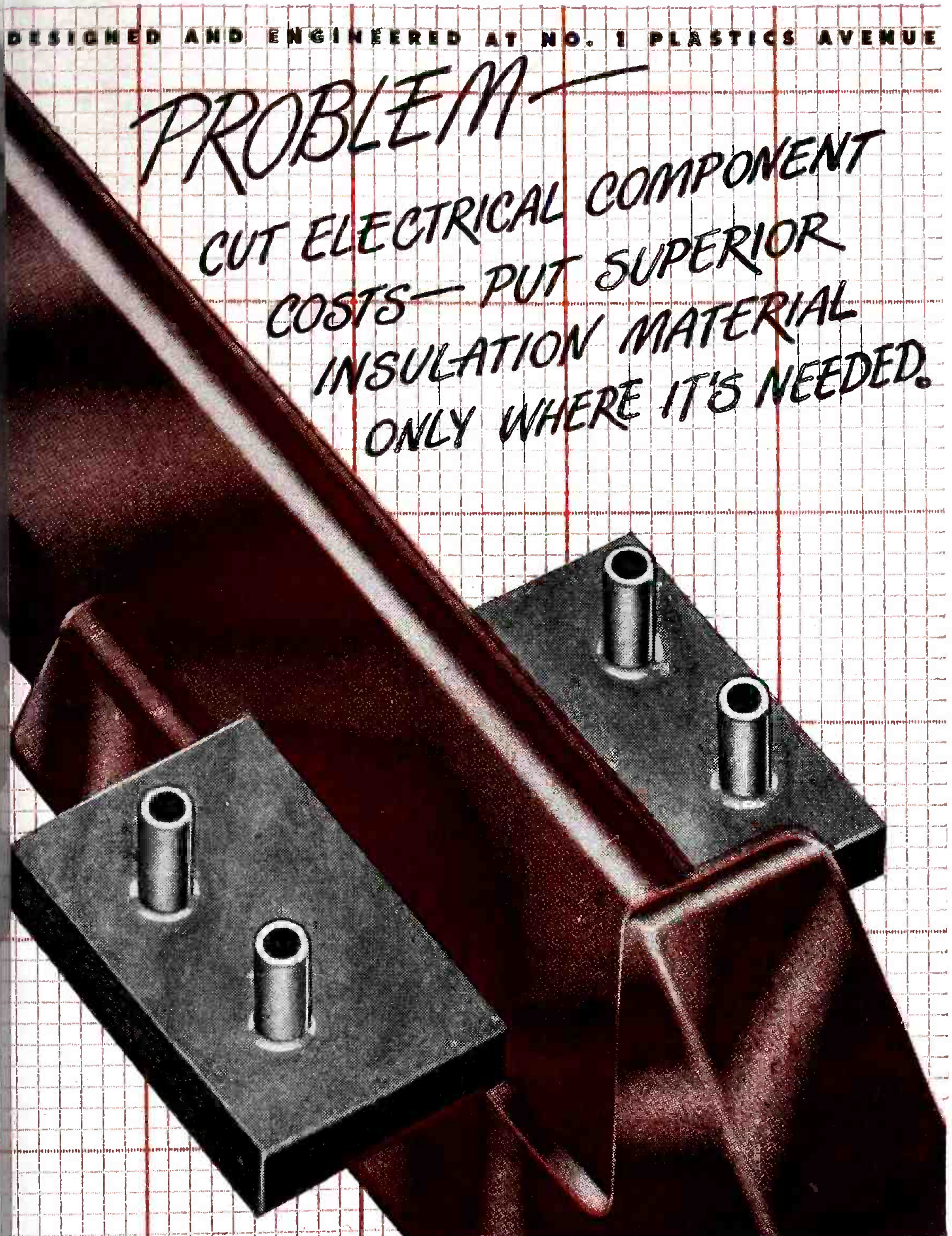


FIG. 4—Using the methods discussed in the text, this series-parallel circuit is evolved



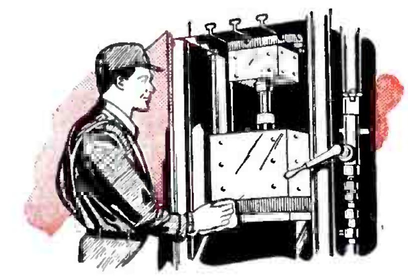
G-E MYCALEX—the insulator
hat can be bonded in an insulator

his rectangular piece of G-E myca-
plays a vital part in the cutouts
t protect street lighting circuits from
rloads. The design of the cutout
s for insulation material with a
erior combination of properties that
be molded as an insert into a less
ensive red phenolic plastics part.
meet these requirements, G-E
calex was selected—a compound
glass and mica that withstands the
uent voltage stresses of the applica-
and stays resistant to heat,
isture, and arcing.
etal studs are firmly molded into
G-E mycalex, and the G-E mycalex insert itself is securely anchored in the phenolic plastic. New and improved designs for electrical components are possible with these two unique features. And in many cases, lower costs are an additional result.

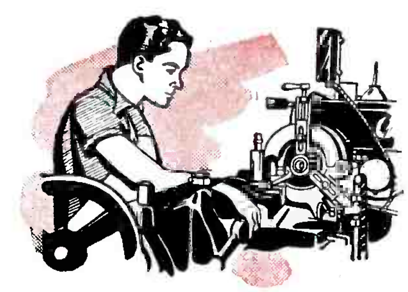
General Electric engineers will be glad to advise you on the uses of G-E mycalex—will mold parts to your own design. Learn the full story of this unique insulating material by sending for our new bulletin—"G-E Mycalex." Write to Section S-16, Plastics Divisions, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Massachusetts.

HOW THE G-E MYCALEX SERVICES CAN BENEFIT YOU NOW

You may order fabrication of sample G-E mycalex parts at surprisingly low cost. Test them yourself in your own equipment. Then, if you decide to specify G-E mycalex, your design can be converted to a molding process which permits speedy and economical production runs.



MOLDING SERVICE



FABRICATING SERVICE

Get This Unique Combination of Properties with G-E Mycalex

1. High dielectric strength
2. Low power factor
3. Prolonged resistance to electrical arcs
4. Chemical stability—no deterioration with age
5. Dimensional stability—freedom from warpage and shrinkage
6. Impervious to water, oil, and gas
7. Resistance to sudden temperature changes
8. Low coefficient of thermal expansion
9. High heat resistance

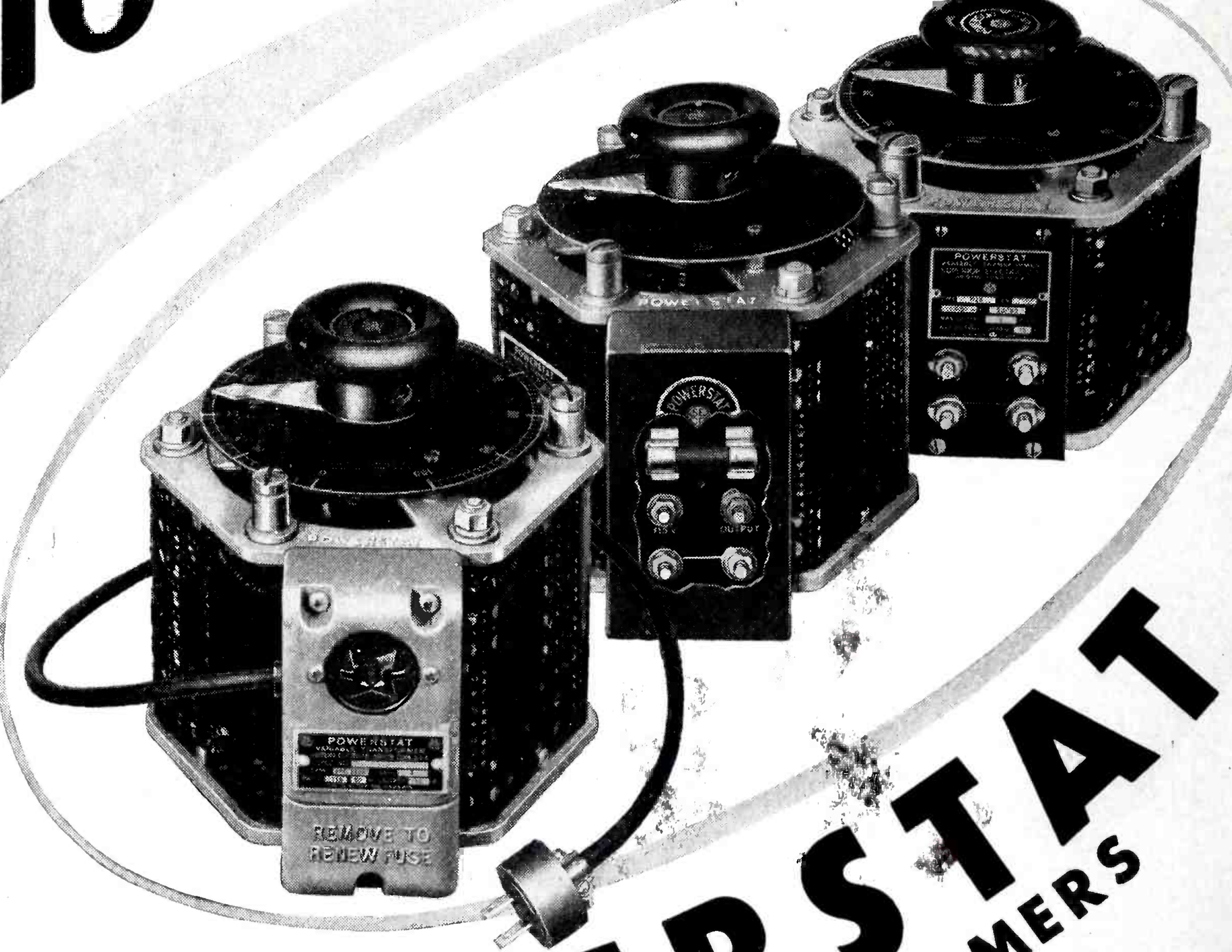
Samples Supplied on Request

MYCALEX

GENERAL ELECTRIC

CD46-M16

To suit each need . . .



POWERSTAT
VARIABLE TRANSFORMERS

ARE MADE WITH VARIOUS TERMINAL ARRANGEMENTS

Examine the POWERSTATS in the photograph. If you conclude from your examination that all three POWERSTATS are identical in physical and electrical size — you are correct. Each POWERSTAT is rated at 115 volts, 50/60 cycles, single phase input with O-135 volts, 15.0 amperes output. The difference is in terminal arrangement . . . to suit each need.

• For the laboratory — Type 2PF1126 with totally enclosed terminal box, fuse protection, output receptacle and input cord-plug.

• As a component — Type 1126 with exposed terminal studs for direct wiring.

• For other needs — Type F1126 with termina studs, fuse protection, and bakelite terminal cover

Ask any SECO sales-engineer for further information

Send for Bulletin 150 LE

THE SUPERIOR ELECTRIC COMPANY
712 LAUREL STREET · BRISTOL, CONNECTICUT, U. S. A.

CELANESE* PLASTICS

join the model railroad brotherhood

CELANESE PLASTICS ARE LIGHTWEIGHT!

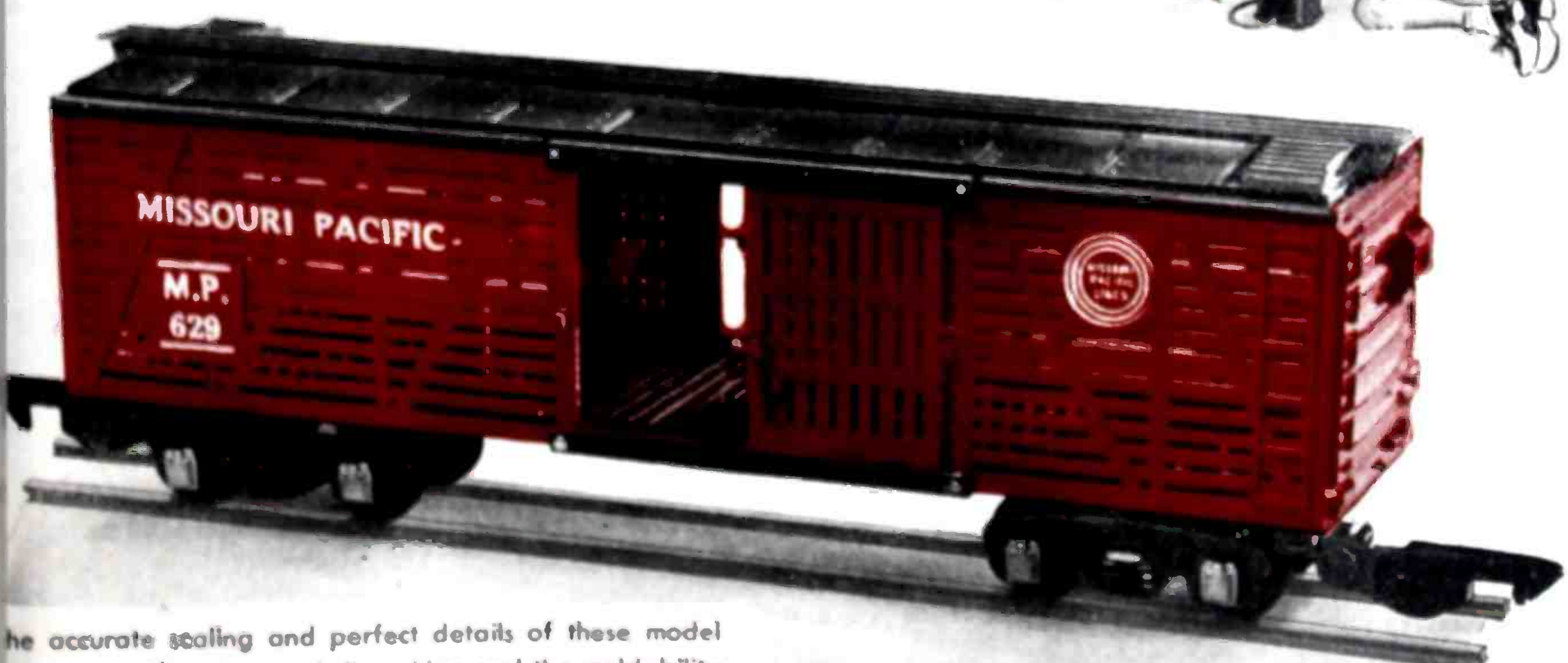
This extra-long train (22 cars) shows the increased realism plastics bring to model railroading. Celanese plastic cars are lightweight—one-third the weight of die cast metal. They make possible longer trainloads, faster pickup and higher train speeds!

CELANESE PLASTICS ARE NON-MAGNETIC!

Magnetic loading cranes work without a hitch. Cranes pick up the iron scrap but not the plastic car!

CELANESE PLASTICS ARE TOUGH!

Pile ups on the roadbed cause no damage to these cars. They are tough—can take it. Celanese plastics are color clear through—no danger of car color wearing or chipping off.

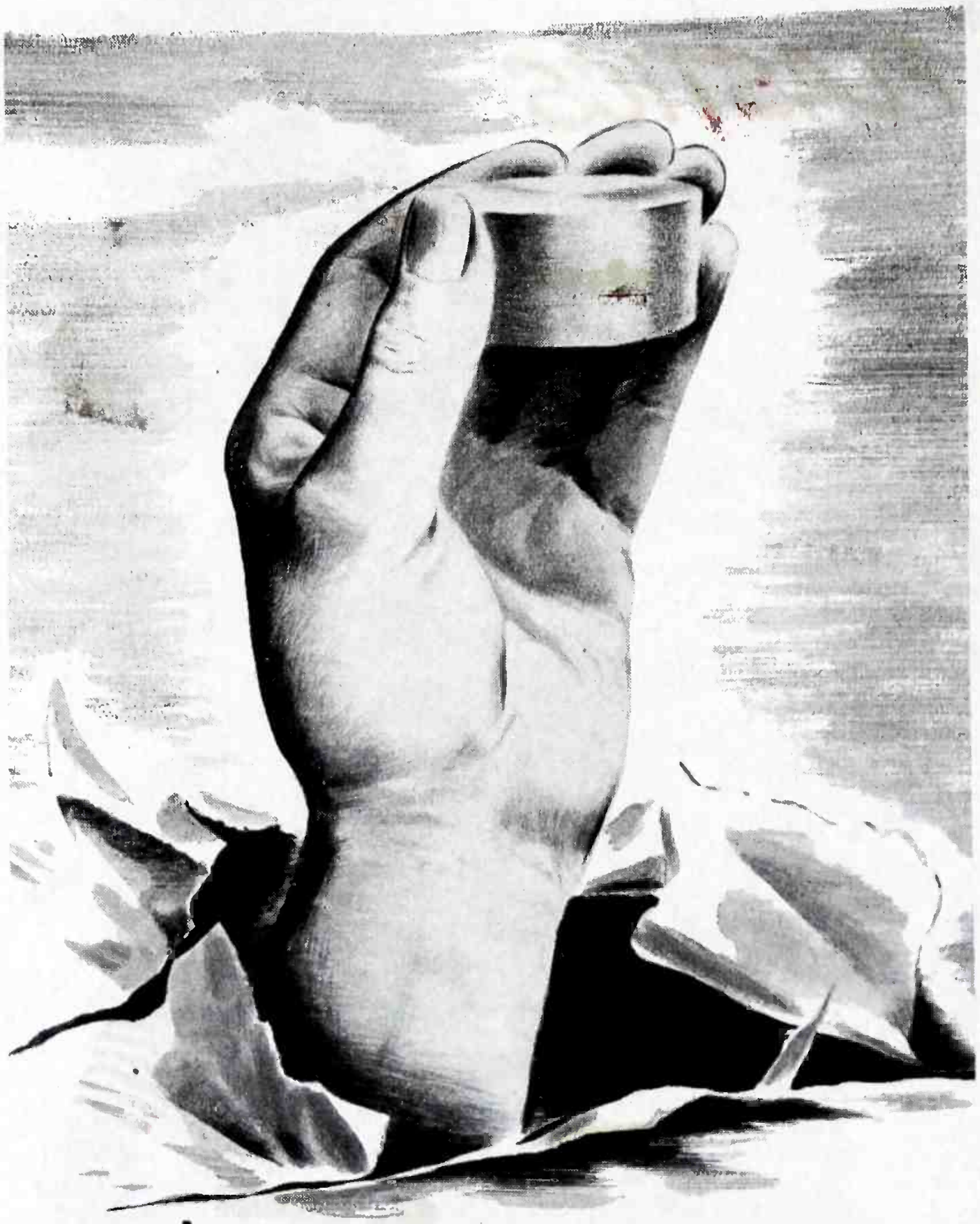


he accurate scaling and perfect details of these model ars are a tribute to good diemaking and the moldability f Celanese *Plastics*. Perhaps the same qualities that spell ccess for Celanese plastics in model railroading can be sed to advantage in your products. The Celanese tech-cal service staff is prepared to show what the high-speed oldability, clear-through color and all-around production conomies of Celanese plastics can do in improving prod-cts and reducing costs. Celanese Plastics Corporation, a ivision of Celanese Corporation of America, 180 Madison venue, New York 16, N. Y.

Celanese
PLASTICS

LUMARITH* CELCON† FORTICEL* CELLULOID* VIMLITE*

*Reg. U. S. Pat. Off.
†Trademark



sary to trigger one of the four tubes. When tube 1 is triggered, tube 2 becomes ionized in a manner similar to that of series operation. Then after tubes 1 and 2 are ionized, transformer *T* operates as before and triggers tubes 3 and 4. Which of these becomes ionized first will probably depend on the individual tube characteristics. A modulator using this circuit and four 5C22 tubes has been constructed and will handle 30,000 volts, 2 microseconds, with 200 pulses per second. It has been operated satisfactorily at about 10 megawatts.

High-Fidelity Phonograph

FREQUENCY RESPONSE within plus or minus one db over the range from 50 to 14,000 cycles is a feature of a new phonograph, the London Reproducer, now on the American market.

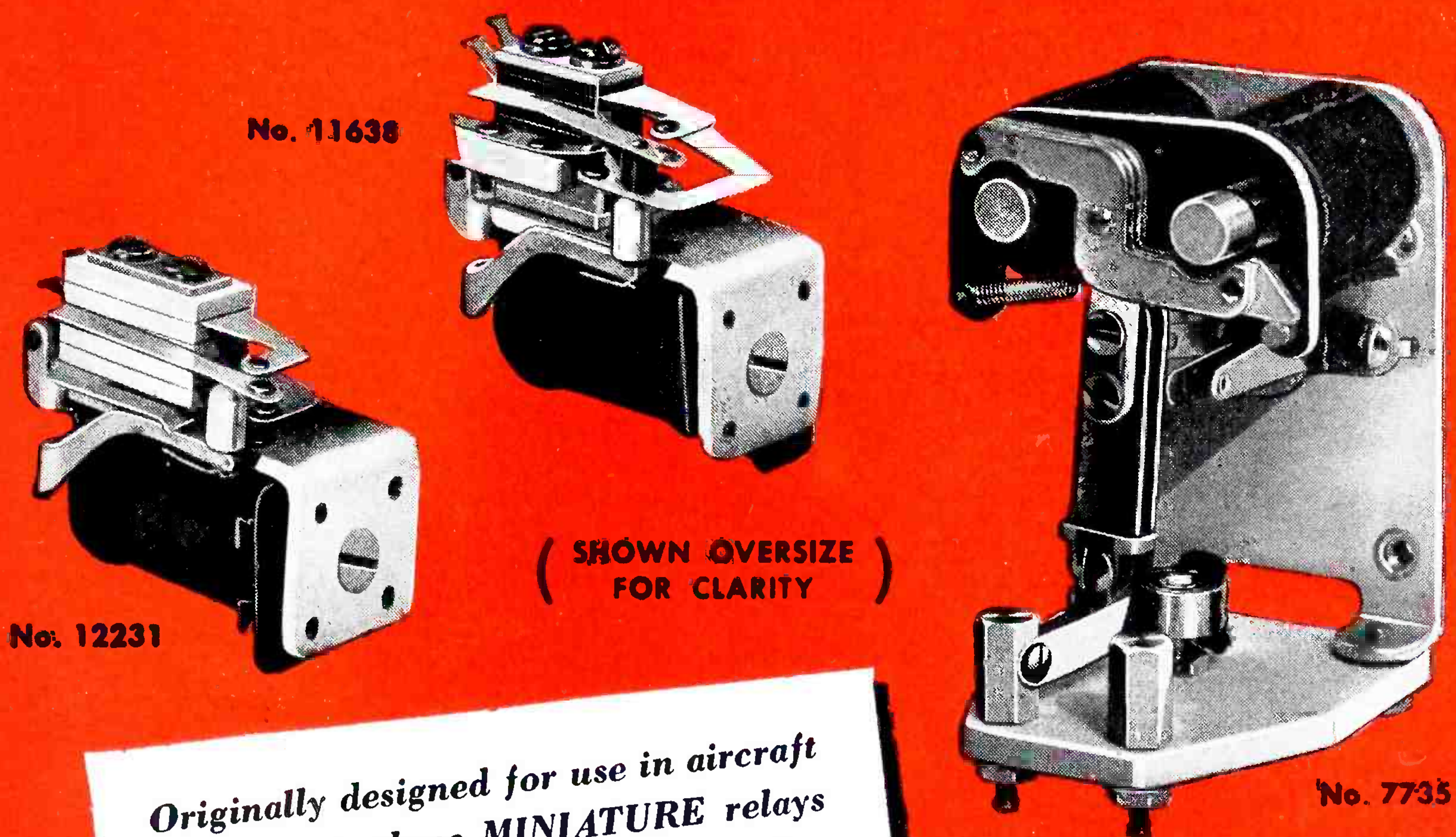
The circuit of the amplifier contains four stages of pushpull triodes. A low-impedance balanced-armature pickup feeds via bass-compensating R-C circuits to the grids of two 6J5 triodes. After passing through a second set of 6J5's, the signal is fed through a compensated twin volume control to another pair of 6J5's which are capacitively coupled to the grids of two PX25 output tubes. (The British PX25 is somewhat similar to the 2A3 but has a higher output rating.)

Each grid load is provided by half of a center-tapped choke having paralleled resistors, so that at all audio frequencies covered the inductive portion of the load is approximately four times that of the resistors to maintain linearity at low frequencies.

In the first three stages, separate unbypassed cathode resistors are used for each tube to correct any existing unbalance and nonlinear distortion. Volume control between stages 2 and 3 is achieved by twin resistance-capacitance circuits shunted across the output of stage 2 anode to anode, the capacitive portions of the network providing bass compensation at low volume levels.

Eight tubes are used, six 6J5

miniaturized RELAYS with Steatite Insulation



Originally designed for use in aircraft equipment, these MINIATURE relays give completely dependable operation under extreme conditions of vibration, humidity and temperature.

The Steatite insulation and gen-ral construction of these relays akes them inherently suitable for vitching circuits requiring perma-ently low leakage, for switching rtain high frequency circuits, and r any application where a com-act, light weight, yet sturdy relay required. Particular attention has een paid to design of relays that ill not "chatter" under vibration en in the un-energized position.

The antenna changeover relay shown is of unique design and provides the wide contact spacing and positive action necessary for this special purpose, for a weight of only 0.2 lb.

The other small relays are provided in the contact combinations illustrated at right, with maximum overall dimensions of $1\frac{1}{4}''$ x $11/16''$ x $1\frac{1}{4}''$ and a maximum weight of 0.07 lb.

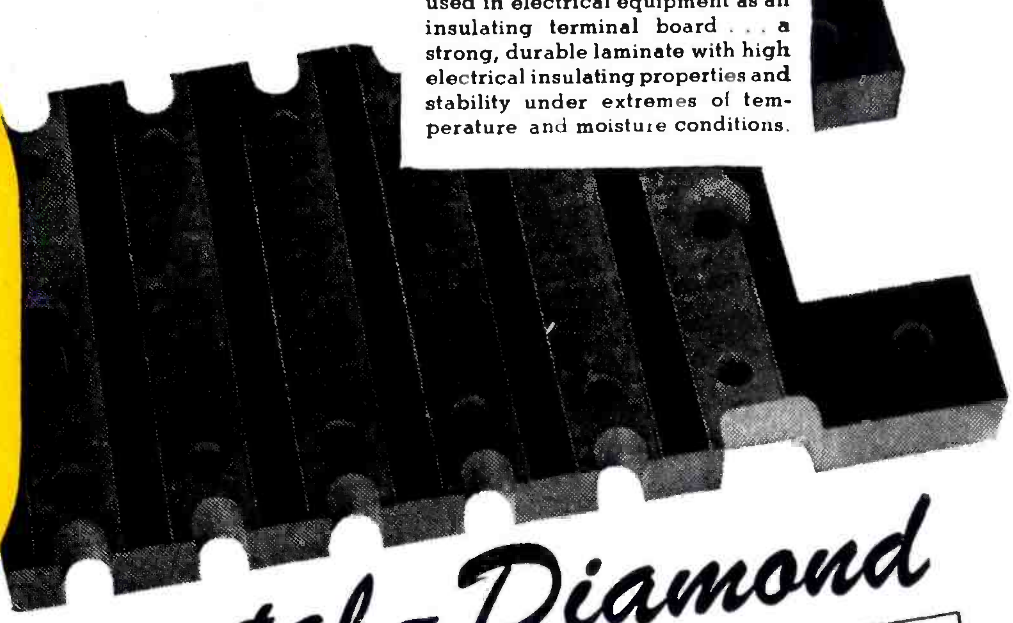
A.R.C. NO.	RATED D.C. OPERATING VOLTAGE	D.C. RESISTANCE	CONTACT ARRANGEMENT
11975	14	90	
12232	28	300	
11914	14	90	
12231	28	300	
11638	28	300	
7735	28	112	

For price and delivery information, write

AIRCRAFT RADIO CORPORATION

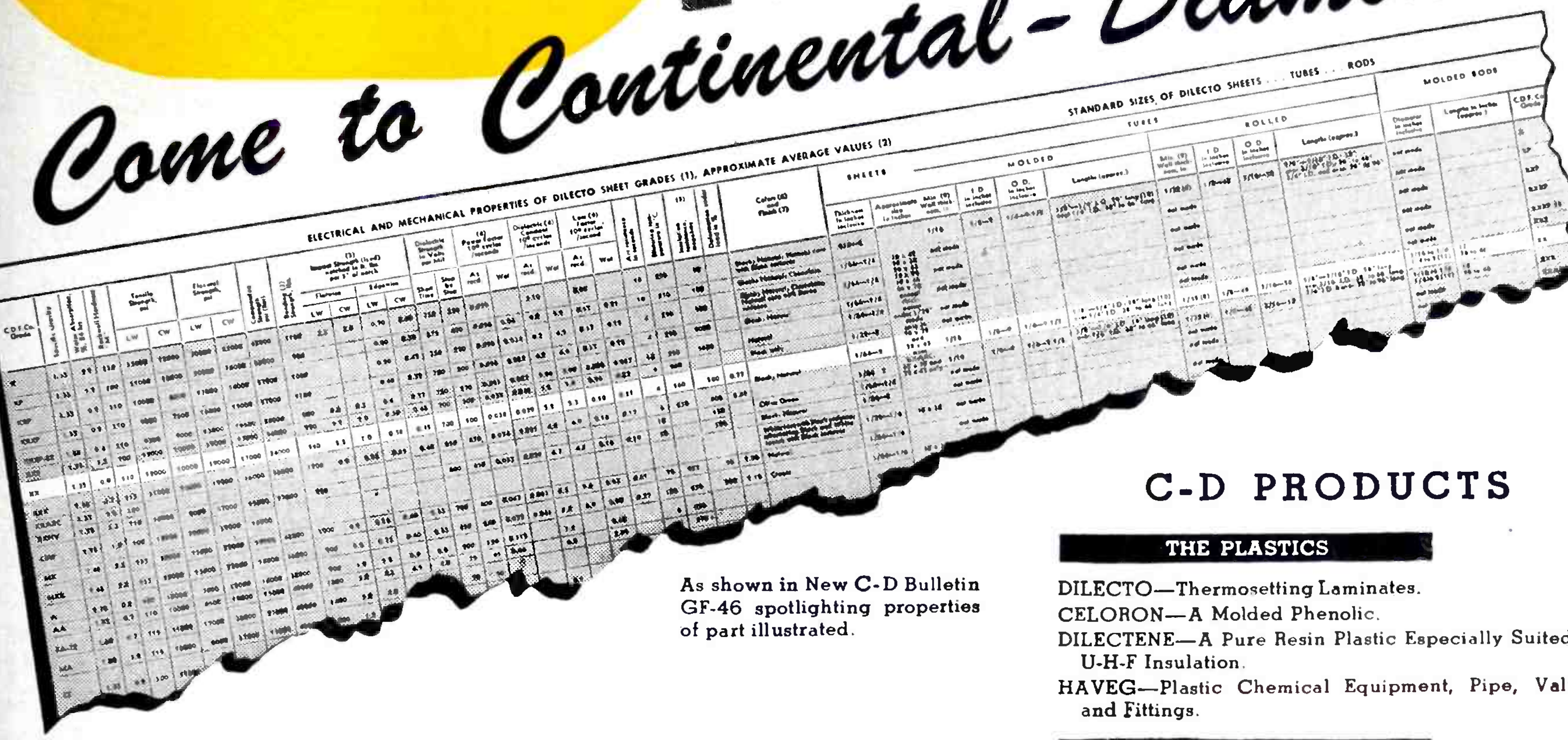
BOONTON, NEW JERSEY

For the "WHERE and HOW to use WHAT PLASTIC"



Paper base Grade XX Dilecto part used in electrical equipment as an insulating terminal board . . . a strong, durable laminate with high electrical insulating properties and stability under extremes of temperature and moisture conditions.

Come to Continental-Diamond



As shown in New C-D Bulletin GF-46 spotlighting properties of part illustrated.

For help in selecting and applying the non-metallic that will give you what you want in more effective insulation, let a C-D technician work it out with you. Make use of our research and engineering facilities which for half a century have kept up with the rising standards of product performance.

The right time to decide what material to use is while your product is in the planning stage . . . before blueprints and detailed specifications are completed. Save yourself costly errors in production and performance by knowing in advance the non-metallic that best meets your required electrical and physical properties.

As a starter, send for our new Bulletin GF-46 which contains engineering data on the complete line of C-D insulating materials.

SEE OUR CATALOG IN SWEET'S

SEC-46

C-D PRODUCTS

THE PLASTICS

DILECTO—Thermosetting Laminates.
CELORON—A Molded Phenolic.
DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.
HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

THE NON-METALLICS

DIAMOND Vulcanized FIBRE.
VULCOID—Resin Impregnated Vulcanized Fibre.
MICABOND—Built-Up Mica Electrical Insulation.

STANDARD & SPECIAL FORMS

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

DESCRIPTIVE LITERATURE

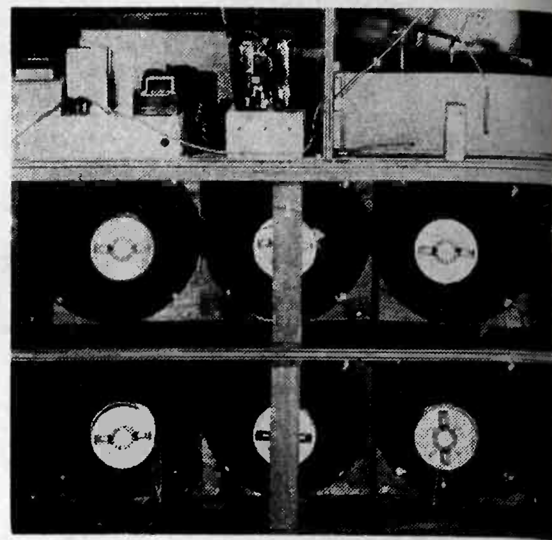
Bulletin GF gives Comprehensive Data on all C-D Products. Individual Catalogs are also available.

Continental • Diamond
C-D
Engineered Non-Metallics

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES
WEST COAST REPRESENTATIVES: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental-Diamond FIBRE COMPANY

Established 1895.. Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE triodes and two PX25 triodes, all in matched pairs. The rectifier is a 5U4G. Precaution against damage to the output tubes has been



Electronic portion, record changer, and loudspeakers of the London Reproducer as viewed from the back of the cabinet. The speaker arrangement is designed to provide 180-degree sound dispersal and avoid high-frequency beam effects

taken by providing individual cathode bias resistors and grid and anode series resistors that act as stoppers to stop parasitic oscillation.

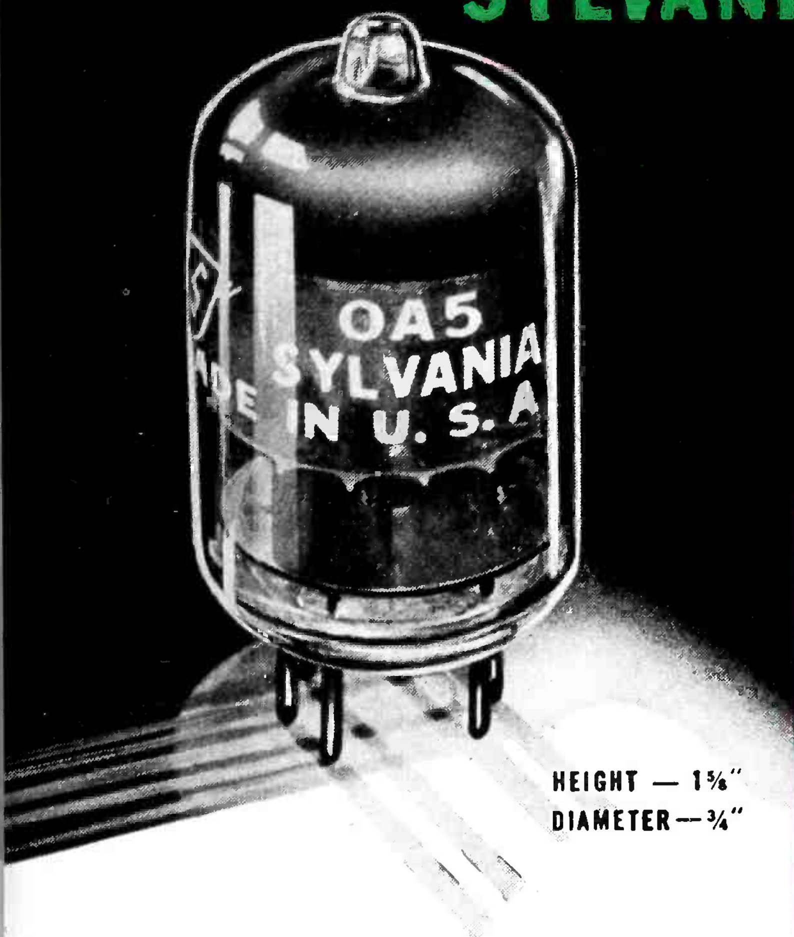
Power consumption in the London reproducer runs to 130 watts at 110 volts and the amplifier output is six watts at 1,000 cycles. It is unnecessary to have a higher wattage because of the efficiency of the speakers. This limitation on a circuit which is normally capable of producing about 12 watts at ordinary distortion levels results in an exceptionally low distortion figure, below one percent. The hum level runs around −50 db.

The record changer is a Garrard R.C. 60 which can play eight 10- or 12-inch records interchangeably. The needle armature unit is about the size of a half-walnut shell and places a weight of only 27 grams on the disc. The case of the pickup is of moulded plastic, the two halves being hinged at the rear and secured by a single screw. The sapphire point is free from self-resonance over the frequency range and has a radius which enables it to track the highest audible frequencies accurately.

Two models are available, one having three 12-inch p-m loudspeakers, the other having six. Of interest to designers of high-fidelity equipment who are price conscious, the London Reproduce

TRIGGERTUBE...

SYLVANIA'S NEWEST



—made specifically for electronic relay applications...

HERE'S a new 5-element, inert-gas filled, internally triggered cold cathode relay tube designed for operation up to 1000 volts on the anode, with a positive pulse on the control or trigger grid—a tube made specifically for triggering.

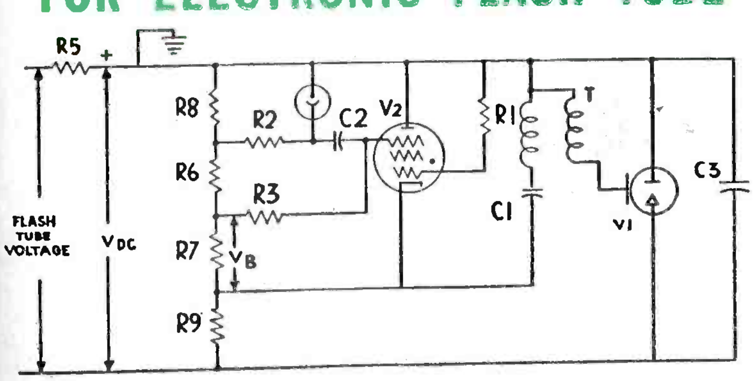
Its cathode structure is similar to that utilized in the well-known 1D21, SN4 type strobotron tubes which are mostly used for stroboscopic applications. This cathode design is characterized by its ability to furnish extremely high instantaneous peak currents—hundreds of amperes.

However, the design of the new Triggertube varies in that the delay time—time required to initiate the arc—as well as the deionization time, is greatly reduced as compared with previous triggering tubes. In addition, since this tube has been especially designed for trigger applications—applications which do not utilize the light flashes produced by the arc—it can be ideally utilized wherever stable characteristics and low switch current are important.

For example: electronic flash equipment in which externally triggered flash tubes can be readily controlled by a hand trip switch, built-in shutter synchronizing switches, or by a photocell.

Write address below for full specifications.

PHOTOCELL TRIPPING CIRCUIT FOR ELECTRONIC FLASH TUBE



R_1	Keep-alive current limiting resistor	20 megohms
R_2	Phototube resistor	0.25 megohm
R_3	Grid current limiting resistor	10 megohms
R_5	Power supply limiting resistor	
R_6, R_7, R_8, R_9	Phototube and Triggertube voltage divider	
C_1	Anode discharge condenser	0.25 µfd.
C_2	Trigger grid condenser	0.01 µfd.
C_3	Flash tube condenser	
T	Ignition coil condenser	
V_B	Trigger grid bias voltage	
V_1	Flash tube type R4330	
V_2	Type OA5 Triggertube	

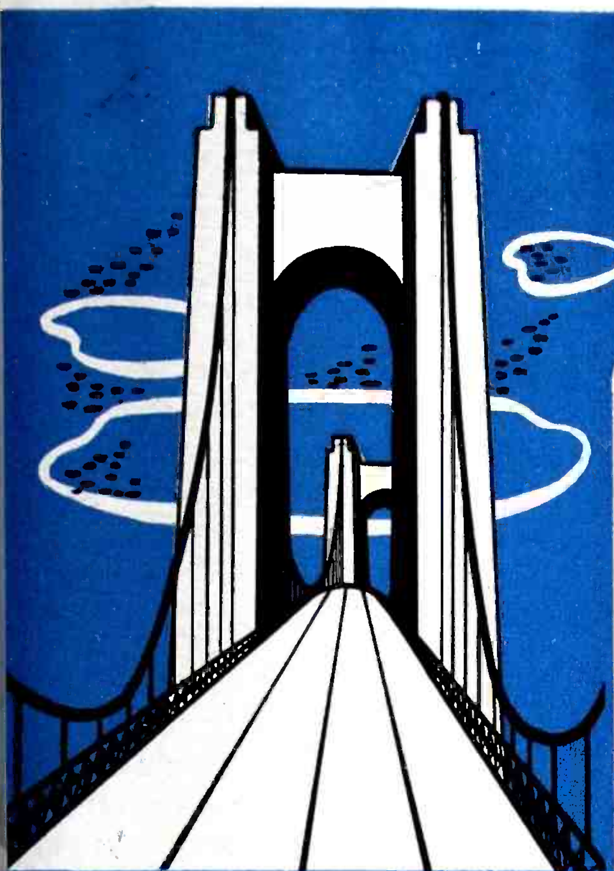
The OA5 is licensed under the tube patents of Edgerton, Germeshausen and Grier, but no license is implied under their circuit patents.

SYLVANIA ELECTRIC

Electronics Division . . . 500 Fifth Avenue, New York 18, N. Y.

MAKERS OF ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

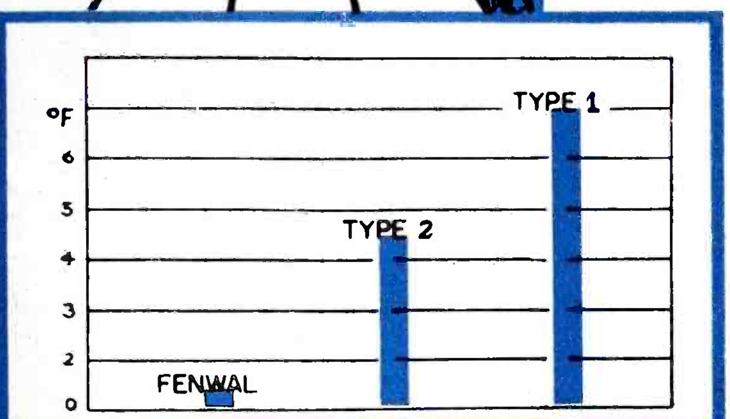
ELECTROSTATIC VOLTMETER



RUGGED DESIGN*

Efficient temperature detection and control practice calls for durability as well as sensitivity in the controlling instrument. The unique design of the Fenwal THERMOSWITCH Control embodies both great physical ruggedness and desirable performance characteristics. The Fenwal design provides double protection against abuse and mechanical shock — the extremely light and stiff bridge structure of the internal electrical assembly and the exceptionally strong outer shell. The patented structure of the internal assembly enables it to function in any position in spite of vibration and shock; the temperature sensitive outer shell is a cylindrical brass or stainless steel tube. This shell, normally 1/32″ thick, can be furnished in greater thicknesses for special applications. Additional ruggedness is afforded the THERMOSWITCH Control by selection of the model with mounting facilities best suited to the particular application. Chart shows the small change in the THERMOSWITCH Control set point, compared to the change in setting of two other thermostats under similar conditions, when the unit is subjected to a mechanical shock of 100G.

The Fenwal THERMOSWITCH Control stands out in the field of heat detection and regulation. Inherent in its unique design are many advantages that make it ideal for most applications that call for temperature regulation. Learn about these advantages. *Send for a copy of the Thermotechnics Booklet which explains the "Fourteen Facts in Fenwal's Favor".*



CHANGE IN CALIBRATION DUE TO 100G SHOCK

COUPLING HEAD THERMOSWITCH CONTROL

FOURTEEN FACTS IN FENWAL'S FAVOR

1.—Fast reaction time
2.—Large heat sensitive area, small heat storage
3.—Short heat transfer path
4.—Small temperature differential
5.—Built-in temperature anticipation
6.—Enclosed assembly
7.—Minimal vibration effects
8.—Tamper-proof and sealed
9.—Rugged construction*
10.—Adjustable over wide temperature range
11.—Minimum size
12.—Directly responsive to radiant heat
13.—Uniform sensitivity over adjustable temperature range
14.—Readily installed

*#9 of the "Fourteen Facts in Fenwal's Favor".

Fenwal

FENWAL INCORPORATED

43 PLEASANT STREET

ASHLAND MASSACHUSETTS

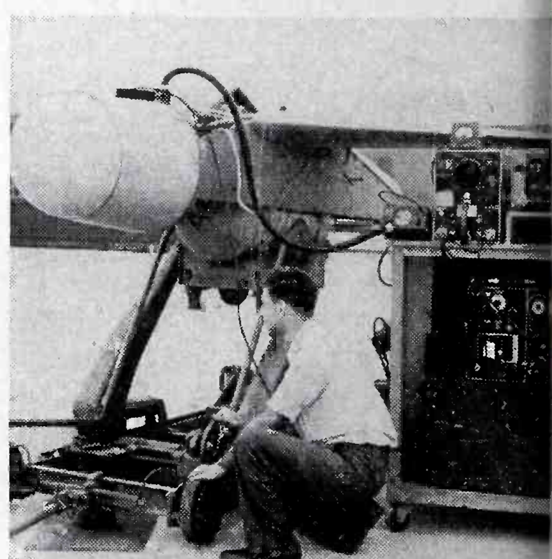
Thermotechnics for Complete Temperature Regulation ranges from $1495 to $2500. No tuner is provided, but space is available in the cabinet.

Radar-Guided Bomb

THE FIRST fully automatic guided missile to be used successfully in combat by any nation was the Bat, a flying bomb launched from a plane and guided to its target by radar. The name suggests the principle on which the weapon operates since live bats give out a short pulse of sound and guide themselves by the echo.

The Bat is a low-angle-of-flight, self-controlled airborne homing missile. It carries a bomb mounted in a glider type airframe (air stabilizer) which is equipped with a radar transmitter and receiver to provide directional correction, a gyroscopic stabilizing unit, and a servo system to move the control surfaces of the air stabilizer. The complete unit is carried by aircraft, suspended under a wing or below the fuselage.

The transmitting antenna, as well



Special electronic gear is used to check the Bat before it is loaded under the carrying plane

as the return pickup for the radar are in the nose, concealed by a half spherical wooden shell. The impulses are transmitted from a cross shaped antenna, the arms of the cross being about six inches across. Directly behind this is a 12-inch metal reflector, mounted off center. When the Bat is in flight, the reflector whirls rapidly with the same sort of gyration performed by a phonograph record off-center. Because of this eccentric movement it is possible for the gyro and rada

Speed Nuts*

Give You More Assembly Advantages

Than Any Other Nuts, Regardless of Price

NT VIBRATION LOOSENING

SPEED NUTS prevent vibration loosening because they provide a *double* spring-tension lock that *absorbs* vibration in-
f merely *resisting* it. Insures a
achment for the life of the product.

G TENSION RESILIENCY

In the assembly of porcelain enamel, plastic or glass parts, SPEED NUTS provide the tension necessary for a tight assembly, yet are sufficiently resilient to prevent damage due to expansion and con-
, vibration or shock.

IED FASTER

SPEED NUTS put wings on your assembly lines because they start easier, pull down faster and no wrench is required to keep them from turning. Made
r use with coarse-thread sheet
crews, requiring fewer turns to
for still faster application.

ATE LOCK WASHERS

You can boot lock washers out the window, for SPEED NUTS are self-locking. They cut both material and han-
sts. Because of their
aring surface, SPEED
lso can eliminate the
panner washers.

SELF-RETAINING

Many types of SPEED NUTS lock themselves in screw-receiving position for "blind" location assembly, eliminating expensive welding, riveting or clinching operations.

PERFORM MULTIPLE FUNCTIONS

Like a one man band, many special types of SPEED NUTS perform multiple functions, replacing two or more parts. SPEED NUT prongs can be incorporated in almost any shape or form to do the job easier and faster.

LOCK ON UNTHREADED STUDS

"Push-On" SPEED NUTS need only be pushed over rivets, nails, tubing, or unthreaded studs to lock parts so securely, you can't wrestle them off. Costly threaded inserts, drilling and tapping are eliminated—molding costs reduced—assembly speeded up.

WILL NOT CLOG

Having no threads, SPEED NUTS cannot clog with paint. No assembly delay for re-tapping threads. This is particularly important where SPEED NUTS are permanently attached to parts for blind assembly.

WILL NOT "FREEZE" TO THREADS

Having no threads, SPEED NUTS will not "freeze" to rusting bolts. They can be easily removed at any time for servicing or replacing. You'll save the repair men a lot of cussing.

WEIGH LESS

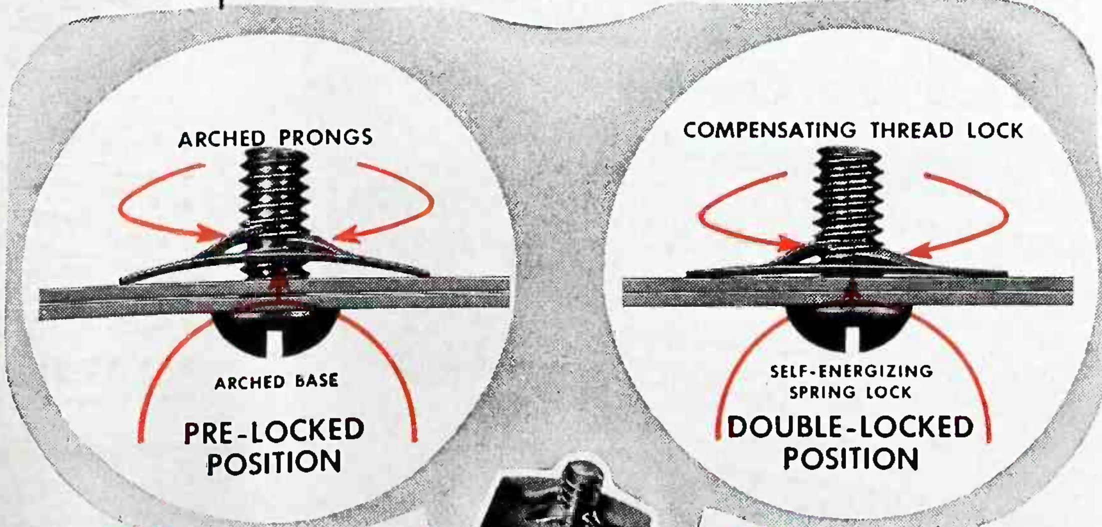
Because they are made of sheet metal instead of bar stock, SPEED NUTS are in the "featherweight" class compared with threaded nuts. By eliminating lock and spanner washers and other unnecessary parts, weight is reduced still further.

MINIMIZE SHIPPING DAMAGE

SPEED NUTS give you free insurance against shipping damage. They provide a resilient lock that defies loosening and prevents cracking of enamel and glass. With SPEED NUTS, your products will reach your customers in perfect condition.

SEND TODAY

We're not fooling about these advantages. They are very real and worth-while as any SPEED NUT user will tell you. Rush your assembly problems to us now, giving complete details. We'll show you which of the 4000 shapes and sizes will do the trick for you.



DA:
ce Barnes, Co., Ltd.
ton, Ontario
ND:
onds Aerocessories, Ltd.
n

IN FRANCE:
Aerocessoires Simmonds, S. A., Paris

IN AUSTRALIA:
Simmonds Aerocessories, Pty. Ltd., Melbourne

AN PRODUCTS, INC. **Speed Nuts*** 2106 Fulton Road, Cleveland 13, Oh

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

EST THING IN FASTENINGS . . . MORE THAN 4000 SHAPES AND SIZES

GRACOIL

"One Good Turn – or a Million"

★ Here, in expanded plant facilities, GRACOIL Coils and Transformers are expertly designed and built to exact specifications. Plan your next product with GRACOILS.

THE GRAMER COMPANY

Established in 1935

Electrical Coils and Transformers

2736 N. PULASKI RD., CHICAGO 39, ILL. U. S. A.

FOR RADIO AND ELECTRONICS

PARTS • SETS • EQUIPMENT

ask NEWARK *they'll have it!*

IF YOUR NEEDS in radio or electronics parts, sets or equipment are available anywhere, you'll save time by phoning or wiring Newark Electric. Tremendous, up-to-the-minute stocks are maintained in all three stores.

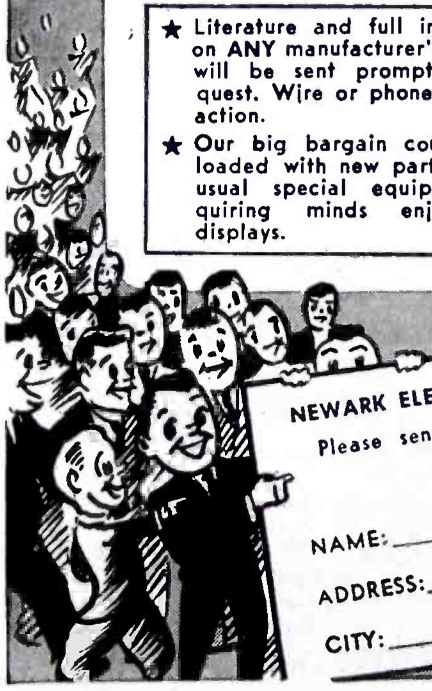
COMPETENT TECHNICAL MEN handle your inquiries intelligently and promptly and can quote prices and delivery dates on specific merchandise. Orders shipped same day. When writing address Dept. R-3

★ Literature and full information on ANY manufacturer's products will be sent promptly on request. Wire or phone for quick action.

★ Our big bargain counters are loaded with new parts and unusual special equipment. Inquiring minds enjoy these displays.

NEW YORK 242-50 W. 55th St. New York 19, N. Y. — NEWARK ELECTRIC COMPANY, INC — CHICAGO 323 W. Madison St. Chicago 6, Ill.

N.Y.C. Stores: 115 W. 45th St. & 212 Fulton St. Offices & Warehouse: 242 W. 55th St. N.Y. 19



NEWARK ELECTRIC COMPANY, INC. Dept R-3

Please send informative literature on the following:

NAME:

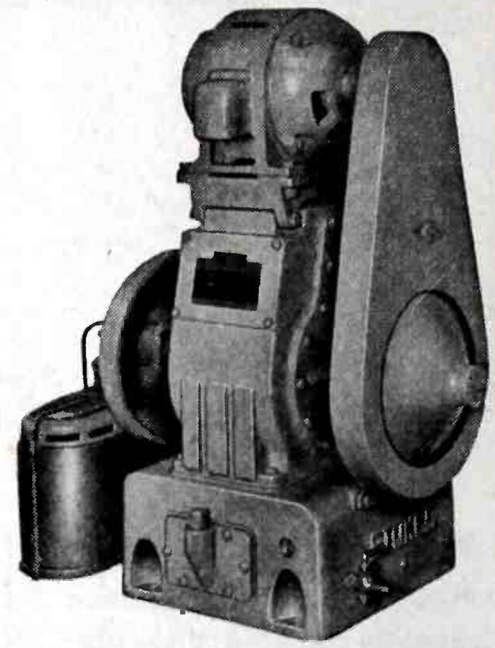
ADDRESS:

CITY: STATE:

P.A. Depts. in all stores. Set & Appl. Depts. in N. Y. C.

Stokes MICROVAC Pumps

HEART OF HIGH VACUUM SYSTEMS



- Higher Vacuum (in the low micron range)
- High volumetric efficiency
- Low power requirement
- Complete discharge of air —no re-expansion
- Continuous dehydration of oil—no moisture to re-evaporate
- Discharges sudden slugs of liquid without injury
- Easily accessible, non-corrosive discharge valve
- Rugged, compact, simple construction
- Long life . . . negligible maintenance
- Five sizes—from 10 to 235 cu. ft. per min.

Stokes VACUUM GAUGES

(Patented McLeod Type)

Are Always Accurate

- Require no calibration
- Rapid readings
- Simple to operate—just tip and read
- Two models (AA) 0 to 5000 microns—(BB) 0 to 700 microns, with readings to 1/10 micron.

F. J. STOKES MACHINE CO.
6046 Tabor Road Philadelphia 20, Pa.

Stokes *High Vacuum*
PUMPS • GAUGES • EQUIPMENT


THE VITAL LINK IN EVERY INDUSTRY...

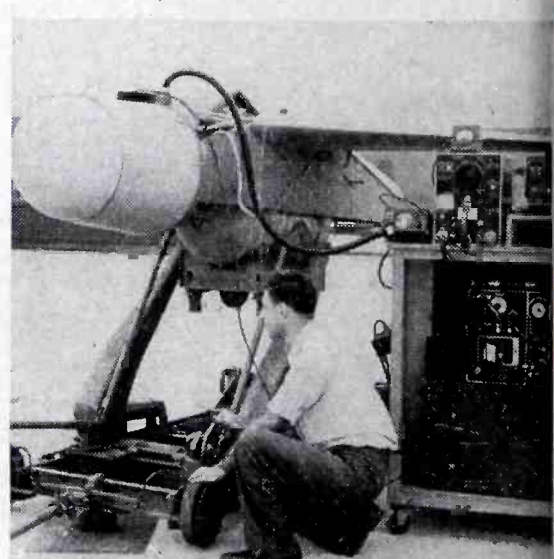
ranges from \$1495 to \$2500. No tuner is provided, but space is available in the cabinet.

Radar-Guided Bomb

THE FIRST fully automatic guided missile to be used successfully in combat by any nation was the Bat, a flying bomb launched from a plane and guided to its target by radar. The name suggests the principle on which the weapon operates since live bats give out a short pulse of sound and guide themselves by the echo.

The Bat is a low-angle-of-flight, self-controlled airborne homing missile. It carries a bomb mounted in a glider type airframe (air stabilizer) which is equipped with a radar transmitter and receiver to provide directional correction, a gyroscopic stabilizing unit, and a servo system to move the control surfaces of the air stabilizer. The complete unit is carried by aircraft, suspended under a wing or below the fuselage.

The transmitting antenna, as well



Special electronic gear is used to check the Bat before it is loaded under the carrying plane

as the return pickup for the radar, are in the nose, concealed by a half-spherical wooden shell. The impulses are transmitted from a cross-shaped antenna, the arms of the cross being about six inches across. Directly behind this is a 12-inch metal reflector, mounted off center. When the Bat is in flight, the reflector whirls rapidly with the same sort of gyration performed by a phonograph record off-center. Because of this eccentric movement, it is possible for the gyro and radar

GRACOIL

"One Good Turn — or a Million"

★ Here, in expanded plant facilities, GRACOIL Coils and Transformers are expertly designed and built to exact specifications. Plan your next product with GRACOILS.

THE GRAMER COMPANY

Established in 1935

Electrical Coils and Transformers

2736 N. PULASKI RD., CHICAGO 39, ILL. U. S. A.

FOR RADIO AND ELECTRONICS

PARTS • SETS • EQUIPMENT

ask NEWARK *they'll have it!*

IF YOUR NEEDS in radio or electronics parts, sets or equipment are available anywhere, you'll save time by phoning or wiring Newark Electric. Tremendous, up-to-the-minute stocks are maintained in all three stores.

COMPETENT TECHNICAL MEN handle your inquiries intelligently and promptly and can quote prices and delivery dates on specific merchandise. Orders shipped same day. When writing address Dept. R-3

★ Literature and full information on ANY manufacturer's products will be sent promptly on request. Wire or phone for quick action.

★ Our big bargain counters are loaded with new parts and unusual special equipment. Inquiring minds enjoy these displays.

NEW YORK 242-50 W. 55th St. New York 19, N. Y.
NEWARK ELECTRIC COMPANY, INC.
CHICAGO 323 W. Madison St. Chicago 6, Ill.

N.Y.C. Stores: 115 W. 45th St. & 212 Fulton St. Offices & Warehouse: 242 W. 55th St. N.Y. 19

Dept R-3
NEWARK ELECTRIC COMPANY, INC.
Please send informative literature on the following:

NAME: ____________

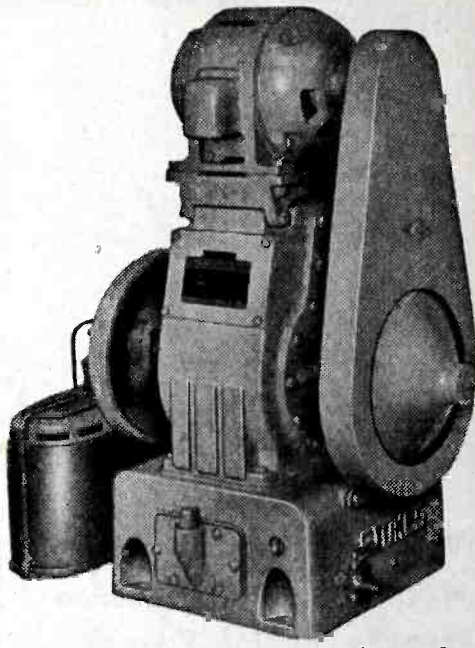
ADDRESS: ____________

CITY: ____________ STATE: ____________

P.A. Depts. in all stores. Set & Appl. Depts. in N. Y. C.

Stokes MICROVAC Pumps

HEART OF HIGH VACUUM SYSTEMS



- Higher Vacuum (in the low micron range)
- High volumetric efficiency
- Low power requirement
- Complete discharge of air —no re-expansion
- Continuous dehydration of oil—no moisture to re-evaporate
- Discharges sudden slugs of liquid without injury
- Easily accessible, non-corrosive discharge valve
- Rugged, compact, simple construction
- Long life . . . negligible maintenance
- Five sizes—from 10 to 235 cu. ft. per min.

Stokes VACUUM GAUGES

(Patented McLeod Type)

Are Always Accurate

- Require no calibration
- Rapid readings
- Simple to operate—just tip and read
- Two models (AA) 0 to 5000 microns—(BB) 0 to 700 microns, with readings to 1/10 micron.

F. J. STOKES MACHINE CO.
6046 Tabor Road Philadelphia 20, Pa.

Stokes *High Vacuum*
PUMPS • GAUGES • EQUIPMENT

WILCO CONTACTS

WILCO PRODUCTS INCLUDE:

CONTACTS
Silver - Platinum - Tungsten - Alloys
Sintered Powder Metal

THERMOSTATIC BIMETAL
All temperature ranges, deflection rates and electrical resistivities.

SILVER CLAD STEEL
JACKETED WIRE
Silver on Steel, Copper, Invar or other combinations requested.

ROLLED GOLD PLATE AND WIRE

NI-SPAN C*
New Constant Modulus Alloy

SPECIAL MATERIALS

*Reg. Trade Mark, The International Nickel Co., Inc.

WILCO

They keep the power flowing!

Modern industry utilizes WILCO CONTACTS in frequency operations of every range both because of their longer service life and because they assure maximum ductility, hardness, density, freedom from sticking, low metal transfer, high conductivity and arc-resistance.

These same peerless WILCO qualities of stamina and precision performance—assured by exclusive WILCO processes—will keep the power flowing in *your* products. WILCO engineers will gladly help you select from a great variety of available WILCO contact materials the particular contacts suited to your needs—or develop new alloys for special purposes.

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, N. J. • *Branch Offices:* Chicago, Detroit, Los Angeles, Providence

PECIALISTS FOR 30 YEARS IN THE MANUFACTURE OF THERMOMETALS • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS

pickup to determine whether the impulses bouncing off the target are coming from the right or the left.

In directing the course of the Bat, the radar unit and gyro work together, the gyro transmitting to the servo unit proper instructions to keep the bomb on even keel, and the radar at the same time transmitting directions to the servo for any necessary changes in course.

The servo manipulates the control surfaces of the wings of the bomb. The weapon is not propelled; the power for the glide is obtained from the speed at release and the pull of gravity.

Operation

The target is located by the standard search radar of the plane. The plane is then headed toward the target and the radar transmitter and receiver in the weapon are directed toward the selected target. The target data from the radar in the missile are displayed on a separate electronic indicator, mounted in the parent plane, which is controlled and interpreted by the operator. After the radar equipment is manually adjusted it is switched to automatic tracking. The plane is maneuvered to aim the Bat.

After release, the missile is completely self-controlled and automatically homes on the selected target. The plane is free to pursue any desired course of further attack or evasion.

Directional correction of the weapon is obtained through the illumination of the target by the radar transmitter in the Bat. Thus echos from the target are continuously detected by the radar receiver and the output to the flight control units indicates the direction of the target with respect to the axis of the missile.

The Bat is approximately 12 feet long, and has a 10-foot wing span. Its speed is comparable to that of high-speed aircraft and its range great enough to allow the mother plane to operate well out of the enemy's longest-range anti-aircraft fire. This missile was developed by the Bureau of Ordnance of the U. S. Navy to accomplish long-range, high-accuracy bombing from aircraft regardless of visibility conditions of the target. Though de-

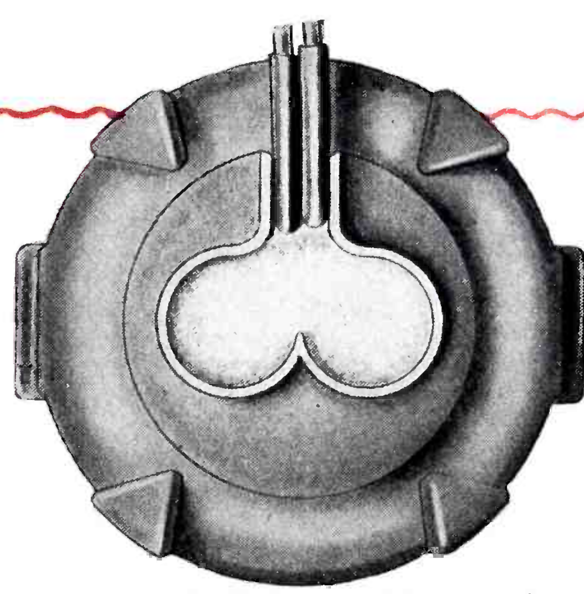
Fibron #5373
flexible plastic tubing

Here is another application where this improved Irvington formulation . . . Fibron #5373 . . . solves an electrical insulation problem involving high temperatures. Hot cement, used to seal the #5373-covered heating elements, has no effect on the flexibility of this unusual plastic. When the heater is in use, the tubing withstands continuous operating temperatures as high as 85° C. #5373 possesses the electrical, mechanical, and chemical properties which distinguish all Fibron tubings. Some of these are:

Dielectric Strength (.020″ wall)	wet	1000 V.P.M.
	dry	1000 V.P.M.
Tensile Strength, P. S. I.		3000
Life at 105° C.		2000 hours

Fibron #5373 tubing is available in all standard B & S wire gauge sizes, in six brilliant colors, in heavy wall thicknesses if required—in 36″ lengths, coils, or cut pieces.

Test this unusual product now. Generous samples and additional technical information gladly sent on request.



**Approved by Underwriters' Laboratories for this application*

Short lengths of Fibron #5373 are used to protect the conductor leads on the heating element of the Electra-Serve, manufactured by Electrical Industries, Inc., Newark, N. J. This bottom view of the unit shows where the hot cement seals over the #5373 insulation. Withstanding this heat and high operating temperatures, #5373 tubing retains its flexibility and high dielectric strength.

STANDARD OF THE WORLD IRVINGTON INSULATION TRADE MARK REG. U.S. PAT. OFF.

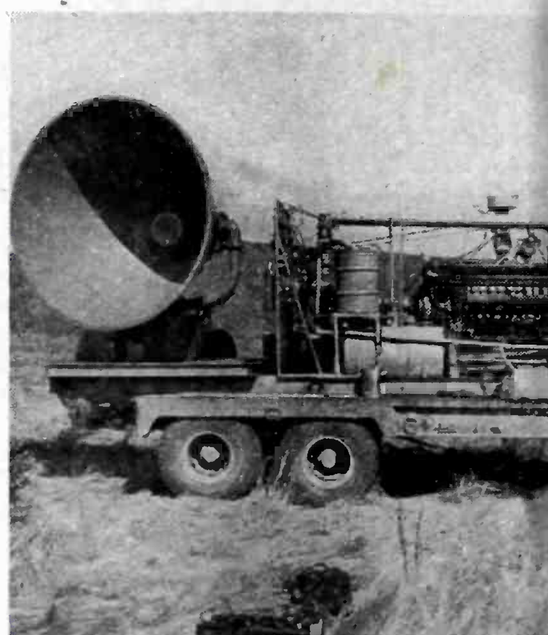
IRVINGTON *Varnish and Insulator Company* IRVINGTON 11, NEW JERSEY, U.S.A.

Authorized distributors in: BALTIMORE · BLUEFIELD, W. VA. · BOSTON · CHARLOTTE · CHICAGO · CLEVELAND · DALLAS · DENVER · LOS ANGELES · MINNEAPOLIS · NEW HARTFORD, N. Y. · NEW YORK · NEW ORLEANS · PHILADELPHIA · PITTSBURGH · ST. LOUIS · SAN FRANCISCO · SEATTLE · HAMILTON, ONT., CANADA

signed primarily for use against sea targets, under certain conditions it may be effectively used against land targets.

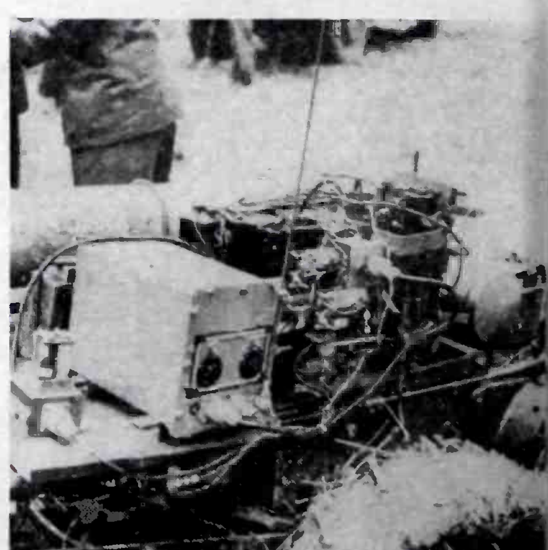
The Bat may be carried by carrier fighters or other shipborne aircraft as well as Navy Privateers. The flight characteristics of the aircraft are only slightly affected by the Bat, and flight operations are not at all affected.

ULTRASONIC DEFOGGER



Although not itself intended to disperse fog, the machine shown above is used experimentally by Ultrasonic Corporation to determine the requirements of equipment which it is hoped will disperse fog ultrasonically. In the laboratory, fog particles bombarded by sound waves collide, form masses heavy enough to fall as rain

GUIDED MISSILE PLOWSHARE



Radio control equipment used in the Queen Bee, target plane for AA practice, has been adapted to control an English farm tractor

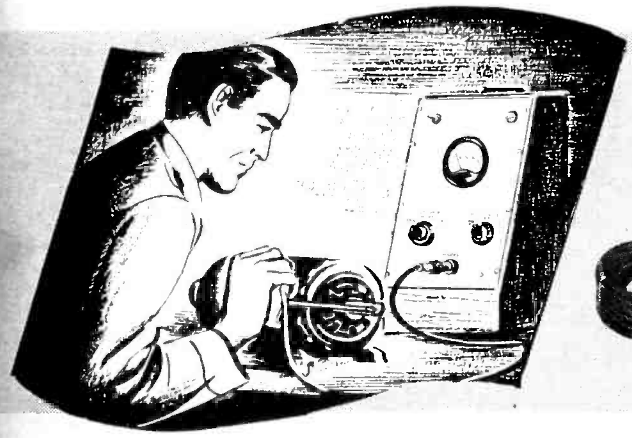
Accurately detects sources of wear, strain and noise . . . . .

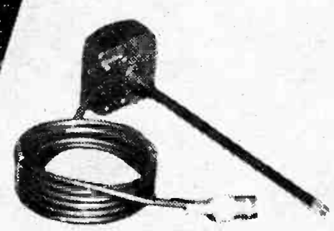
The

TELEVISO

MODEL 11-B

VIBROMETER





● The Televiso Model 11-B Vibrometer electronically measures the ibration characteristics of any moving surface instantly and accu- ately. Unnecessary wear, strain and noise no longer need be tolerated n industrial machinery, and in the integral parts of products.

'he Vibrometer is an invaluable design aid. It prevents breakdowns, ocates trouble, speeds production, reduces rejects.

t is particularly useful in measuring the vibration in motors, gears, earings, rotors, fans, propellers, presses, aircraft structures, stokers, tc. Ninety-five percent of all vibration measurements needed by in- lustry are covered.

ll three types of vibration are registered on a calibrated meter scale: *isplacement,* where the vibration may be felt but not seen; *velocity,* vhere the vibration is minute; *acceleration,* where the vibrating sur- ace is small.

'onsisting of an integrated, amplified vacuum tube voltmeter with a able-attached piezo-electric Rochelle salt crystal search prod; the 'ibrometer is equipped with interchangeable fittings which permit nnumerable applications.

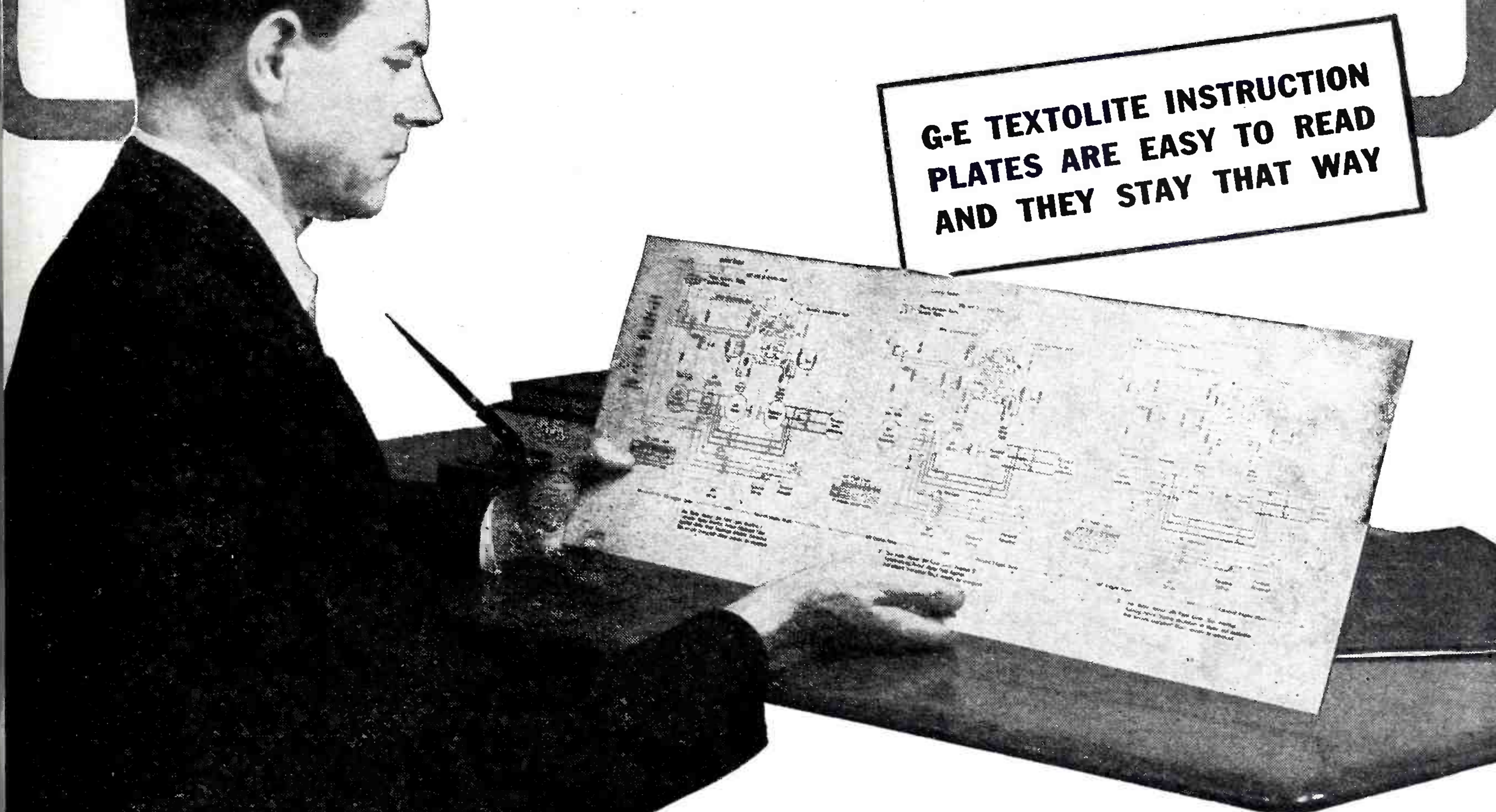
turdily constructed and portable, the Vibrometer is practical for eld, laboratory and production use. Operation is simple. Write today or complete technical data.

Specifications

Operation:	105-125 volt, 50-60 cycle, power.
Frequency Response with Search Prod Plugged in:	5-2500 cps., uniform within 2%. Correction graph to 2 cps. can be supplied.
Weight:	31 pounds.
Size:	17″ high, 12″ deep, 11½″ wide, 10° slope.
Displacement Range:	5 ranges, 0-.01″, 0-.03″, 0-.1″, 0-.3″, 0-1″ in RMS displacement.
Velocity Range:	5 ranges (in inches per second), 0-1, 0-3, 0-10, 0-30, 0-100.
Acceleration Range:	5 ranges (in inches per second per second), 0-100, 0-300, 0-1000, 0-3000, 0-10,000.
Output Jack:	Available at rear of Vibrometer for use with phones, oscillograph, wave analyzer, or recording devices.
Construction:	All aluminum mechanical components housed in a solid oak, copper lined cabinet. The black, wrinkle-finish panel is engraved.
Guaranty:	The Vibrometer is guaranteed for two years.

Televiso
PRODUCTS CO.
7466 IRVING PARK ROAD
CHICAGO 34, ILLINOIS

HOW TO PRESERVE A SCHEMATIC DIAGRAM



Here's a schematic diagram that will last as long as the equipment on which it goes—in years to come, maintenance men will be able to get at a glance the information they need.

It's made of tough and durable G-E Textolite laminated plastics and has good chemical, weathering, and impact resistance—excellent electrical insulating properties too. The precise drawing in red and black is quick to read, and strong construction insures this readability for many years.

G-E Textolite instruction plates, control dials, charts, and nameplates have proved superior to those made with other materials in many applications, and so that various application requirements can be met satisfactorily and economically, several types are available—Graphic, Engraved, Printed, Stamped, or Embossed.

Why not investigate the possibility of preserving that important product information on your equipment with G-E Textolite instruction plates. Write to Section S-6, General Electric Company, Plastics Division, Chemical Department, One Plastics Avenue, Pittsfield, Mass.

G-E TEXTOLITE IS SUPPLIED IN THE FOLLOWING FORMS:

Sheets, tubes and rods | Fabricated parts | Molded-laminated parts
Post-formed laminates | Instruction plates | Translucent laminates
Low-pressure molded parts

EVERYTHING IN *Plastics*

GENERAL ELECTRIC

CD-46-E10

GENERAL ELECTRIC PLASTICS FACTORIES ARE LOCATED IN
Ft. Wayne, Ind. — Meriden, Conn. — Scranton, Pa.
Taunton, Mass. — Lynn, Mass. — Pittsfield, Mass.

INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Fault Locator for Power Lines

THE CIRCUIT OF AN instrument for location of accidental grounds on overhead electric power distribution lines is shown in the diagram. These grounds are frequently not visible by patrolling the lines, and may occur on any one of numerous lateral taps of the main primary circuit. Lightning arresters, particularly the older types still in service in large numbers, are frequent offenders.

Before using the instrument, the fault circuit is energized from the normal power source through a capacitor. The resulting current flow can then be followed with the fault locator directly to the fault location. The sensitivity of the electronic fault locator permits following rural primary lines by car at a distance of 100 yards or more.

An electrostatically shielded loop antenna consisting of 1,500 turns of enameled wire wound in a steel housing is used to pick up the fault current. A shielded cable conducts the signal from the loop to the input of the amplifier. The loop coil is connected in series with an iron-cored reactor, and a capacitor tunes this combination to resonance. Two additional tuned circuits are contained in two following stages of the amplifier.

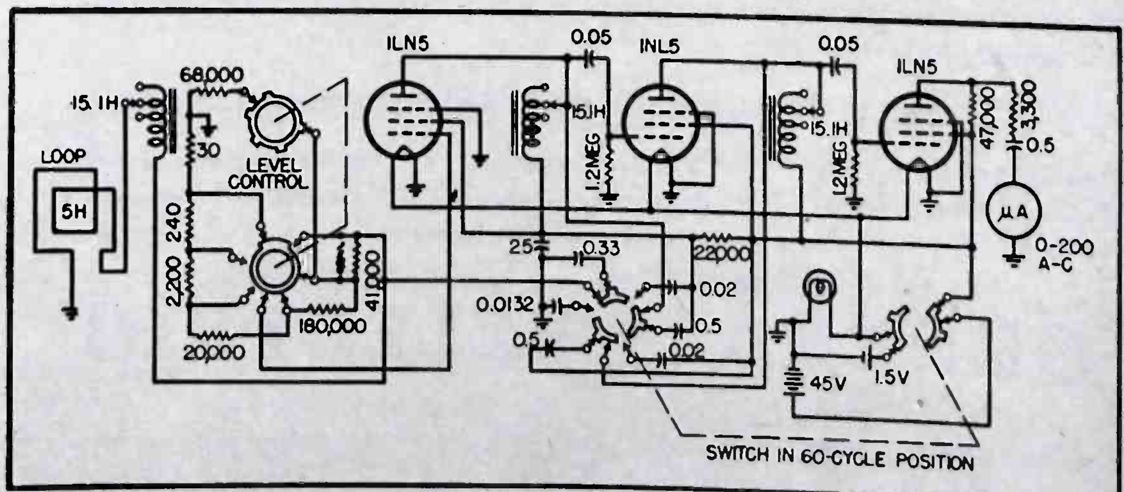
A step attenuator which changes the gain approximately 3 to 1 between adjacent taps is connected between the first tuned circuit and the grid of the first amplifier tube so that amplifier overload does not take place, provided the meter pointer is kept on scale.

Stability

The iron-cored inductances are designed to eliminate changes in inductance as the signal input level varies. This insures that the circuits will remain tuned to the desired frequency regardless of input signal levels. The three tuned circuits provide selection to either of two desired tracing frequencies, 60 or 300 cycles. The sensitivity of the overall instrument is such that good readings are obtained at 10 feet from unshielded 300-cycle currents of 0.0002 ampere or less. When the frequency selector switch is placed in the 300-cycle position, the response to 60-cycle pickup is down approximately 1,000 to 1.

One effect of feeding the faulted circuit with a capacitor is to produce a high percentage of harmonic currents. The equipment is sharply tuned to one of the harmonics for discriminating against signals resulting from nearby circuits carrying normal currents. A second effect of the capacitor feed is to limit the flow of current in the faulted circuit to a safe value. A protective fuse is used with the capacitor, which may be a 15-kva phase-correcting type.

The detector may also be tuned to any frequency not harmonically related to 60 cycles, for use with a special tracing signal generator such as a buzzer or tone generator. According to the manufacturer, Raytron, Inc. of Jackson, Michigan, underground cables can also be checked for faults provided that the fault is broken down to a low resistance by the capacitor feed method, and the tracing current does not flow along the sheath to low-resistance grounds past the fault. In such cases, the signal is followed above ground with the loop and locator.



Circuit of low-frequency amplifier for tracing fault currents on power transmission lines

Supersonic Flaw Detector

During the war, the Reich Government offered a prize for a method of testing for faults in metals that cannot be tested by x-ray or magnetic methods.

These faults are in the nature of "doubling" that occurs when metal is being rolled, as a result of bubbles that existed in the metal before rolling began. With so much sheet aluminum alloy being used in aircraft manufacture it was obviously important that flaws should be detected before flight.

One method of doing this is to pass high current through the test sheet and to measure the voltage drop between various points. This method is workable but the accuracy depends very much on surface conditions.

The method eventually adopted by the Nazis employed a quartz crystal operating at a frequency of one mc as a generator, with the frequency wobbled 100 cycles to avoid standing waves in the test sheet or between the transmitter and receiver.

The vibrations pass from the transmitter through a metal block,

Graphite has Everything

YOU WANT IN AN ANODE!

CANNOT DISTORT!

"National" graphite has no melting point! It cannot melt or soften. This, plus the fact that graphite has a low coefficient of expansion and a high heat transfer rate, is the reason graphite will not warp or distort, regardless of operating temperature.

UNMATCHED THERMAL CONDUCTIVITY!

Because "National" graphite has a higher thermal conductivity than other anode materials, it provides greater protection from excess surface temperature — a cause of secondary or back electron emission. It also lessens the danger from local hot spots so often found in other anodes — the result of thin spots or concentrations of the electron stream.

GREATER THERMAL EMISSIVITY!

"National" graphite is almost an ideal black body, making it a nearly perfect heat radiator. Thus, anodes of "National" graphite operate at lower temperatures for a given amount of energy dissipated. All tube parts therefore operate at lower temperatures, resulting in less distortion of other parts and more uniform tube characteristics.

In addition... "National" graphite has exceptional purity... great strength... fine grain structure... high resistance to erosion... is a good conductor, especially at high frequencies... is free from dust and loosely held particles... provides low electron emission... and can be machined into intricate shapes to very close tolerances.

Yes... anodes of graphite have everything you need to turn out finer tubes. For more facts, write National Carbon Company, Inc., Dept. E.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation
The word "National" is a registered trade-mark of National Carbon Company, Inc.

UCC

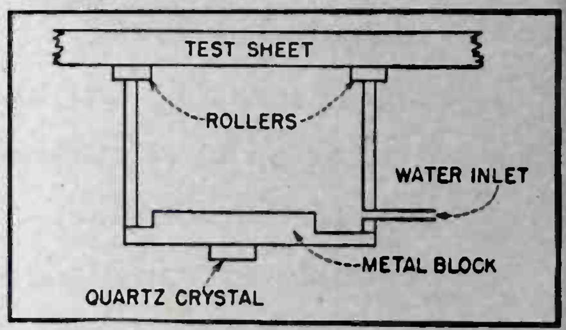
30 E. 42nd St., New York 17, N. Y.
Division Sales Offices: Atlanta, Chicago, Dallas
Kansas City, New York, Pittsburgh, San Fran-

so as not to expose the quartz crystal to water, and thus simplify the insulation problem. Water is admitted to the test chamber by the inlet and is allowed to escape where the chamber makes contact with the sheet being tested, by means of rollers. These rollers maintain the gap constant at 0.5 mm and also facilitate movement of the transmitter.

The continuously flowing water maintains good acoustic contact, even during motion of the sheet, by not permitting air to enter and form bubbles.

Receiver

The receiver is somewhat similar to the transmitter, acoustic contact being again maintained with water,



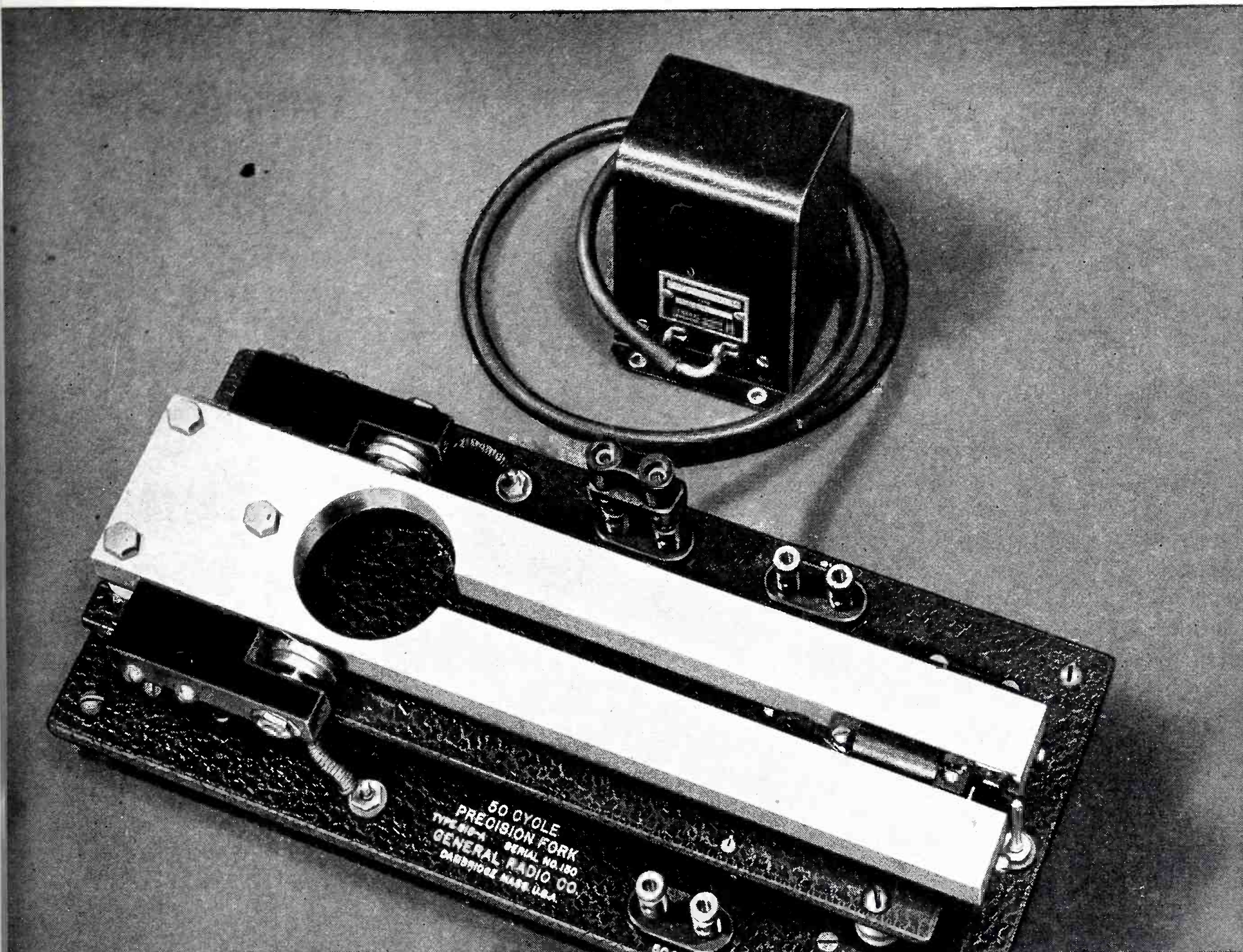
Transmitter unit of the supersonic flaw detector for sheet metal

except that there are two outlets, one at the test sheet and one in the walls of the chamber, so that bubbles formed in the chamber may escape. This is necessary because the main opening is very small in the case of the receiver.

The transmitter and receiver were mounted on long tongs and were pressed into contact with the test sheets by hand or by springs. The apparatus was apparently successful and even rapid movement across the sheet did not interrupt contact. Tests, however, showed that an air gap between the work and the transmitter or receiver was very serious and even one of 10^{-4} mm caused a 99 percent drop in transmission, hence the necessity for avoiding air bubbles. Rust or slag also caused a drop but not so much and since the metal tested would generally be smooth the apparatus was probably very useful.
—J. H. J.

Resin Adhesives for R-F Heating

IN DIELECTRIC heating for gluing of wood, the molecular friction will



TEN PARTS PER MILLION

. . . . and a few in stock!

Where the ultra refinement of temperature control is not required, the G-R Type 815 Precision Forks have more than sufficient accuracy for use both in the laboratory and in the field. They are supplied in frequencies of 50, 60 and 100 cycles with a calibration accuracy of ten parts per million. They make excellent low-frequency standards.

Stock for the forks is low-temperature-coefficient stainless steel, received by us in bars. A sample fork is made from each bar and the coefficient of the stock is obtained after a protracted temperature run.

The forks are then machined in our shops. When measured to one millicycle, the unmounted fork is about 2 cycles below its nominal frequency. After this initial measurement, the excess material is milled from the end of the tines and a second frequency check is made. Occasionally the forks must be milled a second time.

Two adjustable loading screws are placed in holes drilled and tapped in the end of each tine. The fork is then assembled and the temperature coefficient of the outer tine screw is obtained. If necessary, excess material is removed from the outer tine screw. The screws are adjusted so that the frequency is within ±0.001% of its nominal value. The voltage coefficient of frequency is obtained; it averages about 0.005%. Output voltage and harmonic content are then measured.

When orders are received the forks are returned to the standardizing laboratory, given a half-hour run and the frequency is measured at a driving voltage of exactly four volts. With each fork a calibration certificate is supplied to show: the frequency to within ±0.001% at a stated temperature between 70 and 80 deg. F.; the temperature and voltage coefficients of frequency.

TYPE 815-A	50-CYCLE FORK	$175.00
TYPE 815-B	60-CYCLE FORK	185.00
TYPE 815-C	100-CYCLE FORK	185.00
TYPE 815-P1	Transformer (for use between the fork and relatively high-impedance loads)	6.95

AT THE MOMENT WE HAVE A SMALL STOCK OF THESE FORKS

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

vary with the moisture content and density of the wood, neither of which are entirely uniform, and there will be more or less resulting variation in the heat of the wood. The degree of variation is seldom significant, but should not be overlooked.

It is desirable to keep the heat of the wood below the boiling point of water to avoid internal steam pressure and a temperature no higher than 180 F is desirable. At a glue line temperature of 100 F, Amberlite PR-115, a resorcinol-formaldehyde resin, and Uformite CB-552, a urea-formaldehyde resin adhesive, will attain cure in about 90 minutes; at 125 F, 15 and 25 minutes respectively; at 150 F, 3 and 8 minutes; and at 175 F, one and three minutes.

It is therefore important to regulate the temperature and time to secure an initial grip in the glue joint before heat and pressure are released, since further adequate cure will come from the heat stored in the wood or even at normal room temperatures.

Both resins produce highly water-resistant joints. Bonds made with Uformite CB-552 are adequate for products used indoors and in protected locations, while those made with Amberlite PR-115 are more durable than the wood itself and are adequate for weather exposure and the severe service required for boats and marine structures. Both are made by Resinous Products and Chemical Company of Philadelphia.

Materials Tester

WHEN A BEAM of ultrasonic vibrations impinges on a specimen, the energy of the signal is redistributed by several distinct processes. The three general effects are reflection, transmission, and absorption — analogous to light, heat, or audible sound behavior. However, because the wavelengths involved are comparable to the length of travel in portions of specimens frequently examined, and because ultrasonic transmission is a mechanical phenomenon, certain information about the mechan-

IRON SLEEVE CORES

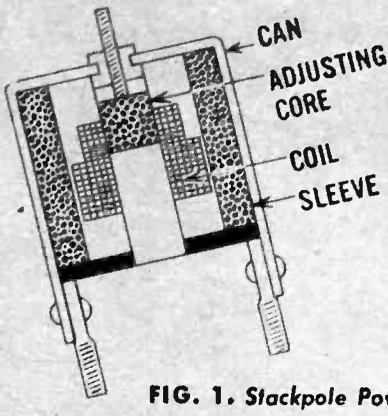


FIG. 1. *Stackpole Powdered Iron Sleeve and Core used for Diode Transformer (I-F); Antenna, Oscillator, or Filter Coils, etc.*

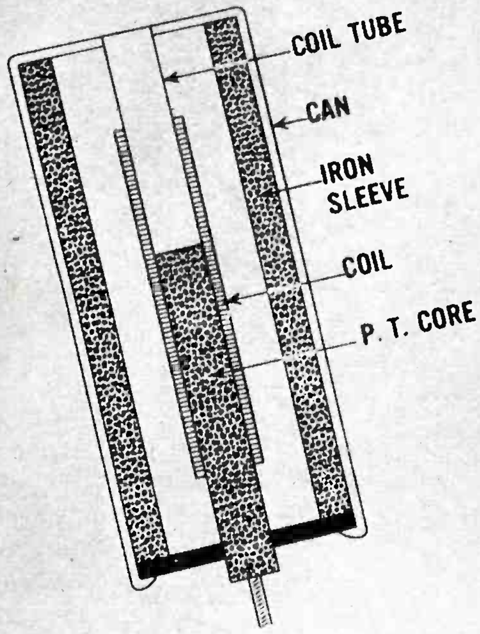


FIG. 2. *Grade SK1 core and powdered iron sleeve (.790 O. D. x 1½" long) used with permeability tuning in auto radio receiver.*

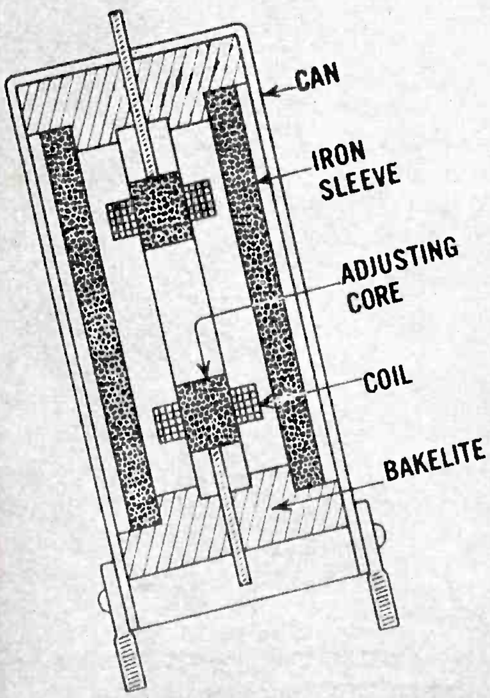
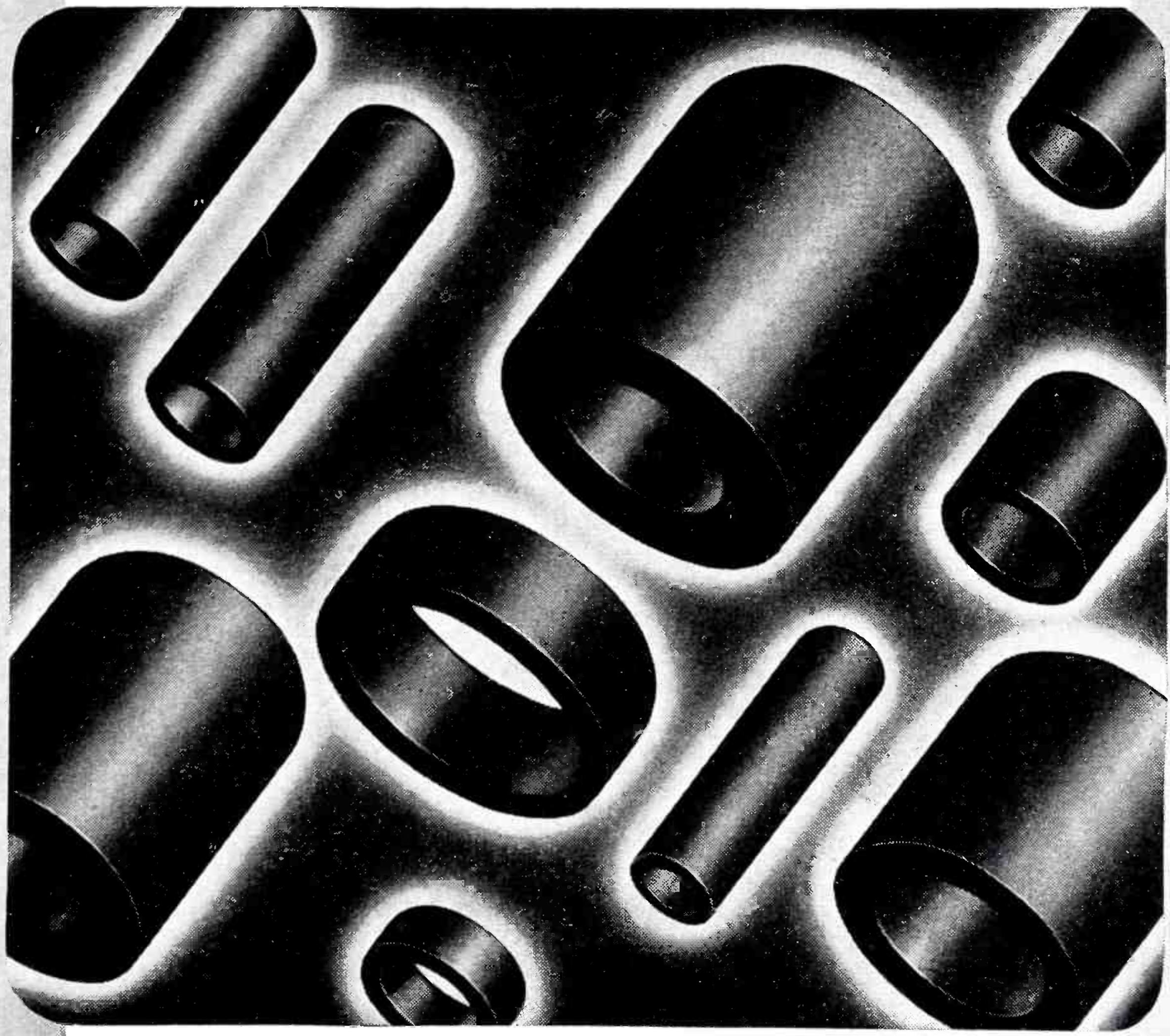


FIG. 3. *Two Stackpole cores and powdered iron sleeve used in a double tuned I-F transformer application.*



The Modern Answer to Better Coils in Less Space

BY USE of Stackpole Sleeve Cores, much smaller cans *of any material* may be used to provide Q that is equal to or better than that of conventional coils and cans. Thus they pave the way to an exceptionally high order of tuning unit efficiency in greatly reduced size. A few of many design possibilities are indicated in the accompanying sketches.

Beside supplying additional electrostatic and electromagnetic protection over that provided by the can alone, sleeve cores result in making the can itself smaller, less critical and less costly. Inexpensive die cast lead cans, for instance, may be used instead of aluminum. In some cases, it may not even be necessary to use a can.

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

EXPORT: Stackpole Carbon Co., 254 W. 34th St., New York 1, N. Y., U. S. A.

STACKPOLE

ELECTRICAL BRUSHES AND CONTACTS (*All carbon, graphite, metal and composition types*) **• RARE METAL CONTACTS • WELDING CARBONS • BRAZING TIPS AND BLOCKS • PACKING, PISTON, AND SEAL RINGS • CARBON REGULATOR DISCS • MOLDED METAL COMPONENTS, ETC.**

More and More Users of Extruded Vinyl Tubing are STANDARDIZING on NATVAR #400

Here's Why:-

ost users, to make sure that they get the right tubing for a particular job, run sts on the various extruded tubings available to find out whether they are itable. For some applications, heat resistance is of primary importance. For hers, it may be tensile strength, high dielectric, oil resistance, low moisture sorption, or a combination.

Before Natvar #400 was available, it was often the practice to stock several fferent types of special purpose tubings. This is no longer necessary. Test ports show that Natvar #400 is able to hold its own on practically every unt for which a special purpose tubing might be considered.

ne of the largest electrical manufacturers reports:

> This tubing has been used in radio transformer construction here at ——— for some time, and it has been found satisfactory ... A comparison of our results with those of the supplier is very favorable ... One peculiar characteristic of this material is the manner in which it behaves after immersion in hot transformer oil. A sample before immersion gave a tensile strength of 4140 psi, and after immersion a tensile strength of 6890 psi. ... The sag test which was conducted in this investigation was more severe than is usually conducted on materials of this type. Nevertheless, this tubing performed remarkably well under these conditions ... A copy of this report is being sent to the various division engineers for review.

nother large electrical manufacturer reports:

> MATERIAL TESTED: #400 Natvar Tubing, Flexible Extruded Vinyl.
>
> Effect of Heat: Like any other plastic, this material softens upon heating, but at 125° C. it does not flow or sag. It remains unaltered, except for darkening, after a week in the drying oven.
>
> Effect of Oil: In oil at 100° C., the tubing does not swell, soften, dissolve or harden. It remains unchanged except for a change in color.
>
> Effect of Compound Treatment: The tubing flatted out due to heat, but was still pliable when removed. It is satisfactory for this application.
>
> Dielectric Strength: Dielectric Puncture Tests, using a metal rod as inner electrode, and copper ribbon as outer electrode, gave the following results (tested in oil at room temperature):

	Short Time	Step-by-Step
; received	19,000 v=725 v/mil	17,600 v=691 v/mil
ied 2 days @ 125°C	19,000 v=744 v/mil	16,800 v=667 v/mil
ied 3 days @ 125°C plus 24 d. in oil : 100°C	26,000 v=1023 v/mil	19,400 v=723 v/mil

derwriters' Laboratories limitations permit wide use. Natvar #400 is now ailable for immediate shipment in most sizes, either from your wholesaler's ck or from our own. Write, wire or phone us your requirements.

Excerpts from the E.T.L. report covering tests made on Natvar No. 400 in accordance with A.S.T.M. Standards.

DIELECTRIC STRENGTH—A.S.T.M. D350-43

Average volts per mil: At 28°C—1090
At 85°C— 700
Wall thickness: .0235"

DIELECTRIC CONSTANT AND POWER FACTOR

Dielectric constant at 29°C and relative humidity 60%
At 60 cycles: 8.15
At 1 megacycle: 4.35
Power Factor: At 60 cycles: .056
At 1 megacycle: .064

ARC RESISTANCE—A.S.T.M. D495-42

Average—135 seconds

OIL RESISTANCE—A.S.T.M. D295-43T

"Turbol 10" at 105°C was used. After 15 minutes immersion there was no apparent change in the tubing. After 24 and 48 hours there was no sign of change in the tubing. Three separate tests were made.

HEAT ENDURANCE—A.S.T.M. D350-43

After 7 days at 125°C the tubing did not crack or otherwise fail when bent 180° around a 5/16" mandrel.

TENSILE STRENGTH AND ELONGATION

At 200% elongation: Average 1980 lbs. per sq. in.
At Maximum: Average 2870 lbs. per sq. in.
Total elongation: 350%

LOW TEMPERATURE FLEXIBILITY

After 3 hrs. at minus 30°F specimens were bent around a mandrel 5/16" in diameter. There was sign of cracking or other failure.

FLAME RESISTANCE—D350-43

Burned about ¼ in. in 10 to 15 seconds and then went out. Three tests were made.

EFFECT OF CHEMICALS

Effect of 7 days immersion in solvents at room temperature; average of 3 tests in each solvent:

Solvent	Change in weight Per cent of weight of specimen as received	Change in dimensions Per cent of dimensions of specimen as received: Length	Outside diameter	Thickness
5 per cent sulfuric acid	+ 0.41	none	none	none
1 per cent potassium hydroxide	+ 0.83	none	none	none
Petroleum	+ 6.62	+2.6	none	none
Ethyl Alcohol	+ 1.66	none	none	none
Benzol	+21.9	+6.6	+10.9	—24.0

WATER ABSORPTION

Average of 5 tests

Water absorption, per cent by weight of dry specimen	0.63
Soluble matter, per cent by weight of dry specimen	0.01
Total water absorption, per cent by weight of dry specimen	0.64
Change in dimensions: in length	none
in outside diameter	none
in thickness	none

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE RAHWAY 7-2171 — CABLE ADDRESS NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

12—NVP—4

ical properties of specimens can be obtained.

Reflection is an indication of discontinuities, absorption results from internal porosity, viscosity, etc, and transmission is a measure of the beam energy not dissipated by reflection or absorption in the specimen. The most complete information can be obtained if the specimen can be examined over a wide range of ultrasonic frequencies.

Instrument

The General Electric ultrasonic materials tester provides on the screen of a cathode-ray oscilloscope an instantaneous response pattern of a complete ultrasonic transmission system to a wide band of ultrasonic frequencies. It provides simultaneously an indication on a panel instrument which corresponds to the total ultrasonic energy transmitted through the system.

The materials tester contains a high-frequency signal source which is automatically frequency-modulated over a band of frequencies about 500 kilocycles wide. The response of the transducers, the transmitting medium, and the specimen to these frequencies produces the ultrasonic spectrogram on the oscilloscope screen. Panel controls adjust the generator output, the range of frequencies, and the center frequency.

The transducers are resonant crystals sealed for immersion in water. They operate at one megacycle and have a response range of about 200 kilocycles. If other liquids or frequencies must be used special transducers are required.

The receiver is a wide-response type which requires no tuning and operates continuously at maximum sensitivity. Its useful response range extends from 100 kilocycles to two megacycles.

To examine regularly shaped specimens for internal voids, cracks, porosity, and laminations, only the final instrument reading must be considered. Small specimens can be rapidly examined by inserting each between the transducers in the liquid medium and comparing the reading with that for a specimen shown to be sound by x-ray, mechanical breakage, or

Announcing

A NEW LORD PRODUCT

HERE are the new Lord Vibration Control Mountings which isolate destructive vibration, *regardless of the direction of disturbing forces.* They are called MULTIPLANE (many planes) because they are equally soft in all directions. MULTIPLANE Mountings — made in three sizes, four types, and nine load ratings — are easily applied to most light and medium-weight installations. In your efforts to obtain maximum protection for delicate equipment, or to build smoother, quieter machines, you should investigate the new MULTIPLANE Mountings — the latest contribution to product improvement from "Vibration Control Headquarters."

...d for *Bulletin 106* for detailed ...rmation concerning the MULTI-...NE, and tell us your specific ...blems in vibration control.

...ONDED RUBBER *In Shear* TO ABSORB VIBRATION

...MANUFACTURING COMPANY

ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
NEW YORK - - - 280 MADISON AVE.
CHICAGO - - - 520 N. MICHIGAN AVE.
DETROIT - - - 7310 WOODWARD AVE.
BURBANK, CAL. - 233 S. THIRD STREET
WASHINGTON - 14TH & G STREETS, N. W.
CANADIAN REPRESENTATIVE
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

...inators of Shear Type Bonded Rubber Mountings

sectioning methods. Large specimens can be tested by rotating them between the transducers.

Internal flaws produce measurable decreases in total transmission and a consequent drop in the instrument reading. Because of the very broad response of the tester, small changes in dimensions or placement of the specimen will not ordinarily affect the transmission reading, making it far more versatile than ordinary sharply tuned sonic transmission equipment. On the other hand, these effects if important, will show up on the oscilloscope screen as a change in response pattern.

The instrument reading and response pattern obtained when the transducers are immersed in a liquid depends on two important properties of ultrasonic propagation through the liquid: attenuation and velocity. It is therefore possible to monitor continuously any property of the liquid which significantly changes either attenuation or velocity. These important properties are viscosity, compressibility, and density.

The information obtained can be compared, in terms of the analogy to light behavior, with those of a light meter and a spectroscope. The light meter, similar to the panel instrument of the ultrasonic receiver, indicates the total amount of energy passing from a source through a medium to the meter. The spectroscope, like the oscilloscope of the receiver, shows the distribution of this energy in terms of wavelength. In both examples each type of information may be necessary or useful for a given testing, analysis, or research problem.

FLOCKING electrostatically has been done at General Electric Schenectady Laboratories. 200,000 cloth fibers stand erect, perpendicular to an adhesive-coated backing material in one square inch of fabric.

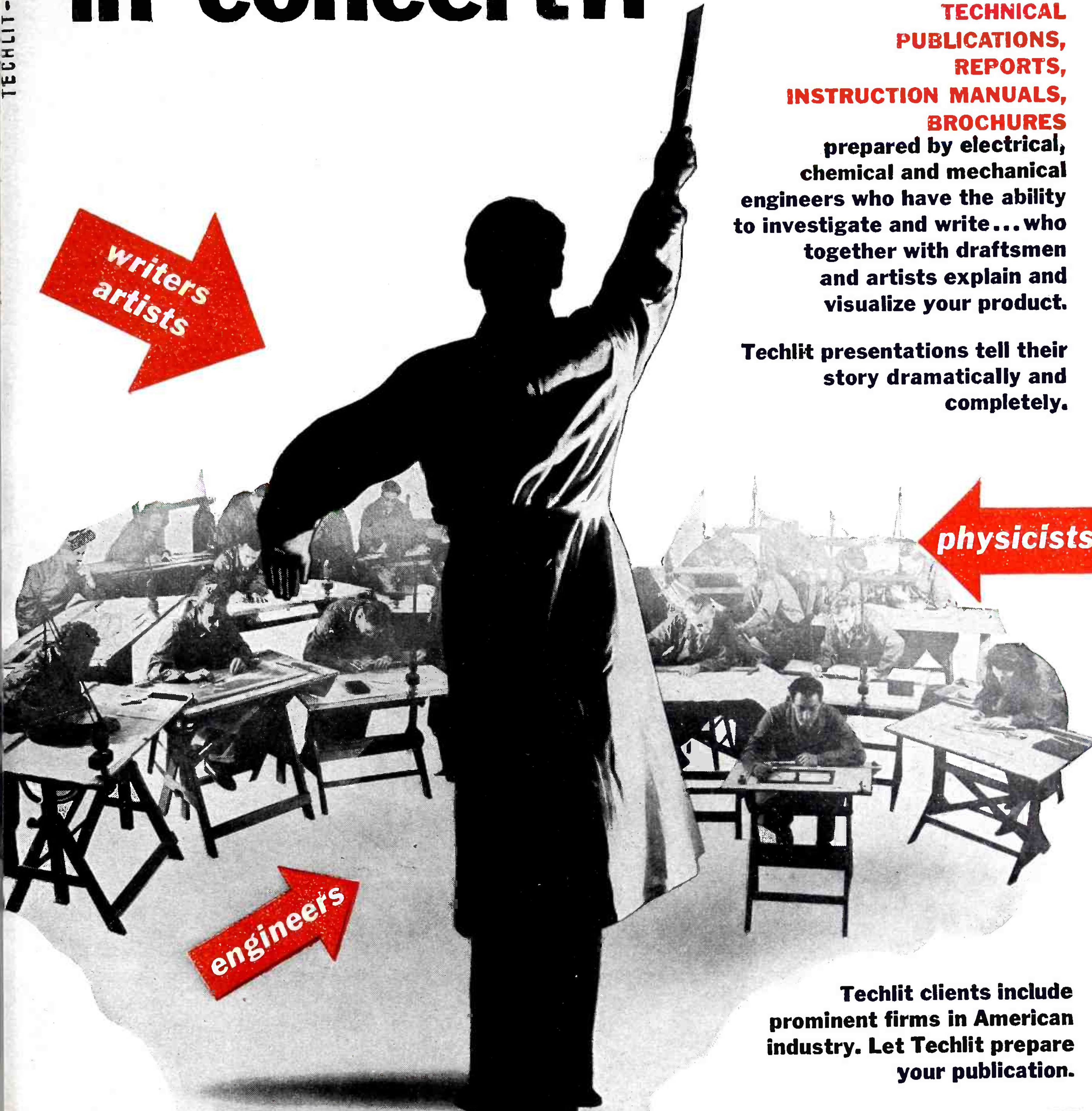
A COMPENSATED BOLOMETER at the focus of a 60-centimeter mirror was the basic equipment of a fire-control system for gunnery that was being unpacked by the Germans on the Normandy beach on D Day. It was an alternative for radar fire control if that were made useless by jamming.

TECHLIT-xanti

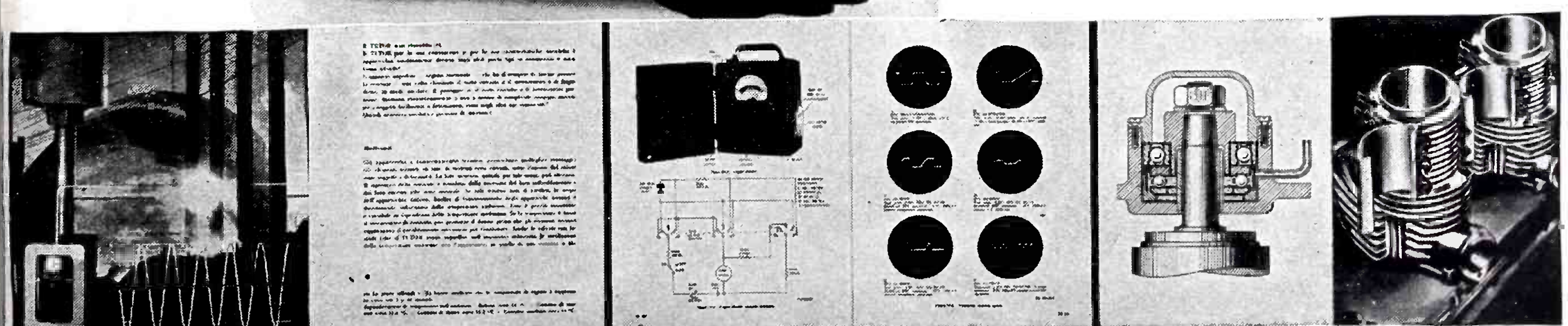
in concert..

TECHNICAL PUBLICATIONS, REPORTS, INSTRUCTION MANUALS, BROCHURES prepared by electrical, chemical and mechanical engineers who have the ability to investigate and write...who together with draftsmen and artists explain and visualize your product.

Techlit presentations tell their story dramatically and completely.



Techlit clients include prominent firms in American industry. Let Techlit prepare your publication.



TECH-lit

TECHLIT CONSULTANTS, INC.
140 NASSAU STREET, NEW YORK 7, N. Y.
BEekman 3-1166

THE ELECTRON ART

Edited by FRANK ROCKETT

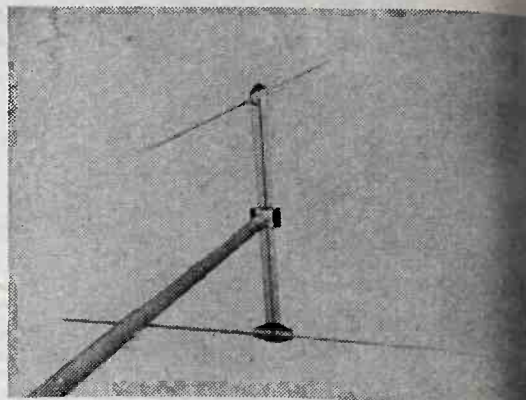


Fig. 3—Array for receiving circularl[y] polarized radio waves

Antennas for Circularly Polarized Waves

To study the effects of polarization on propagation, a transmitter array composed of a vertically polarized coaxial radiator and a horizontally polarized folded dipole loop was used. The vertical radiator was mounted in the center of the horizontal loop which in turn was located at the lower end of the vertical radiator as shown in Fig. 1. When the two antennas are fed

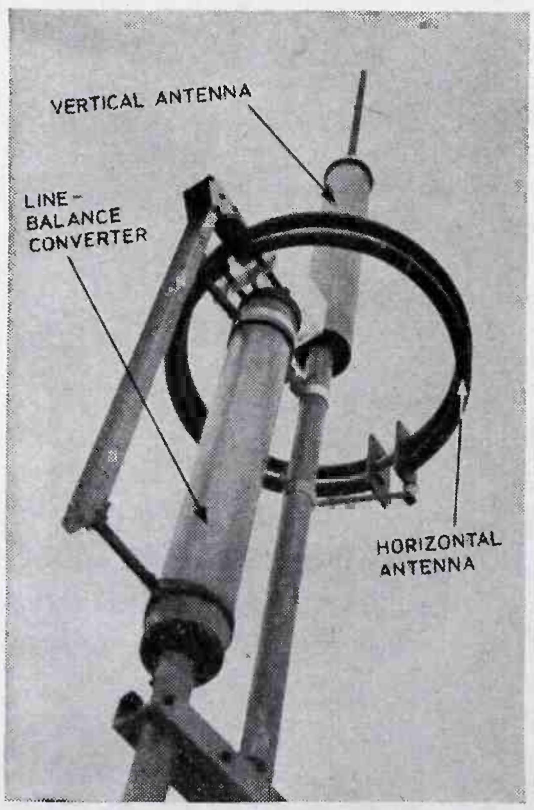


Fig. 1—Combination of horizontal and vertical radiators produces a circularly polarized radio wave

from a common point directly below, the radiated fields of the two antennas are ninety degrees out of phase because of the additional quarter wavelength up to the feed point of the coaxial dipole. This ninety-degree phasing of the two polarizations, together with the equal fields from the two antennas, tends to produce a circularly polarized radiated field.

Figure 2 shows the performance of the array. The field of the array

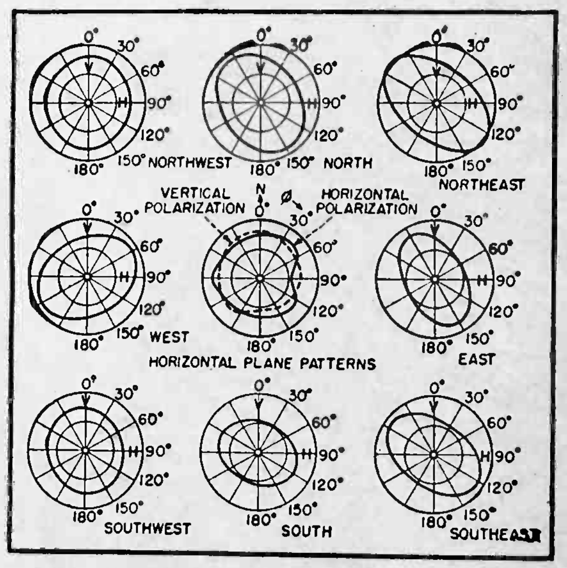


Fig. 2—Pattern at center shows the field intensities of the two components radiated by the array of Fig. 1. Ellipses indicate the polarization perpendicular to the indicated directions of propagation

is elliptically polarized for the most part because the horizontal element radiates with slightly different phases and magnitudes in different directions relative to its center. The field pattern of the horizontal antenna is typical of a loop radiator which approaches a quarter wavelength. The irregularities of the vertical antenna field are probably due to currents flowing on the vertical members of the support.

A receiving array for circularly polarized waves was mounted on a hollow wooden pole. The parallel-wire transmission line ran down the core of the pole. As shown in Fig. 3, the array consists of two half-wave dipoles, one oriented vertically, the other horizontally, and spaced a quarter wavelength apart. The aluminum angles tha[t] serve as spacers are the conductor[s] as well and serve to connect th[e] dipoles in parallel. The pole wa[s] fastened to the center of the spac[ers] with the transmission line.

Measurements made with thi[s] equipment by the United Broad[casting] Company at their experi[mental] f-m station W8XU[B] Cleveland, Ohio, indicate that i[f] circularly polarized radiation i[s] used, the orientation of receivin[g] antennas for acceptable receptio[n] will be less critical than with eithe[r] horizontally or vertically polarize[d] radiation. It was also observe[d] that outside antennas appreciabl[y] improved reception, and tha[t] increasing the height of the receiv[ing] antenna caused marked im[provement] in reception, providin[g] that the antenna was kept awa[y] from buildings. Mounting the an[tenna] at the peak of the house roo[f] and close to the roof was not a[s] good practice as mounting slightl[y] lower but well away from th[e] house. FCC has made circular pol[arization] optional for f-m broad[casters].

Cosmic Ray Measurements

Measurements made with tele[scopes] consisting of Geiger-Muelle[r] tubes between lead plates that wer[e] carried in the heads of rocket[s] traveling 100 miles into the atmos[phere] (Aug. 1946, p 264) indicat[e] that cosmic-ray showers are 30[0] times more numerous in the uppe[r] atmosphere than at ground level. Peak concentration of secondar[y] particles (mesotrons) generated b[y] cosmic rays is at 100,000 feet, high enough for cosmic rays not to hav[e]

Where there is Horsepower... *There is Wire*

The earth . . . like a busy caterpillar . . . spun round itself a cocoon of copper wire.

And from that chrysalis there hatched a brood of flying horsepower that brought a new civilization . . . brought dignity to drudges . . . power to the weak—a new joy in living to almost everyone.

Each day finds new fields of progress . . . new services to man . . . each with its peculiar *need* for wire, to generate . . . to direct . . . to harness . . . to control . . . and to utilize its particular breed of horsepower. These special wire requirements are met with ten thousand different engineering achievements by the wiremakers—such as Belden.

been filtered out by the atmosphere, but low enough so there are sufficient atmospheric particles with which to collide.

Equipment used for these measurements, designed by scientists of the Applied Physics Laboratory of Johns Hopkins University and produced by the Wilmotte Manufacturing Co., consisted of two sets of detectors, the telescopic pair sensitive only to particles coming from a single direction with sufficient energy to trip all counters, and others to indicate charged particles accompanying radiation striking outside the telescopic set. Data were recorded both on a slowly rotating steel drum in the rocket, and on the ground from telemetering signals. In both cases, amplifiers were used to raise the signals to a useful level. The Geiger-Mueller tubes were of the same type used in the Bikini atomic bomb tests. Results will enable scientists to understand more fully the nature of atoms and cosmic rays.

German Industrial Techniques

REPORTS of Allied technical missions investigating German factories can be seen at the Department of Commerce, Office of Technical Services, Washington, D. C. Some of these reports have been reviewed (July 1946, p 200); reviews of others are presented below. Of these reports, three are available from the Department of Commerce, Office of Publication Board; of those previously presented, C-8 is PB-418, and C-58 is PB-1292; C-51 below is PB-2609. Manufacture of metalized paper capacitors, previously reported, is described in PB-421.

Detectors and Resistors

Silicon detectors (Bartel cells) that are less sensitive to shock than Allied detectors were manufactured by depositing silicon crystals from silicon tetrachloride on a carbon rod within a quartz tube using aluminum as a binder in a furnace at 800 C. An electrode of nickel or tungsten of 0.1 mm diameter was made to press lightly on the silicon crystals. No ad-

justment was made. The completed detector withstands an acceleration of ten times that of gravity and a potential of ten volts. Improved fluorescent screens were also made (C-12: 1 p).

Crystal detectors were also made from a mixture of magnesium and titanium powders pressed and heated (C-19: p 1). Captured Allied silicon detectors were analysed by the Germans for impurities and found to contain traces of aluminum and beryllium which, as German experience had indicated, improved their rectifying properties. Translucent conductive layers were produced as bolometers used in intensity measurements of centimeter waves (C-37A: 4 p).

Carbon resistors were formed on unglazed porcelain which was first inspected for freedom from surface pits, foreign particles, and size—the latter done automatically. These cores were sand cleaned, washed, and carbonized. Spiral grooves for high-resistance resistors were cut with a resin bonded wheel, the last portion of the spiral being cut slowly with the resistor in a bridge to obtain the desired resistance. Resistors were sorted automatically at 12,000 per hour into six groups each with twenty subclasses (C-43: 1 p).

Sound Recording

The magnetophone, a magnetic sound recorder using plastic tape, was widely used throughout German radio and broadcasting both military and industrial. Large libraries of tape recordings were provided at broadcasting studios. The tape has low noise, is run at 80 cm per second for recording frequencies up to 10,000 cps, is 0.05 mm thick and 5.0 mm wide. The recording material is magnetic ferric oxide dried onto the tape. The surface of the tape is run in contact with electromagnetic armatures having very narrow slots running cross-wise to the tape motion. Tapes are wiped to reduce noise and erase previous signals by high frequency. High frequency currents are fed with the program material to the recording head to overcome hysteresis effects and improve linearity. For office use the entire recording-reproducing equipment was built into a volume about the capacity of a console radio cabinet and designed to


Imprisonment . . . for life!

require no special knowledge or skil to operate (C-59: 13 p).

Toneschreiber models using pape tape as backing for the magneti coating were developed for portabl and field use. Operation and con struction are reported in detai (C-59: 12 p).

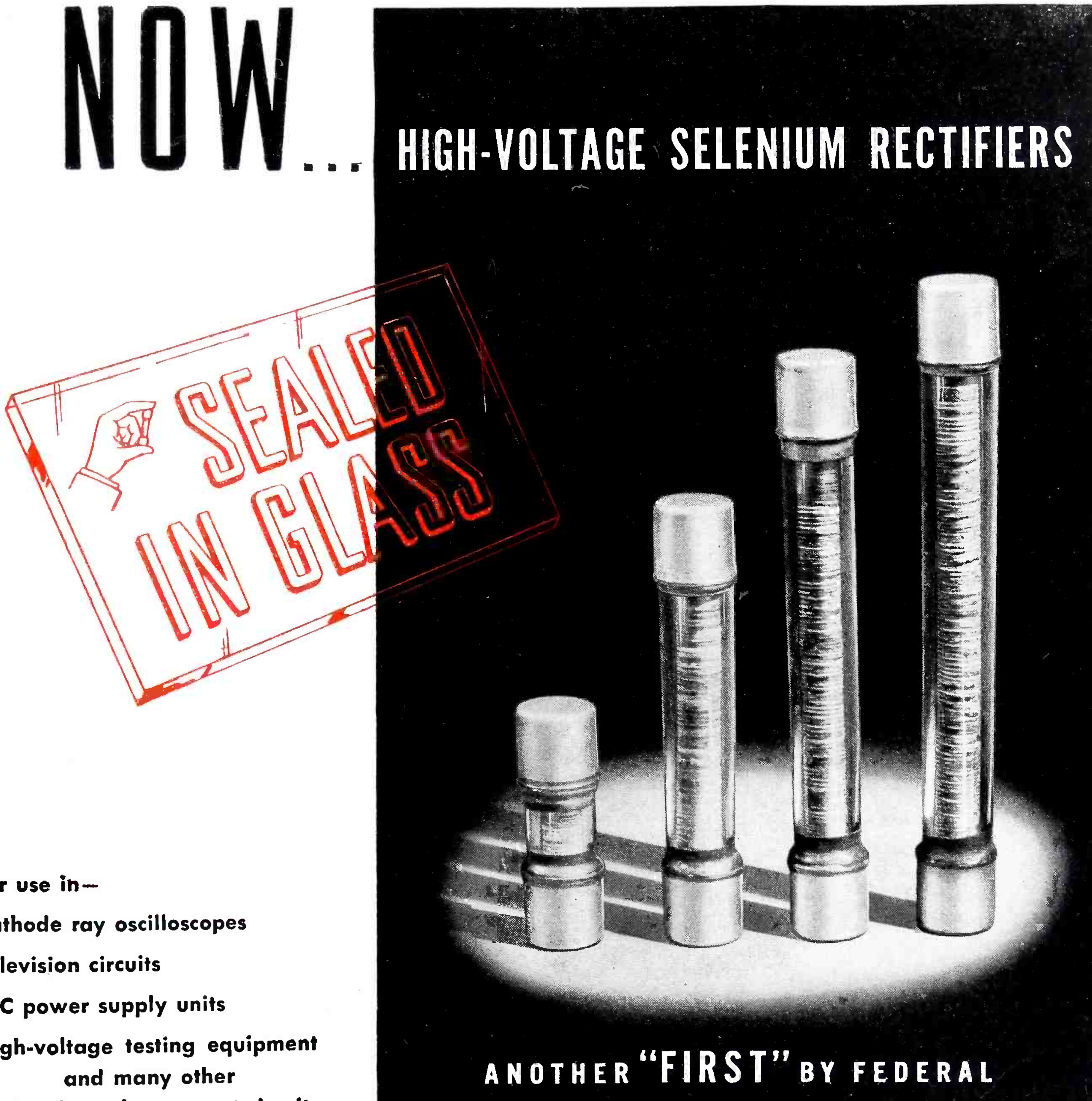
Ceramics

CAPACITORS OF REDUCED size were pro duced by developing materials o high dielectric constants, high per meability, high or low insulation plus negative temperature coeffi cients. For high dielectric constant titanium dioxide in one of its crystal line forms was the basic constituent A high-dielectric ceramic mixed wit oil to form a paint was applied t submarines to reduce reflection o radar signals. For complete absorp tion of the incident wave, high per meability of the coating was als sought. A one-to-one mixture o ceramic powders in triacetate pro duced a flexible dielectric suitabl for winding small foil capacitor (C-51A: 7 p).

Ceramics having at the same tim high dielectric constant and ver small electric phase angle were pro duced. Dielectric constants up to 50 were obtained in manufacture. Ce ramic bonds for ferromagnetic core were also used (C-51B: 7 p).

Ceramics were used as spacers an supports in vacuum tubes as substi tutes for mica. High voltage capaci tors were made of vitrified cerami bodies. Low-voltage tubular cerami capacitors were also produced. Afte firing, the thin-walled tubes ar nicked with a rubber bonded silico carbide wheel and broken by hand t length. Ceramic discs are used a rotors in trimmer capacitors. Meta pins were fastened into ceramic bod ies by placing the pin in a hole wit a serrated edge, heating the pin wit a spot welder and pressing the pi into the ceramic body. Pins mounte this way can not be removed with out breaking the ceramic. Meta layers are fired onto ceramic bodie and built up by electrolytic deposi tion. (Metallized ceramics used a anodes in tubes, are vacuum seale to the metal case.) Vacuum tigh bonds were produced between Steatite body and iron for ring joint (C-63: 31 p).

Some small grids were made b



For use in—

Cathode ray oscilloscopes

Television circuits

D-C power supply units

High-voltage testing equipment and many other high-voltage low-current circuits

- **RATINGS UP TO 4000 VOLTS**
- **"FOUNTAIN-PEN" SIZE**
- **FUSE-CLIP MOUNTING**
- **LIFE—UNLIMITED**
- **MAINTENANCE—ZERO**

Federal's new, hermetically-sealed, high-voltage rectifier stacks combine the rugged stability of the selenium dry-plate rectifier and the sealed-in moisture-resistance of the vacuum tube.

Ultra-compact and light in weight, they permit valuable savings in installation space—the largest unit having overall dimensions of only 4½ by ½ inches. The silver-plated end ferrules, solder sealed to the glass, are designed for mounting in standard 30-amp fuse clips, making the complete rectifier stack as easy to install as a cartridge-type fuse. Either the plain or polarized type is obtainable.

These rectifiers are designed for inverse voltages up to 4000-volts and have a current rating of 5 ma with a resistance load, at ambient temperatures up to 35C (105F). They are suitable for use in much higher temperatures, with reduced current rating.

Selenium rectifiers were first made in this country by Federal, and every unit is backed by 37 years of specialized skill and experience. Write today for data and description.

Federal Telephone and Radio Corporation

anada:—Federal Electric Manufacturing Company, Ltd., Montreal
t Distributor:—International Standard Electric Corporation

Newark 1, New Jersey

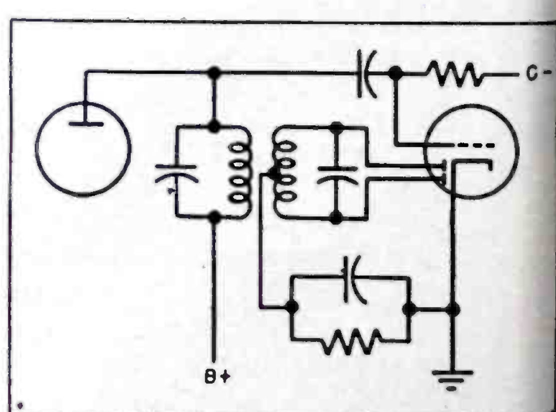
AN IT&T ASSOCIATE — FEDERAL TELEPHONE & RADIO FTR welding instead of notching and swedging. Tantalum was produced in evacuated electric furnaces, cooled and cold worked into wire. It was found that every time the cross section was halved, the wire had to be heated in vacuum to remove the hardness produced by working (C-46: 1 p).

Electron discharge from closely spaced cold electrodes was investigated by German scientists. Results of experiments, which are given in a translated paper written by the experimenter, indicated that under highly controlled conditions electron discharge is produced by potential gradients approaching those required by the theory of Schottky. An interferometer for measuring electrode spacing, vacuum-tight diaphragm for coupling to movable electrodes from outside the evacuated tube, and high-vacuum techniques are described (C-64: 25 p).

Combined Limiter and Squelch Circuit

U. S. Patent No. 2,405,845
Granted to ERNEST R. PFAFF
Assigned to Admiral Corp.
Chicago, Ill.

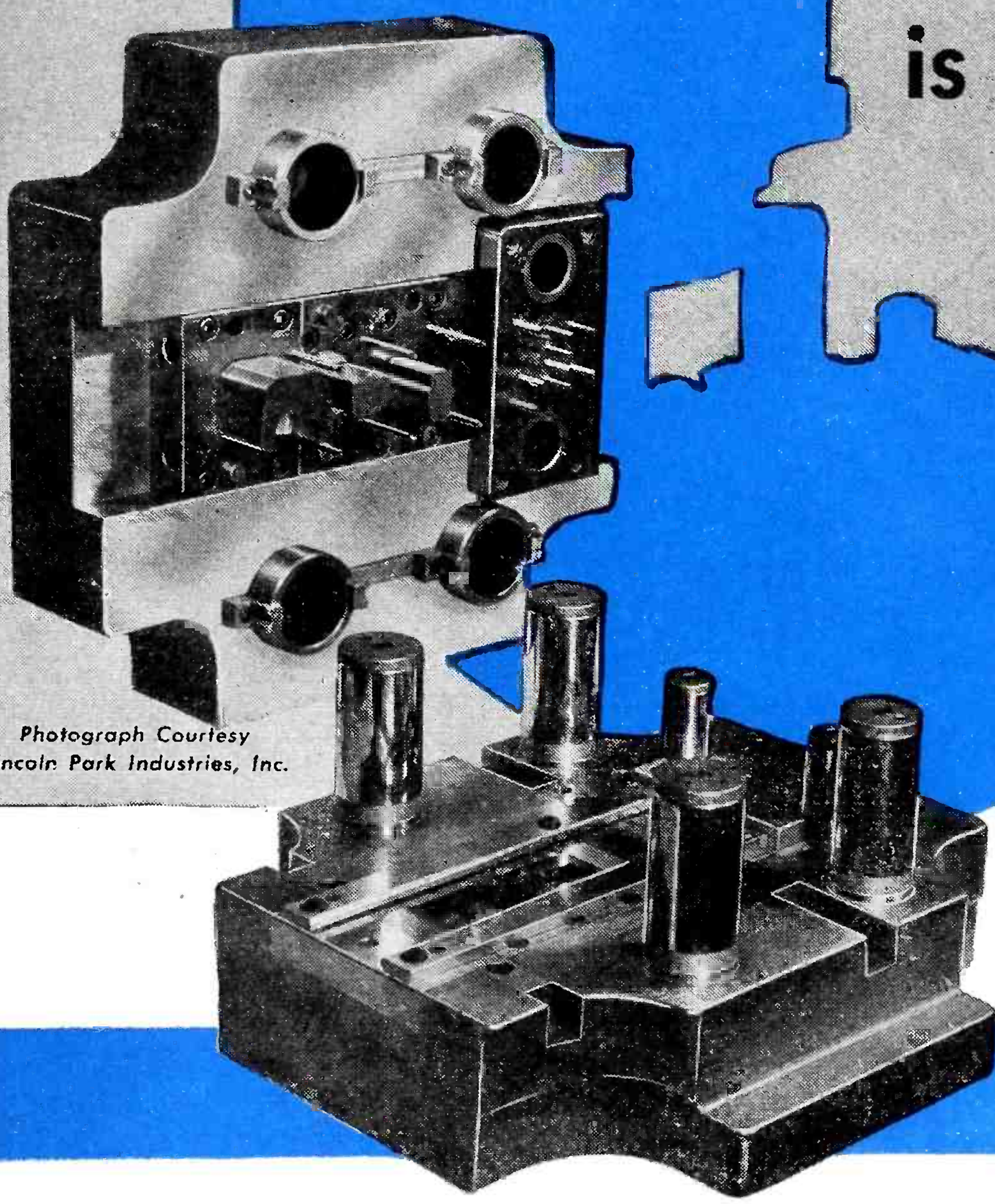
A VOLTAGE LIMITER for removing high-amplitude portions from a frequency-modulated signal consists of a center-tapped transformer magnetically coupled to the normal amplifier coupling transformer, in addition to the usual coupling from the anode of one amplifier tube to



Diode loads transformer on peaks

the grid of a second amplifier tube. The center-tapped transformer is a part of the circuit shown in the accompanying diagram. The resistance-capacitance circuit biases the anodes beyond conduction for normal signal amplitudes, but in

How COLGATE *Engineered Service* is breaking the bottleneck of the metals shortage



Photograph Courtesy
Lincoln Park Industries, Inc.

MANY MANUFACTURERS have asked us whether it is possible to make an assembly or part in another metal *temporarily,* and still use the fabricating and stamping tools, when the time comes, for the preferred metal.

It's not only frequently *possible* . . . Colgate is *doing it.* By designing double purpose dies so that they may be used, during this interim period with a second-choice material, and later converted, Colgate is breaking the bottleneck of the metals shortage.

Dies engineered to serve a double purpose is just one example of Colgate *Engineered Service* in sheet metal fabricating and stamping of aluminum, magnesium, stainless steel and many other light metals.

If your product is ordinarily made of steel (let's say), perhaps some other material could be used. Then, when steel becomes *available,* in many cases the tools can be converted, at reasonable cost, through Colgate's *Engineered Service.* Write for more information.

STAMPING • FORMING • DRAWING • WELDING • FINISHING • ASSEMBLING

COLGATE *Manufacturing Corporation*

AMITYVILLE, LONG ISLAND, NEW YORK.

LIGHT METALS PRODUCTS

the presence of a signal of exceptional amplitude, the anode circuit conducts. The added loading of the conducting diodes on the internal resistance of the first amplifier reduces the available voltage to the second amplifier. Thus for proper operation, the first amplifier should have high internal resistance (poor regulation). In addition to its use as an f-m limiter, the circuit can be used to remove r-f noise in a-m receivers if it has a very long time constant.

Miscellaneous U. S. Patents

VARIATION of anode-cathode current of a vacuum tube is produced by movement of an external member of a beam-forming structure. Movement of the external beam-forming electrode deflects the electron beam relative to the receiving anode to produce current variation. (2,376,882, Space Discharge Device, Hyman Olken, May 29, 1945).

Means of controlling the ignition system or guarding against pilot-light failure of burners are provided by several electronic techniques such as d-c bias and phase shift control of the rectifiers that operate control relays. Operation of the bias or phase shift networks depends on the rectifying impedance of a flame which is interposed in a normally nonconducting gap in the control circuit. (2,379,871, Burner Control Device, Vilynn O. Bean and John M. Wilson, assigned to Minneapolis-Honeywell Regulator Co., July 10, 1945; 2,379,872, Electronic Control Apparatus, Willis H. Gille, assigned to Minneapolis-Honeywell Regulator Co., July 10, 1945; 2,379,873, Electronic Control Device, Frederick E. Lange, assigned to Minneapolis-Honeywell Regulator Co., July 10, 1945).

Using a cathode-ray tube, a printing high-speed telegraph is obtained. The transmission consists of a series of single pulses for each character. The individual pulses are shifted in phase relative to their normal occurrence position by an amount corresponding to the particular character they represent. At the receiver is a cathode-ray tube having a rotary sweep. In

This Is Good News!

. . our greately increased production on Simpson Model 260 makes it available to you NOW at your jobber's

The Simpson 260 is easily the world's most popular set tester for elevision and radio servicing. You cannot touch its precision, its iseful ranges, or its sensitivity in any other instrument selling for the ame price or even substantially more.

It has been a long time since we have been able to produce enough 260's to meet the demand, because the 260 has consistently out-sold very other remotely similar test instrument. The reason is simple: t out-performs and out-values them all. Simpson advanced engineer-ng and unyielding standards of quality and precision manufacture nable it to *stay* accurate under conditions ordinary instruments cannot survive.

Incidentally—production on other Simpson instruments is clearing, too. We feel confident that it will not be long before you can uy those Simpson instruments you have waited for.

Ask your jobber for the Simpson 260—he has it now!

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie St., Chicago 44, Ill.

Simpson

INSTRUMENTS THAT STAY ACCURATE

SIMPSON 260, HIGH SENSITIVITY SET TESTER FOR TELEVISION AND RADIO SERVICING

Ranges to 5000 Volts—Both A.C. and D.C.
20,000 Ohms per Volt D.C.
1000 Ohms per Volt A.C.

At 20,000 ohms per volt, this instrument is far more sensitive than any other instrument even approaching its price and quality. The practically negligible current consumption assures remarkably accurate full scale voltage readings. Current readings as low as 1 microampere and up to 500 milliamperes are available.

Resistance readings are equally dependable. Tests up to 10 megohms and as low as ½ ohm can be made. With this super sensitive instrument you can measure automatic frequency control diode balancing circuits, grid currents of oscillator tubes and power tube, bias of power detectors, automatic volume control diode currents, rectified radio frequency current, high-mu triode plate voltage and a wide range of unusual conditions which cannot be checked by ordinary servicing instruments. Ranges of Model 260 are shown below.

Price, complete with test leads $38.95
Carrying case $5.55

Volts D.C. (At 20,000 ohms per volt)	Volts A.C. (At 1,000 ohms per volt)	Output
2.5	2.5	2.5 V.
10	10	10 V.
50	50	50 V.
250	250	250 V.
1000	1000	1000 V.
5000	5000	5000 V.

Milli-amperes D.C.	Micro-amperes	Ohms	
10	100	0-1000	(12 ohms center)
100		0-100,000	(1200 ohms center)
500		0-10 Megohms	(120,000 ohms center)

(5 Decibel ranges: —10 to +52 DB)

ASK YOUR JOBBER

the path of the beam is a dis around the periphery of which hav been punched holes of the shape o the letters of the alphabet an other characters to be transmitted The electron beam rotates in syn chronism with the rate of puls transmission. When a pulse is re ceived, the electron beam is de flected to pass through th appropriate hole in the stenc plate. The shape of the hole form the contour of the beam so that i projects the image of that characte on a reading screen. Additiona means of beam deflecting spread the sequence of characters apar across the screen. The character so projected can be photograph ically recorded if they appear to fast to be recorded otherwise. (2, 379,880, High-Speed Telegrap System, Harry A. Burgess, as signed to Bell Telephone Labora tories, Inc., July 10, 1945).

By projecting a strip of ligh across the picture to be transmitte by facsimile and imaging the illum inated strip on a long, narrov signal-generating screen of a iconoscope, the moving parts of facsimile scanner are greatly sim plified. (2,379,906, Continuou Facsimile Scanner, John V. L Hogan, assigned to Faximile, Inc. July 10, 1945).

Oxide Coated Cathodes

PULSED OPERATION of vacuum tube has led to further study into th characteristics of oxide coate cathodes. Under conditions of high pulse currents, cathodes are not operating at equilibrium, as was assumed in developing from statistical mechanics the theory of an impure semiconductor in its solid state to explain cathodic emission. Rather, there is a loss of the cathode coating metals and their oxides from the outside surface accompanied by migration of metals and oxides from the coating interior to the surface, considerable interaction between the coating and the base metal (the exact extent and nature of which is still to be determined, although much light has been shed on the problem), and an interface resistance between coating and base in the form of a crystal compound that appears to behave as do oxide rectifiers; that

Amphenol Components

GIRDLE THE GLOBE—

and the Frequency Spectrum, Too!

In the eyes of amateurs and professionals of every nation Amphenol components represent the last word in electrical and mechanical design and correct manufacture.

From high voltage, high-frequency uses in the temperamental top segments of the spectrum, down through the high-current, low-voltage industrial applications — there are Amphenol cables, connectors, plugs and fittings designed and built to hold to the irreducible minimum loss of power, potential or waveform.

For Radar, Television, F.M., Railroad, Broadcast and Industrial use; Amphenol components speak the universal language of scientific efficiency, and they are available in the most complete line available from any one source in the world today. Write today for prompt attention to your needs.

AMERICAN PHENOLIC CORPORATION • Chicago 50, Ill.

In Canada • Amphenol Limited • Toronto

AMPHENOL

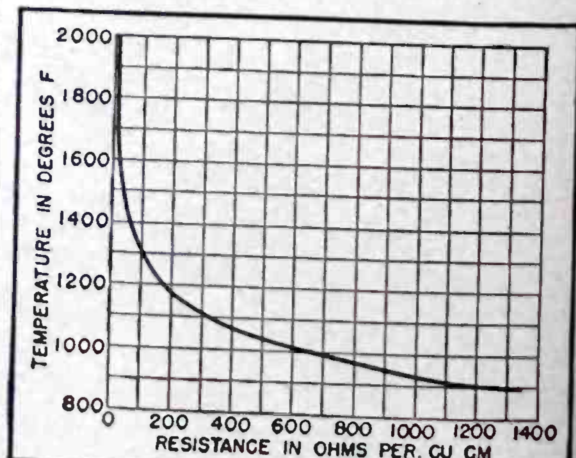
COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO COMPONENTS • PLASTICS FOR ELECTRONICS is, there is a metal (nickel cathode sleave), a blocking layer (crystalline interface), and a semiconductor (oxides of barium and strontium).

Measurements show that this interface resistance behaves like multiple-layer oxide rectifiers, bearing out this supposition. (Oxide Coated Cathode Literature, 1940-1945, John P. Blewett, a review with bibliography of basic research papers on advances in emission theory; The Pulsed Properties of Oxide Cathodes, Edward C. Coomes; A Study of Oxide Cathodes by X-Ray Diffraction Methods, A. Eisenstein; and Studies of the Interface of Oxide Coated Cathodes, A. Fineman and A. Eisenstein, three papers presenting some of the results of studies at the MIT Radiation Laboratory, all in *Jour of Appl Phys*, Aug. 1946, see also a thesis paper by Harold Jacobs, *Jour of Appl Phys*, p 596, July 1946.)

Source of Infrared Radiation

SIGNALING by modulating the intensity of a light beam has been used for ship-to-ship and ship-to-shore and similar communication. For privacy, such communication is frequently made over beams of infrared radiation. Infrared radiators are also used in infrared spectrometers and burglar alarms.

A type of radiator suitable for such applications is a steatite refractory operated in free air. The negative resistance coefficient of the ceramic results in its being an insulator at normal temperatures

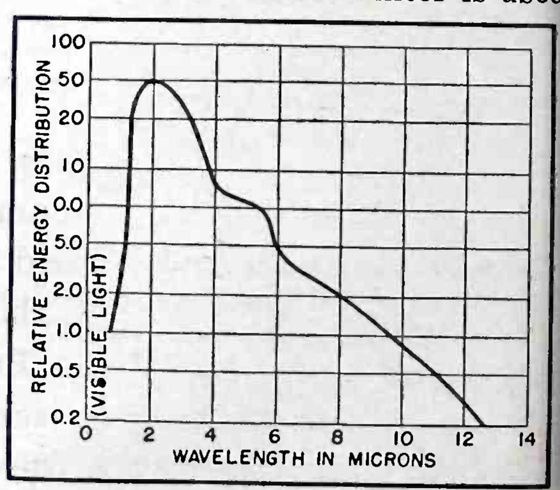


Steatite has a negative specific resistance characteristic, and thus at high temperatures it is a conductor that can be modulated at voice frequencies

but as it is heated it becomes a progressively better conductor. To make the ceramic conductive, an exciting current—either direct or r-f—is applied to heat the radiator to 700 F. If the current is held constant the temperature will remain constant. It is necessary to use either a ballast resistor or a regulated current source to prevent the exciting current from increasing without limit.

Emission can be readily modulated by superimposing an audio-frequency current on the exciting current. Under some conditions the exciting current can be removed after the modulating current is applied. Because the emission of the glower varies as the fourth power of the absolute temperature, intensity modulation of the beam is pronounced. Because of conductive cooling to the surrounding air and the negative resistance characteristic, the emitter, despite its considerable mass, responds to voice frequencies.

The radiator can be small enough to constitute a point source, and thus be readily used with a spherical mirror to produce a beam, and still give appreciable radiation. The spectral response has its peaks where other infrared sources are deficient. An infrared filter is used



Spectral response of steatite shows a sharp peak just outside the visible region. Infrared radiation penetrates smoke and rain more effectively than visible light

to remove visible light from the beam.

Modulation of an Insulcon Glower, the emitter described above, is described in U. S. Patent No. 2,389,649, granted to Rawson E. Stark and Donald E. Stark, Stupakoff Ceramic & Mfg. Co. The German Army used a photophone for communication over short distances. A mechanical modulator controlled the amount of projected

I'm a Design Engineer

"My job is to dream up electronic equipment that will knock dollars off operational costs, improve end products or accomplish something that's never been done before.

"But I can't dream in a vacuum. I must be 100% up-to-date on everything happening in my field. I must have accurate product information and definite knowledge of all available sources for everything designed for use in electronic equipment.

"*That's why* . . . I use the ECTRONICS BUYERS' GUIDE almost ly and for the same reason, it's why ctically everyone else in my type of rk does too.

re's what the ECTRONICS BUYERS' GUIDE does for me . . .

ives me, in one book, the most complete informative picture of components, kaged' equipment, and allied products is available— information that I must e at my finger tips at all times. Previously, ve wasted considerable time searching for e individual company's literature in order etermine the characteristics of their prod- Now it's just a matter of seconds to look istings in the 'GUIDE' in order to get information.

en, too, there are many times when I'm rtain as to who makes a certain product, here again the 'GUIDE' comes to my aid a complete list of all available sources. I wouldn't want to get along without this rence book of the industry'— it's vitally ortant to me particularly when I design-in ucts and specify purchases."

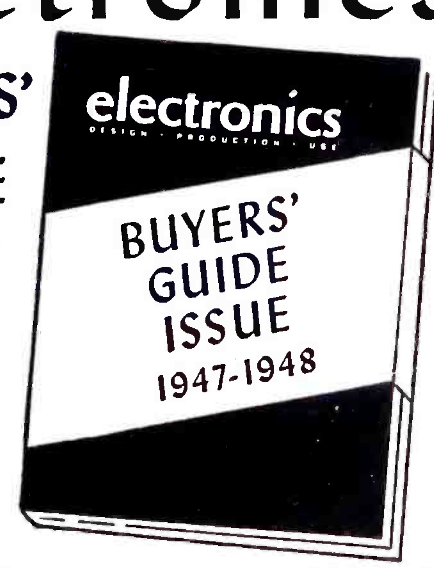
Mr. Manufacturer . . .

This is not an isolated case—it's typical. Therefore, make sure your products are fully represented in the coming issue of the ELECTRONIC BUYERS' GUIDE which will be read and studied by the men who design, specify, create, and directly or indirectly influence purchases.

electronics

BUYERS' GUIDE ISSUE

Coming JUNE 15 1947



ABC • A McGRAW-HILL PUBLICATION • ABP

Established 1930

330 West 42nd Street, New York 18, N. Y.

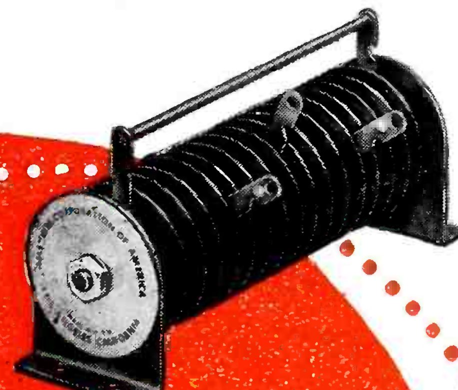
radiation. A photocell received th beam. Vacuum tubes provide signal amplification, and a lens sys tem focused the beam. The equip ment and its operation ar described in Dept. of Comm reports PB-19746, 21 p; PB-161 14 p; PB-1623, 11 p; PB-2336, 2 p; and PB-1531, 54 p. Infrare sources bright enough to illuminat a road for 200 meters, used fo driving in blackout, illuminatin sniper targets, and identifyin planes at night, are described i Dept. of Comm. report PB-158 See also ELECTRONICS, Jan. 194 p 156; June 1946, p 95 and 224.

Wideband I-F Amplifiers

REQUIREMENTS of radiolocation i- amplifiers are more stringent tha for television amplifiers. Minimu background noise, rather tha large gain or bandwidth, is th foremost requirement. A compara tively low i-f value gives low nois and makes use of conventiona tubes but lacks wide band-pass an presents difficulties in separatin the i-f carrier from the modulatio in the detector. A higher i-f valu gives better image frequency rejec tion and is less likely to amplif higher components of suppressio pulses. Normally the i-f value lie between 10 and 60 mc.

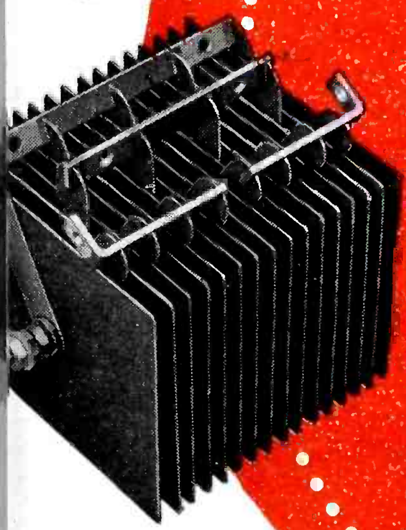
Other things being equal, nois power is proportional to bandwidth Important components of a rec tangular pulse lie within a band $1/T$ cps wide, where T is the widt of the pulse. Ideally the i-f ampli- fier bandwidth should be about $2/T$ cps wide. Optimum bandwidth is however, best found by experiment. Investigations made to discover a particular shape of frequency- response curve for maximum sig- nal-to-noise ratio show little preference. Single circuits, all in tune, are very inefficient couplings. Stagger-tuned circuits are easily set up and give high stage gain and an amplifier having broad bandwidth.

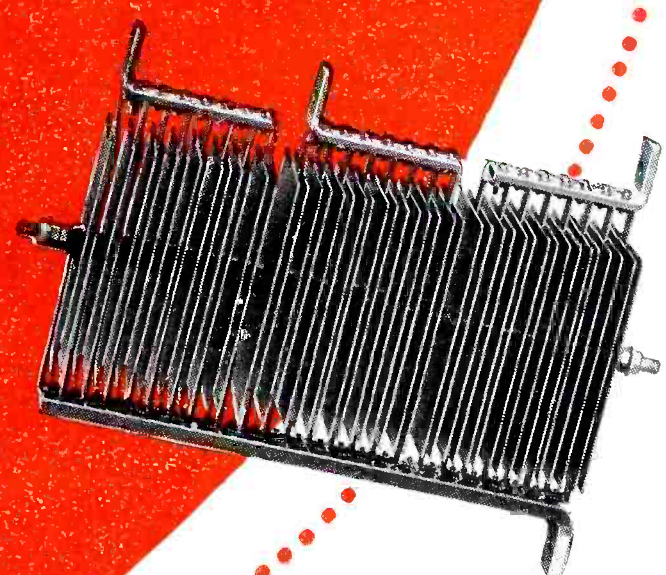
If the radiolocation i-f amplifier were left at full gain during trans- mission of pulses, the tubes would be overloaded. To overcome this damage, the amplifier is rendered



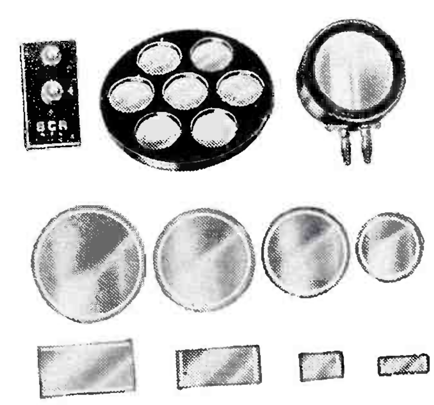
9 reasons why

SCA SELENIUM RECTIFIERS ARE RAPIDLY BECOMING STANDARD IN INDUSTRY FOR ALL RECTIFIER APPLICATIONS





1. Permanent characteristics.
2. Adaptability to all types of circuits and loads.
3. Unlimited life—no moving parts.
4. Immunity to atmospheric changes.
5. High efficiency per unit weight.
6. From 1 volt to 50,000 volts rms.
7. From 10 microamperes to 10,000 amperes.
8. Economical—simple to install—no maintenance cost.
9. Hermetically sealed units available.



The Modern Solution for all Rectifier applications. Selenium Rectifiers are ENGINEERED FOR ENGINEERS. Selenium Corporation of America meets exacting specifications of modern electronic developments. Manufacturers of a broad line of Selenium Power and Instrument Rectifiers, Self generating Photo-Electric cells and allied scientific products. Selenium Corporation of America's engineering experience can be called upon for the development and production of special rectifiers for any application.

SCA

SELENIUM CORPORATION OF AMERICA

Affiliate of VICKERS Incorporated

1719 WEST PICO BOULEVARD • LOS ANGELES 15, CALIFORNIA

46-F

inoperative by a large negati *suppression pulse,* usually appli to the screen grid of the first tub The circuit must recover quick after removal of the suppressic pulse so that returns from nearl targets will be received. Becau pulses from close targets will be large amplitude, gain of the i amplifier may be raised slowly aft removal of the suppression pulse b means of a saw-tooth wave. Su gain control is called *swept gai* When it is more important to ope ate at the greatest gain consiste with background noise, avc is use

Because the bandwidth of t i-f amplifier is very small co pared to the transmitted carri frequency, a discriminator circu and automatic frequency control the local heterodyne are used hold the intermediate frequency the center of the i-f band-pa despite frequency drift of t transmitter. Details of the di criminator are modified fro those used in continuous-wa transmission to deal with pul modulation. Further details of th investigation may be found in paper by W. L. Watson, I. F. Ampl fiers for Radiolocation Receiver *South African Engr,* p 177, Au 1946.

Movie of a Movie

Chinese cinematographers, sent to Holl wood by the Chinese government to stud American motion picture production pra tice, are making a documentary film f use in teaching motion picture techniqu to students at the Chinese University. Joh Cass is shown explaining to Chen Yan methods for mixing and monitoring voic signals at a portable console used on s

ALTEC LANSING

now offers

A UNIQUE LINE OF LOUDSPEAKERS UNEXCELLED IN ANY FIELD...FOR ANY USE

604 Duplex 15-inch

603 Multicell Dia-Cone 15-inch

600 Dia-Cone 12-inch

THE MODEL 604 DUPLEX fulfills professional requirements for a full 2-way speaker, reproducing the entire FM range without intermodulation or distortion. It provides the ultimate in sound quality . . . unsurpassed by any unit at any price.

THE MODEL 603 MULTICELL DIA-CONE meets the tremendous need for ultra high-fidelity sound that approaches the Duplex in quality, but is more economical in price. This speaker incorporates all the advantages of a 2-way multicellular speaker system.

THE MODEL 600 DIA-CONE is designed primarily for manufacturers catering to discriminating musical tastes. It is priced within the range of all connoisseurs who demand faithful reproduction of tone. They select this inexpensive unit as an auxiliary speaker for their receivers.

hearing is believing . . . ask your dealer for a demonstration

Cabinetry designed to enhance sound reproduction and harmonize with interiors is available for Models 604 and 603.

ALTEC LANSING CORPORATION

1161 N. Vine St., Hollywood 38, Cal.
250 W. 57th St., N. Y. 19, N. Y.

The Models 603 and 600 both employ the exclusive Dia-Cone construction principle, reproducing low frequencies and high frequencies from separate diaphragms.

"KEEP ADVANCING WITH ALTEC LANSING"

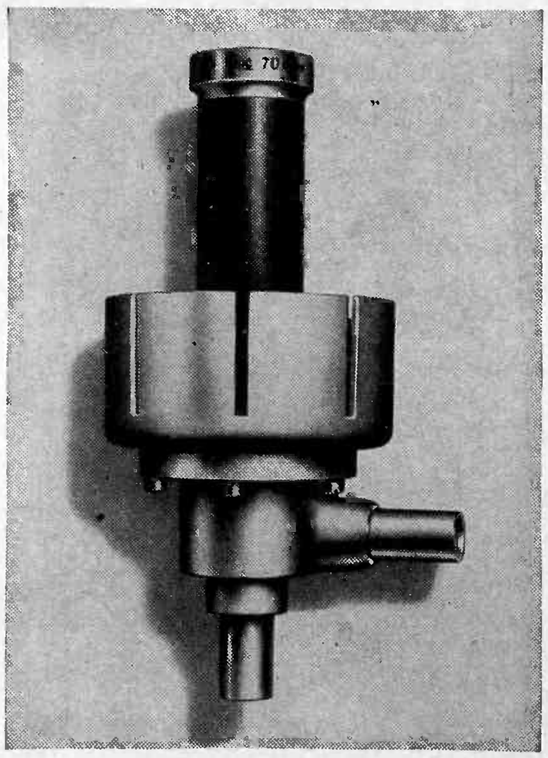
NEW PRODUCTS

Edited by A. A. McKENZIE

New apparatus, component parts, packaged units and allied equipment are described. Catalogs and manufacturers' publications are reviewed

Water-Cooled Resistor

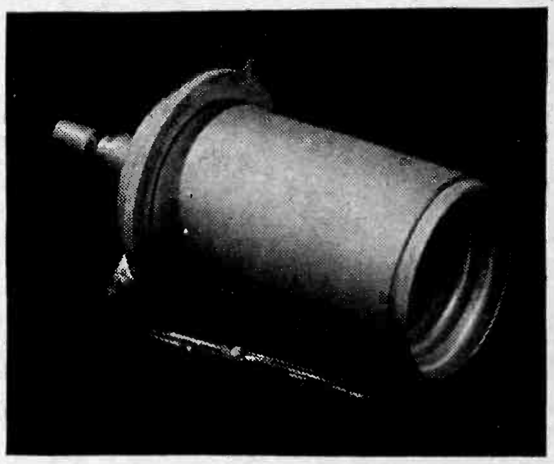
INTERNATIONAL RESISTANCE CO., 401 North Broad St., Philadelphia, Pa. A new development is the type LP liquid cooled, high-frequency, high-power resistor designed particularly for television, f-m, and dielectric heating applications. The resistance film is thin and has an



active length considerably less than a quarter wavelength at f-m frequencies. A high-velocity stream of water flows against the film to cool it. Power dissipation up to 5 kilowatts is permissible. The resistor is available in values between 35 and 1,500 ohms. Standard tolerance is plus or minus 15 percent.

C-W Magnetron

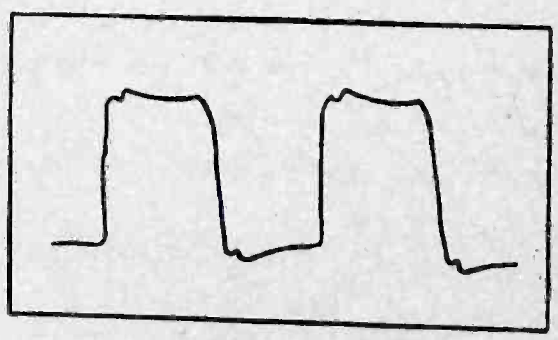
GENERAL ELECTRIC CO., Syracuse, N. Y. A new magnetron furnishing 5 kilowatts of continuous-wave power at 1,050 megacycles is expected to prove useful in plastics



and industrial heating applications. The tube is water-cooled, but is fitted for quick insertion in the electrical circuit and connection to water lines.

Music Amplifiers

BROOK ELECTRONICS, INC., 34 De Hart Place, Elizabeth, N. J. The Brook amplifiers, models 10C, 10C2 and 10C5 comprise the same basic unit, a square-wave response curve



Response of the model 10C amplifier to a 5,000 cycle square wave

of which is illustrated, but differ in the amount of supplementary control equipment. All units are built on a 17-inch chassis suitable for rack mounting. Audio transformers of special design are used throughout, and the output transformer will not saturate with 34 watts output at 25 cycles. Response of the amplifiers is flat within 0.2 db from 15 to 25,000 cycles.

The Model 30A preamplifier and mixer is powered by either the 10C amplifier to which it is attached or from a separate supply. It can be mounted adjacent to or at a distance from the output amplifier depending upon requirements.

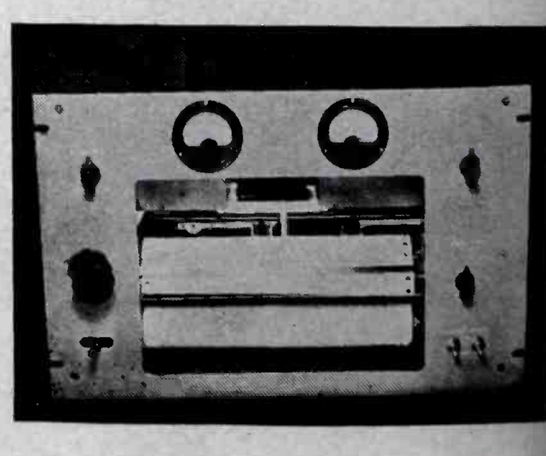
Talking Letters

THE BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. The Mail-A-Voice recorder-reproducer uses paper recording blanks coated with a magnetic material. When records are made or played back a grooved spiral plate, concentric with the paper record, is

placed upon the turntable to serve as a guide for the magnetic tone arm. Since there are no grooves in the records themselves, they can be folded without damage, the voice erased with a small magnet, and the records reused a great number of times.

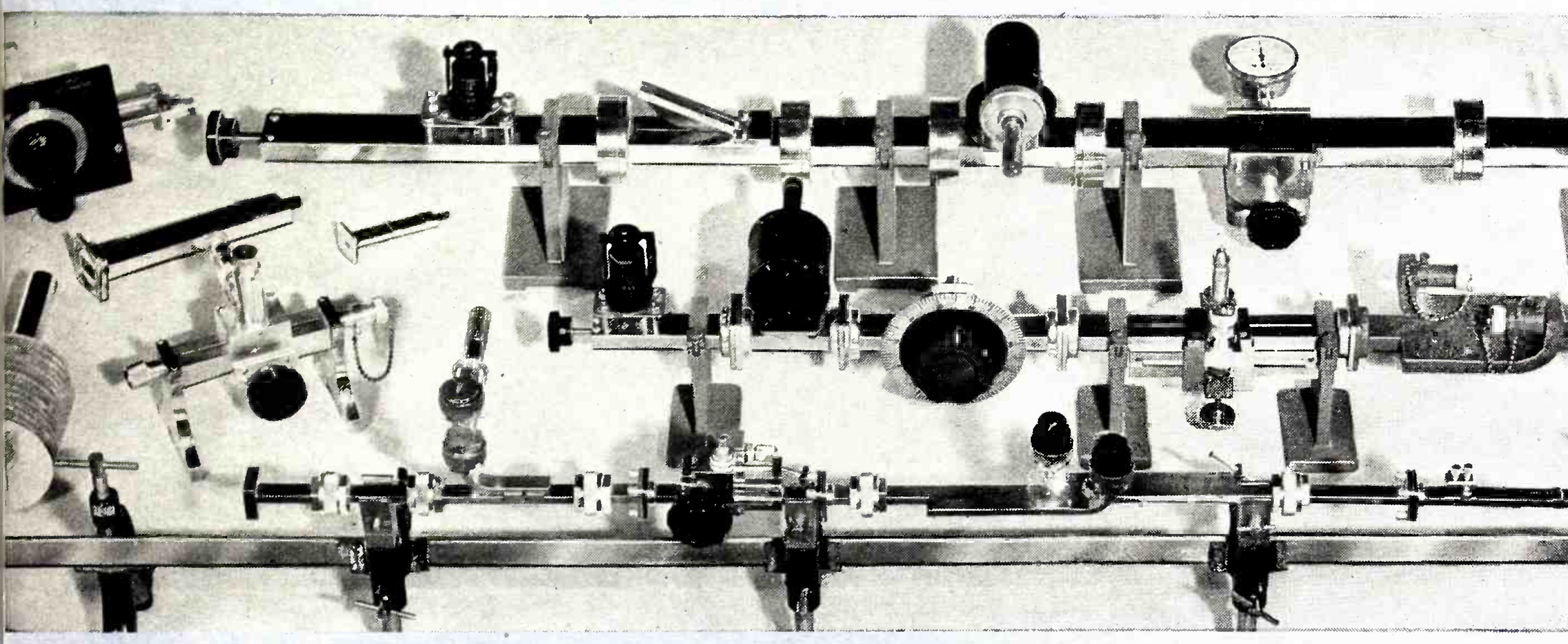
Twin Recorder

SOUND APPARATUS CO., 233 Broadway, New York 7, N. Y. A newly developed dual recorder can be used



DE MORNAY • BUDD STANDARD TEST EQUIPMENT

For Precision Measurements in the Microwave Field



The complete line of De Mornay·Budd standard test equipment covers the frequency range from 4,000 mcs. to 27,000 mcs. It provides all R. F. waveguide units necessary for delicate, precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

To eliminate guesswork, each item of this De Mornay·Budd test equipment is individually tested and, where necessary, calibrated, and each piece is tagged with its electrical characteristics. All test equipment is supplied with inner and outer surfaces gold plated unless otherwise specified.

NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.

The three test set-ups illustrated above include:

- Tube Mount
- Flap Attenuator
- Frequency Meter
- Calibrated Attenuator
- Tee
- Stub Tuner
- Tunable Dummy Load
- Standing Wave Detector
- Type "N" Standing Wave Detector
- Directional Coupler
- Hight Power Dummy Load
- Cut-Off Attenuator
- Stands, etc.

DE MORNAY
BUDD

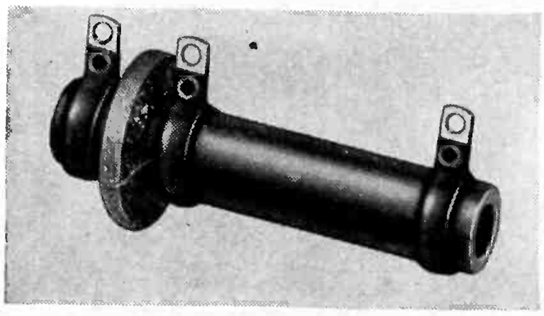
EQUIPMENT
FOR
97% OF ALL
RADAR SETS

DE MORNAY • BUDD INC., 475 GRAND CONCOURSE, NEW YORK 51, NEW YORK. CABLE ADDRESS "DEMBUD," N. Y.

for the simultaneous observation of two different phenomena, such as noise and vibration, or average and rms values. Built in rack form, measuring 12¼ by 19 inches, the unit has two synchronous motors, one for the writing pens and one for moving the chart.

Video Network

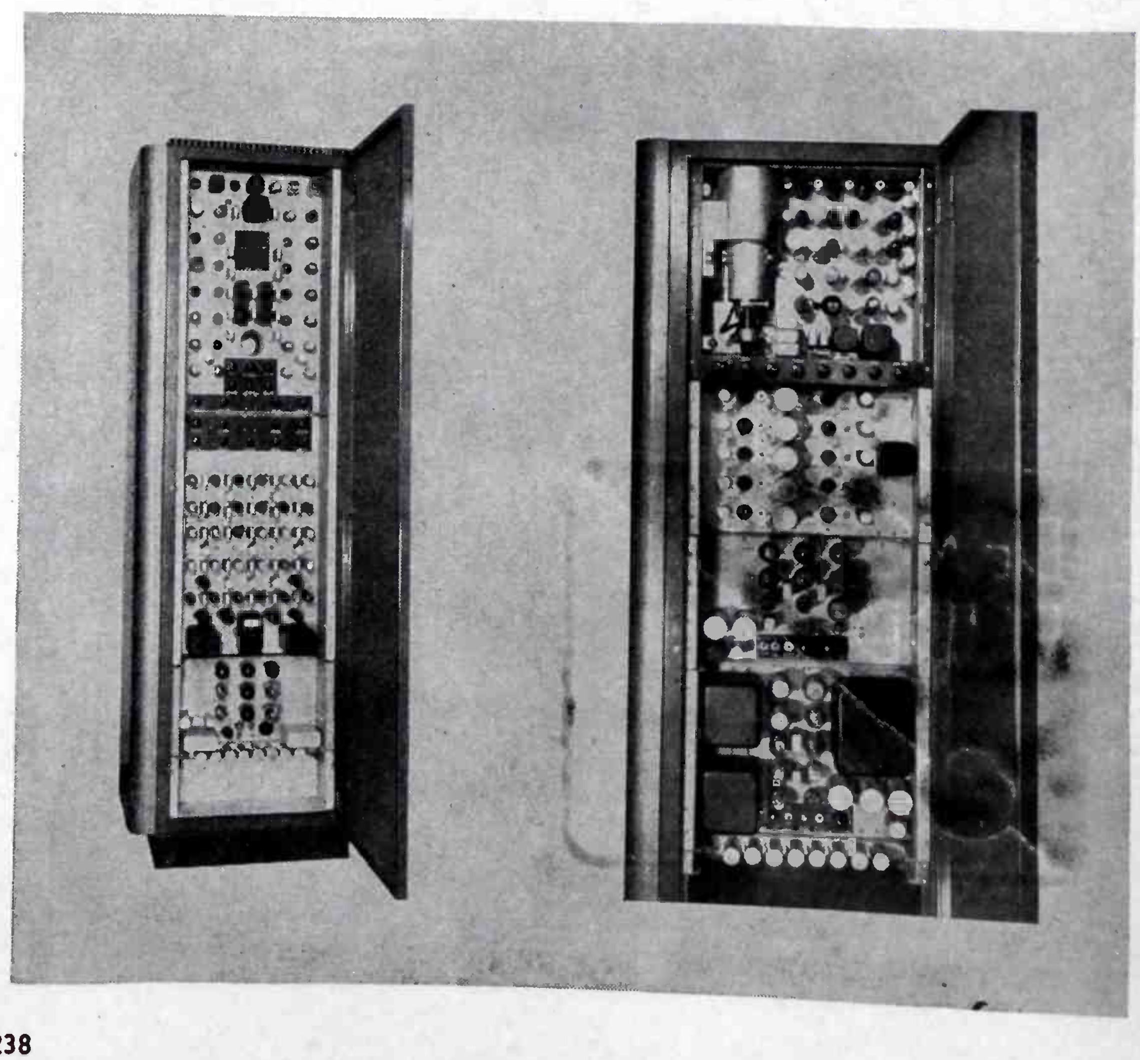
P. R. Mallory & Co., Indianapolis, Ind. The Videocoupler is a three-terminal network designed to cou-



ple the video amplifier to the picture tube in television receivers. The unit comprises two peaking inductors and a load resistor.

Television Test Units

Radio Corp. of America, Camden, N. J. Television test units illustrated here for broadcast stations and production lines comprise the type TG-1A synchronizing generator at the left, as well as the type TK-1A monoscope camera, and type TA-1A distribution amplifier shown at the right. The synchronization generator produces five fundamental timing and synchronizing impulses necessary for RMA standard 525-line, 30-frame interlaced scanning systems. The monoscope provides a fixed standard video signal, while the amplifier serves to mix the signal impulses or send them out through separate lines with complete isolation of input and output circuits.

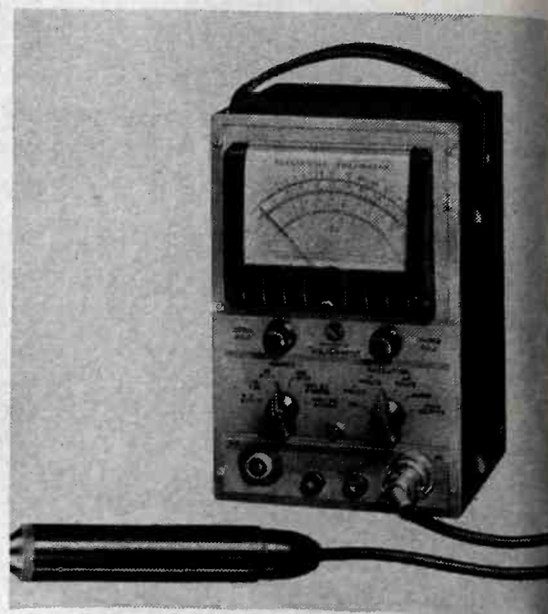


Microphone Stand

Snyder Mfg. Co., 22nd and Ontario Sts. Philadelphia 40, Pa. The new microphone stand features a heavy cast-iron base and quick-grip locking nut to hold the stand at any position from 30 to 60 inches high. List price is $7.75.

New Voltohmyst

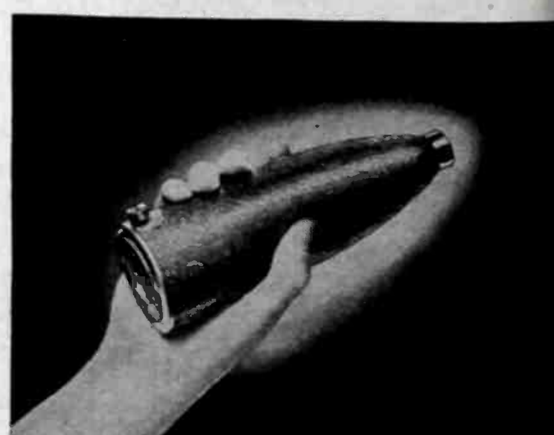
Radio Corp. of America, Camden, N. J. Using a newly developed diode probe, the type WV-75A meter can be employed for high-impedance circuit testing at frequencies up to 250 megacycles. Radio receiver voltages up to 1,000 volts can be



measured directly on either a-c or d-c. Bias cell, afc, and avc voltages can be checked. Six resistance scales allow measurements up to 1,000 megohms. The meter weighs only 9 pounds.

Condenser Microphone

Western Electric Co., Inc., 195 Broadway, New York 7, N. Y. The type 640AA studio microphone was originally developed and used for laboratory and field work in sound studies. Recently this microphone has been used with great success in high-fidelity broadcasting. A fea-

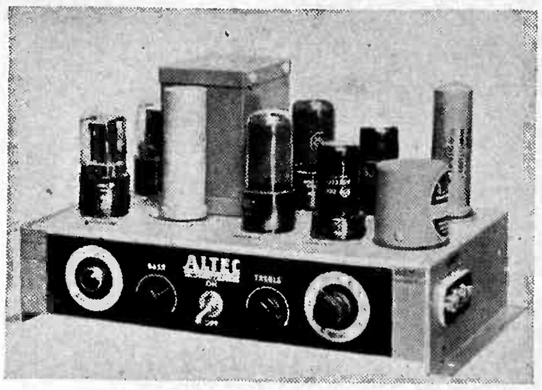


ture of the microphone contributing to its excellent response is the fact that the diaphragm is flush with the end of the microphone, avoiding cavity resonance effects. The microphone serves to cover a large area and can be suspended so as to give essentially nondirectional pickup.

Wired Music Amplifier

Altec Lansing Corp., 250 West 57th St., New York 19, N. Y. A new high-quality, low-price ampli-

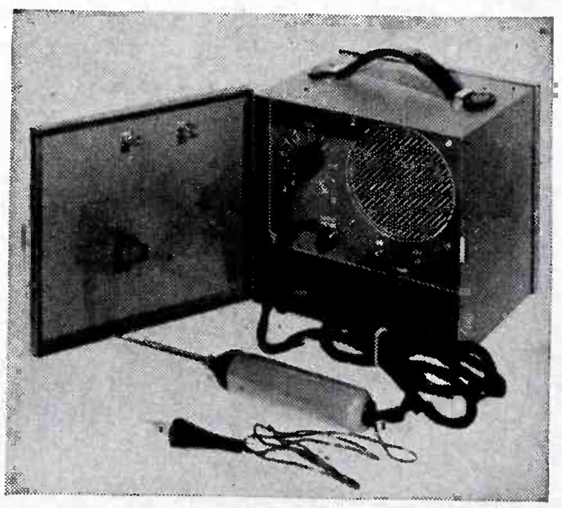
fier, type A-319, has been designed for home phonograph or commercial wired music systems. Bass and treble boost are provided, but



the amplifier is essentially flat from 40 to 15,000 cycles without use of these controls. The power output is 4 watts and the equipment can be operated on either a-c or d-c lines. There are two models, A and B, that differ in weight and line input impedance.

Signal Tracer

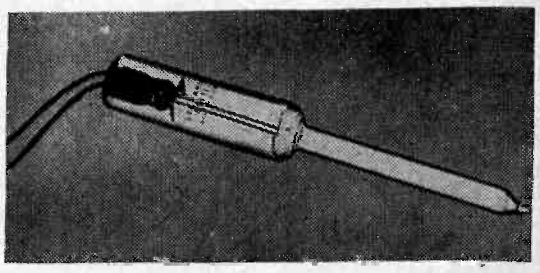
SPECIAL PRODUCTS CO., Silver Springs, Maryland. A battery-operated portable signal tracer weighing less than 5 pounds includes a



long probe to reach inaccessible points in a receiver, a gain control, and a loudspeaker. A jack is provided for an output meter.

Pirani Tubes

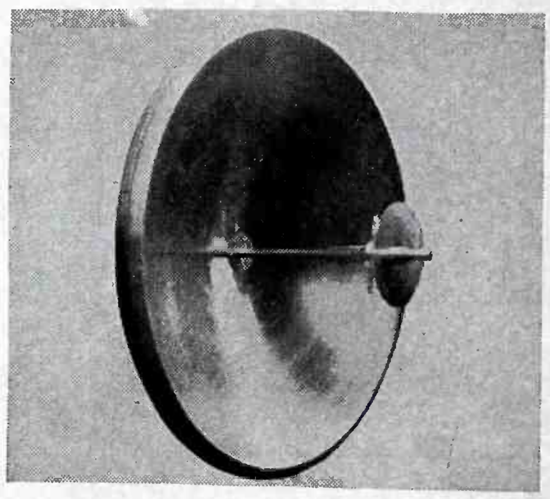
SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. Pirani tubes with tungsten filaments operating at 1.5 volts, 100 milliamperes, are available in matched pairs for use with a 0-1 milliampere meter in a simple bridge circuit. The type R-1111 tubes so used give readings accur-



ate to plus or minus 5 percent within a pressure range of one to 1,000 microns. Nonex envelopes with tubulation are provided.

Relay Antenna

THE WORKSHOP ASSOCIATES, INC., 66 Needham St., Newton Highlands 61, Mass. Antennas for use in the 920 to 960 megacycles and 1,295 to 1,375 megacycle relay bands are now in production. The dish-type



antennas have a power gain of 50 with half-power angles of 21.5 degrees in the vertical and 18.5 degrees in the horizontal plane. Standing wave ratio is less than 1.5 to 1 when the antenna is connected to a 52-ohm line.

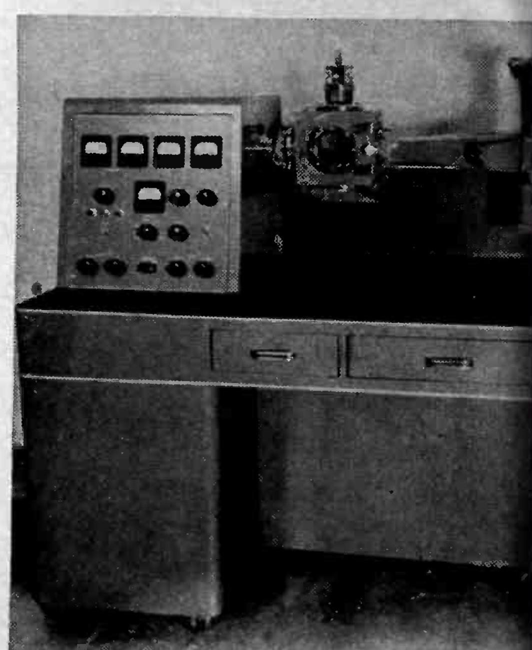
Modulation Meter

SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. The type X7018 modulation meter

will be useful to radio amateurs, well as police and marine static in the frequency range 1.8 to megacycles. When properly stalled near an a-m transmitter will indicate percentage of modu tion and any carrier shift. A hea phone jack is also provided aural check of modulation dist tion and hum. The equipment relatively simple in constructi and requires no batteries or ext nal power connection by virtue using two crystal diodes.

Electron Diffraction

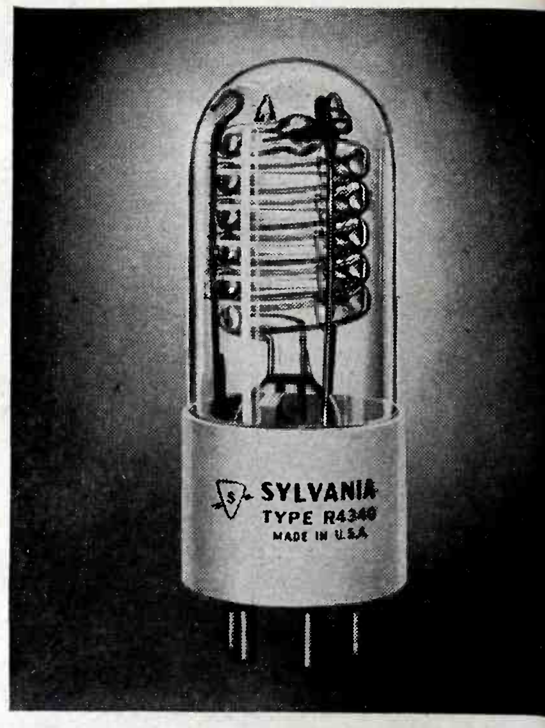
GENERAL ELECTRIC CO., Syracu N. Y. Fifteen electron diffracti instruments are now being man factured for the study of qua crystals and metal surfaces. Spe mens weighing up to 40 pounds a



bombarded, under vacuum, w electrons that bounce off to be ph tographed in the form of a diffra tion pattern on a plate. The equi ment is useful in a submicroscop study of surfaces and in determi ing the photoelectric work functio of various alloys.

Flash Tube

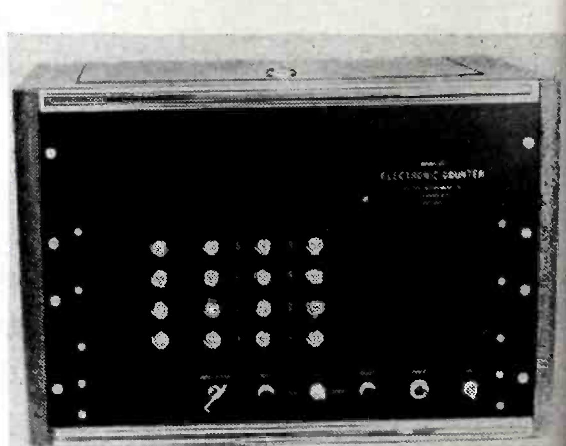
SYLVANIA ELECTRIC PRODUCTS INC 500 Fifth Ave., New York 18, N. The new type R-4340 flash tube pr vides a peak output of 48 millio lumens or four times that of th type R-4330. Uniformity of the il lumination between 4,000 and 7,00 angstroms makes the new tub



ideal for color photography. A circuit employing a 120-microfarad capacitor charged to 2,500 volts is used to flash the tube for about 200 microseconds. It can be flashed four times a minute.

Decimal Scaler

POTTER INSTRUMENT CO., 136-56 Roosevelt Ave., Flushing, N. Y. Four 4-tube decades are used in the Model 85 instrument that will respond to rates as high as 100 kilo-

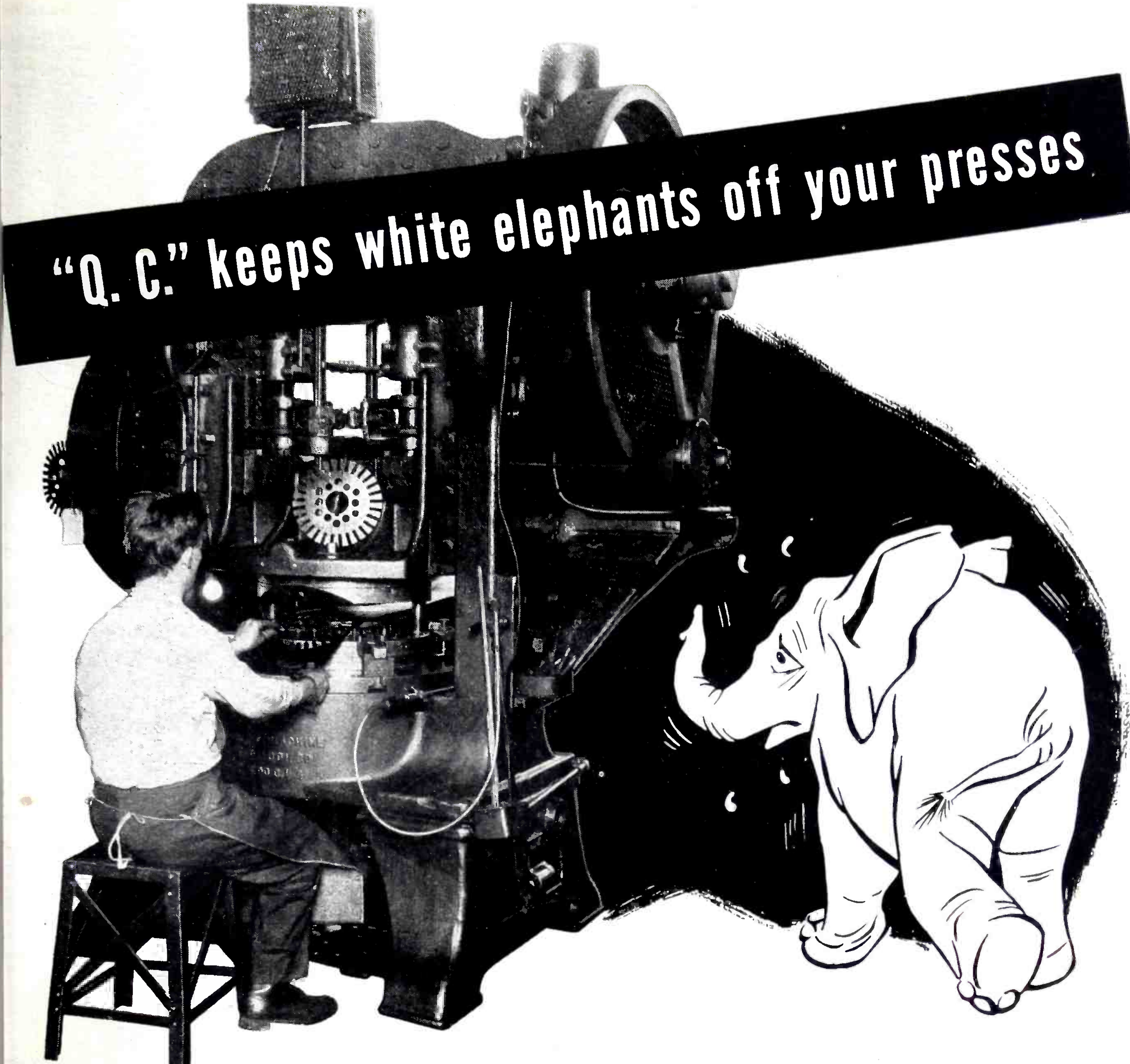


cycles a second and scale them by factors as high as 10,000 to 1. Mainly designed for application in the fields of physics, medicine and chemistry, the equipment will undoubtedly find use in other fields where rapid counting is essential.

F-M Signal Generator

BOONTON RADIO CORP., Boonton, N. J. The type 202-B f-m signal generator covers the frequency range from 54 to 216 megacycles and provides two frequency devia-

"Q. C." keeps white elephants off your presses



One of the kingpins in Armco's production of Quality-Controlled Electrical Steels is the mill representative. In a sense he works for *you,* not us.

This roving ambassador of "Q.C." who visits your plant has only one objective: to see that you get the *one right electrical steel* for your products. He wants no "white elephants" holding up your presses or clogging production lines.

"Q.C." — Quality Control — is no stranger to Armco mill representatives and production supervisors. Control charts and statistical analysis are developments of recent years; they help assure consistent production of prime Armco sheets.

But control charts are only part of the story. For almost 20 years "Q.C." has been a live, familiar term in the Armco mills. It governs the control of sheet steels even before the "charge" goes into the open-hearth furnace.

INDIVIDUAL ROUTINGS

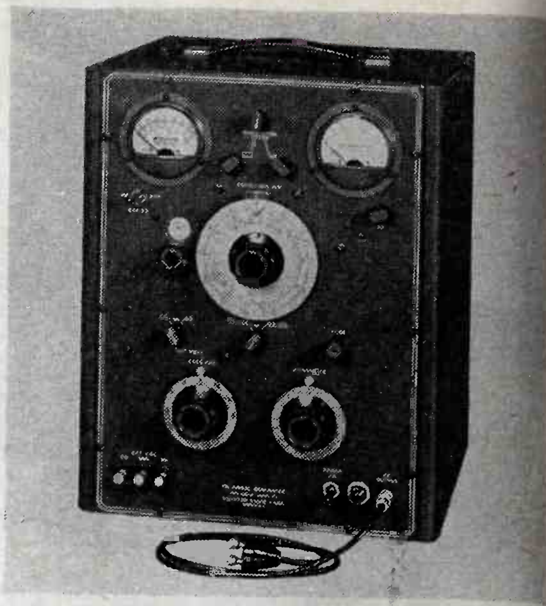
The salesman, mill representatives and metallurgists study your order and its requirements—determine for what purpose the steel will be used and how it will be fabricated. Then, on your individual routing card, metallurgists specify the mill routing that will give your electrical steels the properties they need.

In all these deliberations the Armco mill representative first keeps *your* problems in mind. He is your assurance of a high "Q. C." in the ARMCO Electrical Steels that go into your products. The American Rolling Mill Company, 4731 Curtis Street, Middletown, Ohio.

ELECTRICAL ★ ARMCO ★ SHEET STEELS

THE AMERICAN ROLLING MILL COMPANY

Special-Purpose Sheet Steels • Stainless Steel Sheets, Bars and Wire



tion ranges, 0 to 80, and 0 to 240 kilocycles. The instrument is also available for amplitude modulation tests with 30 and 50 percent modulation. A monitoring meter standardizes the output level. Output impedance is 26.5 ohms. Power supply is self-contained and operates from ordinary socket power.

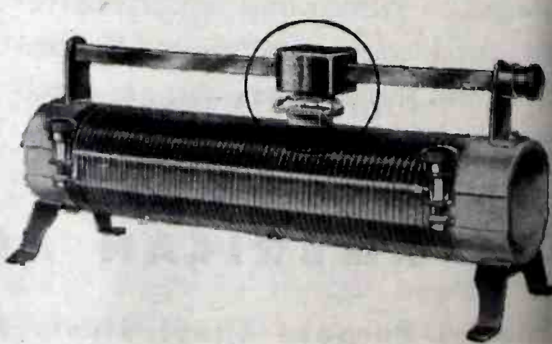
Auto Radio Vibrators

NATIONAL UNION RADIO CORP., Newark, N. J. Replacements for over 2,500 different models of auto

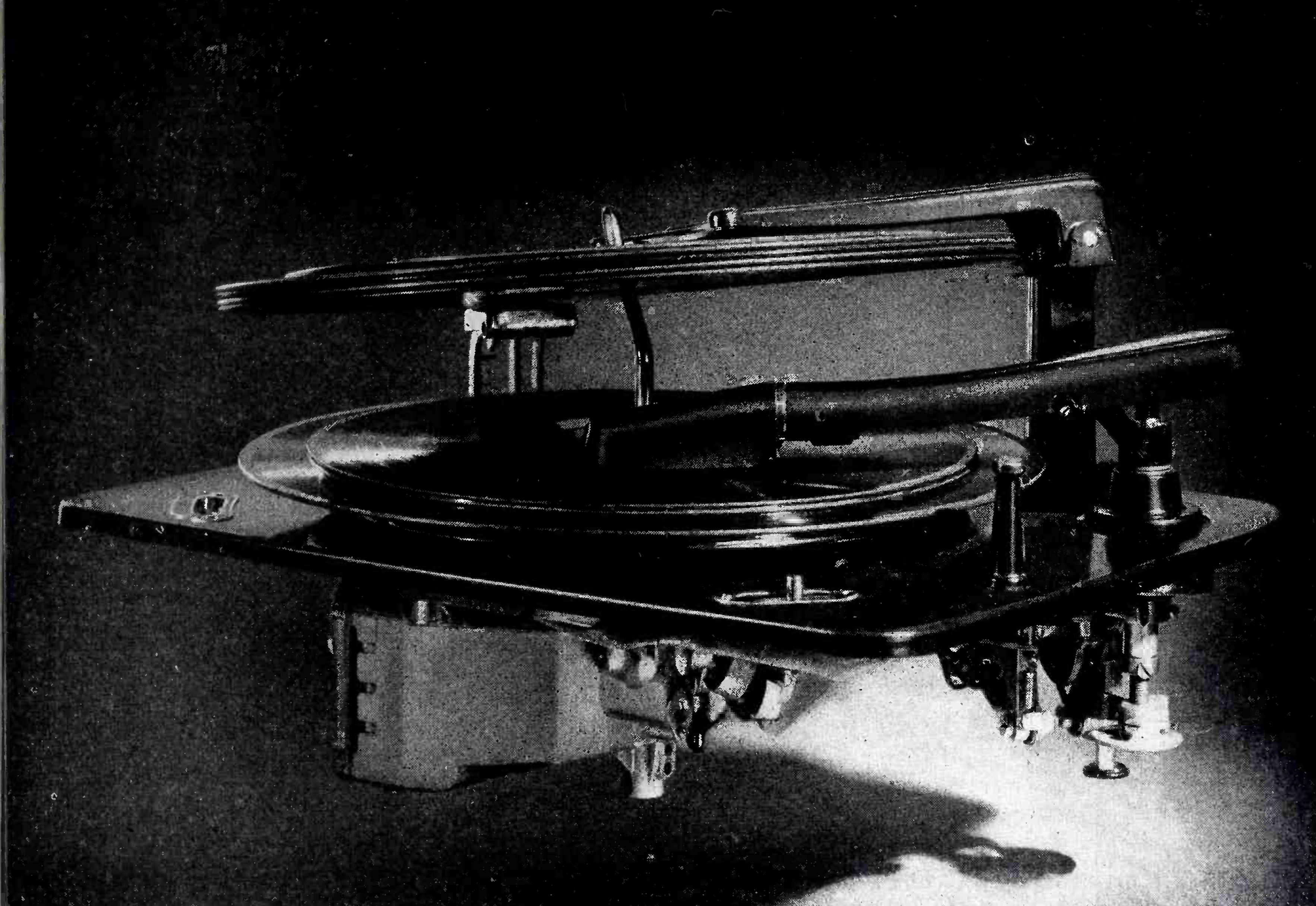
radio vibrators have been standardized to a minimum of 8 types now being manufactured under the brand name Univibes.

Tubular Rheostat

REX RHEOSTAT CO., 3 Foxhurst Road, Baldwin, L. I., N. Y. A new tubular slide-contact rheostat, type



For phono-combinations that aren't being born in a hurry . . .



If you manufacture the kind of combination that takes its precious time coming off the drawing board – and off the assembly line – Garrard is your record changer.

For the most part, Garrard changers have been finding their way into those custom-built assemblies where every component is hand-picked, without a sidewise glance at cost. Your finest combinations are made that way, and there is every reason why you can and should select Garrard.

It's as simple as this: with Garrard in your combination, you can feature the changer as you feature cabinetry and tone quality. You can point up the watch-like construction; the exclusive governor-controlled, speed-regulated motor; the non-slip spindle . . . and more. Most important . . . Garrard has the "look" of belonging in distinctive sets.

Send for a sample changer. Garrard Sales Corporation, 315 Broadway, New York 7, New York.

PRECISE AS A WATCH

1. Exclusive speed-regulated, governor-controlled motor
2. Completely automatic intermixing
3. True tangent, jewelled-pivot tone arm
4. Exclusive non-slip spindle
5. Automatic stop
6. Heavy fly-wheel action built into turntable
7. Only one operating control required
8. Full swivel tone arm for changing needles
9. Kind to fragile records; no knives or trick spindles

. . . they ask for it by name . . .

GARRARD

WORLD'S FINEST AUTOMATIC RECORD CHANGER

...RRARD ADS APPEAR CONTINUALLY IN EVERY IMPORTANT CONCERT PROGRAM AND IN LEADING HOME-FURNISHINGS PUBLICATIONS

E, features a pair of copper-graphite contact blocks, connected by a leaf spring of phosphor bronze. One block bears against the resistance winding and the other against the slider bar so that the contact is lubricated and arcing prevented. There are 16 ohmic values in which the resistor is regularly manufactured. Power rating of any unit is 450 watts. Other types of units manufactured by the company are described in Catalog No. 3.

Individual Receiver

EMERSON RADIO AND PHONOGRAPH CORP., 111 Eighth Ave., New York 11, N. Y. A broadcast receiver equipped with an output for a hear-

ing aid receiver on a separate volume control, in addition to the regular loudspeaker and its control, has been announced. The table-model receiver will retail for $45.

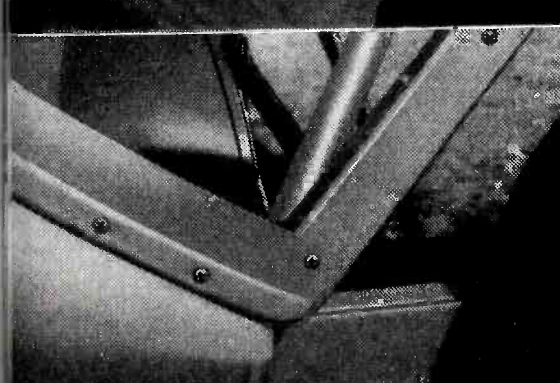
Shunt Capacitance Meter

KALBFELL LABORATORIES, 1076 Morena Blvd., San Diego 10, Calif. The model 401A Micro-Miker has been particularly designed to meas-

"DRIVE TWICE AS FAST"

—Phillips Screws help Piper build 1100 Cubs a month!

20 Phillips Screws hold instruments in panel, and six more fasten panel to cowling of the Cub Super Cruiser. Before using Phillips Screws, one driver slip often required removal of all screws and scrapping or repairing damaged panel.



'astenings near fabric covering – no place or driver slips – no slips with Phillips Screws.

The 20,000th Piper Cub, completed June 1946. Phillips Screws speeded this big production!

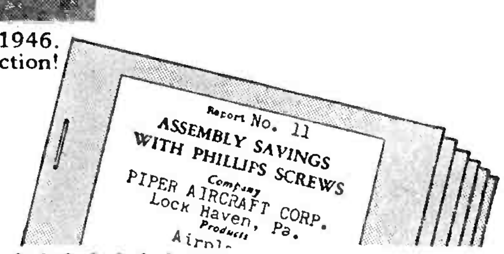
"We started using Phillips Screws back in 1938, when . . . and because . . . we were getting set for large scale production," declared Piper's Assistant Chief Inspector to the James O. Peck Co. investigator, studying assembly savings with Phillips Screws in well-known plants. "Today we're shipping our 20,000th Piper Cub. That proves how much faster Phillips Screws are to drive.

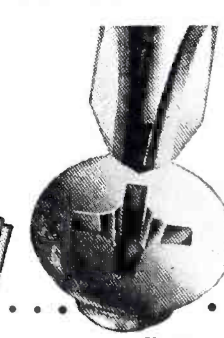
"IDEALLY SUITED TO POWER DRIVING, which we needed for high production. Unlike slotted screws, Phillips Screws hold the driver bit in place without a guide or other support, automatically center themselves in the screw holes and catch the thread quicker. Phillips Screws are easily twice as fast to drive.

"TAKES LESS TIME TO MAKE SKILLED ASSEMBLERS. It takes a man much less time to become familiar with and do a good job of driving Phillips Screws. Since the Cub is fabric covered, any driver slips would cost us expensive, undesirable patching, doping and repainting . . . up to $1.00 a slip. Same thing on the instrument panel where a single driver slip would cost up to $3.50. If we were using slotted screws, assemblers would have to go much slower, especially at the learning stage, to avoid such damage.

"WE GET A BETTER INSPECTION. Don't have to watch out for burred heads as we used to do with slotted screws. Fabric tears and instrument panel scratches are out. And the Phillips Recessed Head certainly makes a more attractive, workmanlike job wherever screw heads are exposed."

GOOD IDEAS FOR YOUR ASSEMBLY LINE in this independently made report of Piper's assembly savings with Phillips Screws. Similar studies . . . covering metal, wood and plastic products . . . available to you without cost or obligation. Use the coupon TODAY!





PHILLIPS *Recessed Head* SCREWS

ood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

26 SOURCES

erican Screw Co.
antic Screw Works
as Bolt & Screw Co.
tral Screw Co.
ndler Products Corp.
tinental Screw Co.
bin Screw Div. of
merican Hdwe. Corp.
H. M. Harper Co.
rnational Screw Co.
son & Sessions Co.

Milford Rivet and Machine Co.
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.

Pheoll Manufacturing Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wolverine Bolt Company

Phillips Screw Mfrs., c/o Horton-Noyes
2300 Industrial Trust Bldg., Providence, R. I. E-11

Send me reports on Assembly Savings with Phillips Screws.

Name ....

Company ....

Address ....

....

ure small capacitances in amplifiers, including stray capacitances between wiring and chassis. The measurement is made by direct substitution in a parallel resonant circuit at a frequency between 2.5 and 3.5 megacycles. Range of the equipment is 1 to 230 micromicrofarads.

Radioactivity Probe

INSTRUMENT DEVELOPMENT LABORATORIES, 817 E. 55th St., Chicago 15, Ill. A portable beta-gamma count rate meter has been developed for locating radioactive material. The model 2610 meter has

three ranges, up to 20 milliroentgens per hour full scale. A detachable four-foot cable allows probing with the Geiger tube. A headset is furnished for rapid surveying. Self-contained batteries will operate the equipment for 500 four-hour-daily periods.

Small Motor

FAIRCHILD CAMERA AND INSTRUMENT CORP., 88-06 Van Wyck Blvd., Jamaica 1, N. Y. A new 117-volt,

Conventional multipliers wound with ordinary enamelled wire cannot operate safely at much more than the one MA called for in government specifications. Sprague Precision Meter Multipliers, however, can be used at *twice their normal current rating,* with only a slight decrease in long time stability. Plus or minus 1% resistance tolerance should be specified.

This cutting of resistance value in *half,* with approximate halving in meter multiplier cost, results from use of wire that is insulated before winding, with a 1000° C. heat-proof ceramic and wound on special high-temperature plastic forms. *Larger wire sizes* are used through reduction of resistance values.

It all adds up to a net saving of as much as 50% in multiplier cost . . . because it allows exactly half the resistance value and, in some cases, half the number of multipliers, to be used for a given application. Sprague engineers will be glad to make recommendations for your specific application.

Write for the new Sprague Resistor Catalog No. 100E.

SPRAGUE ELECTRIC COMPANY, Resistor Division, North Adams, Mass.

SPRAGUE *KOOLOHMS

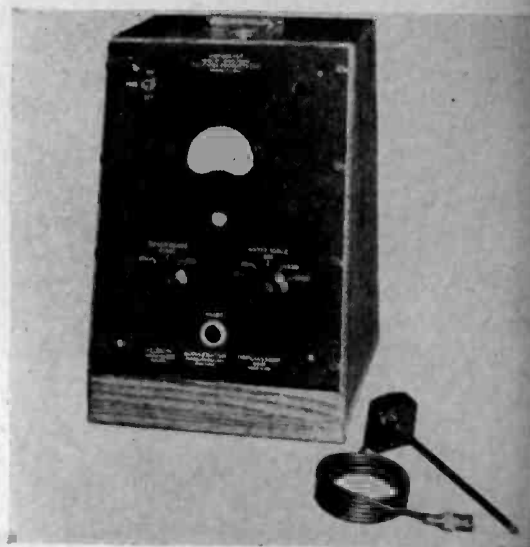
POWER TYPES • BOBBIN TYPES • METER MULTIPLIERS • MEGOMAX, ETC.

*Reg. U. S. Pat. Off.

60-cycle motor operating at 3,600 rpm has a starting torque of 0.75 ounce/inches, weighs 18 ounces and will be useful for record changers, wire and tape recorders, and instrument product applications.

Vibration Meter

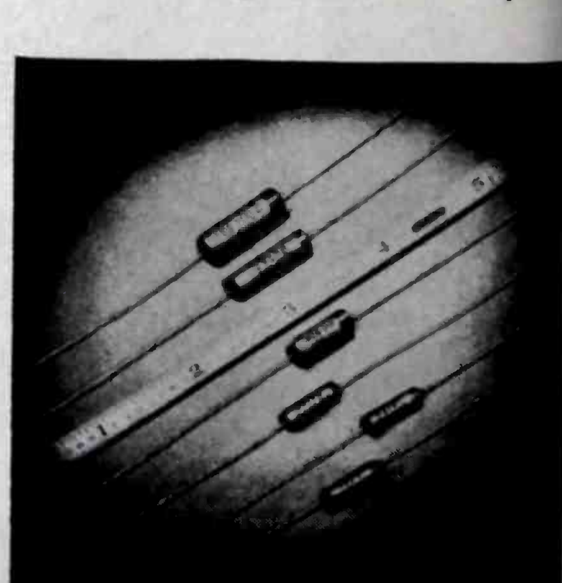
TELEVISO PRODUCTS CO., 7466 Irving Park Road, Chicago 34, Ill. The model 11-B Vibrometer consists of a search probe attached by cable to a vacuum tube voltmeter. The meter



responds to frequencies from 5 to 2,500 cycles and can be read in terms of displacement, velocity, and acceleration. Displacements under 0.01 inch and accelerations up to 10,000 can be measured. The equipment is completely described in Bulletin 33.

Midget Capacitors

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. A new line of midget capacitors, types ZY and ZZ, are among the smallest cylin-



little-known property of Nickel keeps temperatures ight in the SIMMONS ELECTRONIC BLANKET

Acting as the temperature-sensitive element in an electronic control is a new use for Nickel.

Here's how the job is carried out in the Simmons Electronic Blanket:

In the embedded gridiron pattern of heating wires is 355 feet of fine Nickel wire. Acting as a "feeler," it constantly measures blanket temperature.

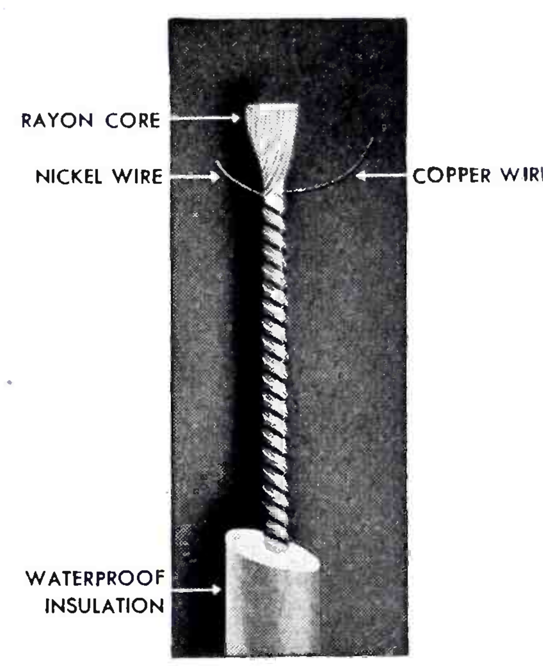
If temperature falls below a chosen level, the decreased resistance of the Nickel wire instantly transmits a signal to the control box. There, electronic tubes amplify the signal, making it strong enough to actuate a relay that sends current through the heater wires.

Once the chosen temperature has been restored, signals from the "feeler" wire similarly shut off the current.

Nickel was selected for this job because its coefficient of electrical resistivity is higher than that of any other commercial metal—.0043-.0050 (68-212° F.). But, as so often occurs when Nickel or Nickel Alloys are used, there were contributing advantages. Nickel offers fatigue resistance *(needed to withstand repeated flexing)*. Nickel is rustless and corrosion resisting *(important, since the blanket must be washable)*. Nickel is both workable and strong *(the "feeler" wire is only 0.0037" in diameter)*.

***Remember to investigate* Nickel and INCO Nickel Alloys whenever you need metals with a *combination* of hard-to-find properties.**

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



THE HEATING ELEMENT

Shown above is the heating element of the Electronic Blanket made by the Simmons Company. Floating in channels inside the blanket, it is composed of two conductors, each insulated from the other by enamel and both covered by an over-all jacket of waterproof plastic insulation. One conductor is the heating wire. The other conductor, consisting of 355 feet of fine Nickel wire, acts as a "Feeler" and constantly measures blanket temperature.

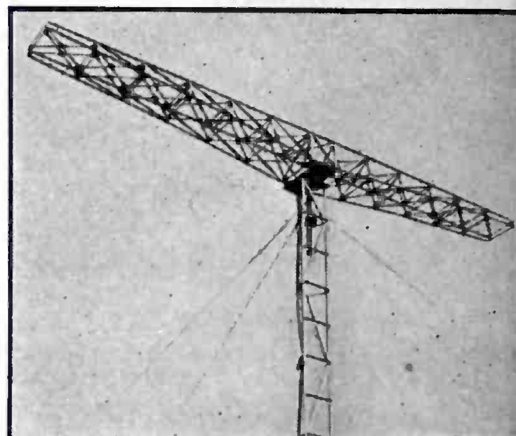
Nickel plays an important role in the control box, too. For, with 3 electronic tubes used, there are jobs that can be done only by Nickel . . . jobs like the anodes, grids, supporting rods and lead-ins, which require Nickel's great thermal endurance, strength and corrosion resistance.

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

drical units ever manufactured. Standard ZY units are ¾ inch long and not over 9/32 inch in diameter. Capacitance values range from 0.001 to 0.03 microfarad at d-c rated voltages from 150 to 600 volts. The ZZ units are smaller and have correspondingly lower maximum values of capacitance and voltage breakdown.

Rotary Beam

WIND TURBINE CO., West Chester, Pa. The new Trylon rotary beam antenna support can be used for a 4-element amateur 20-meter directive antenna or for any other high-



frequency array that may be required in special receiving installations. Overall length of the support is about 19 feet, but it weighs only 31 pounds. Ball-bearing design allows the use of either manual or motor drive.

Insulating Tubing

INSULATION MANUFACTURERS CORP., 565 W. Washington Blvd., Chicago 6, Ill. Dieflex tubing products are made from braided cotton or braided glass and so treated that they will not fray. Silicone-treated Fiberglas varnished tubings are also available.

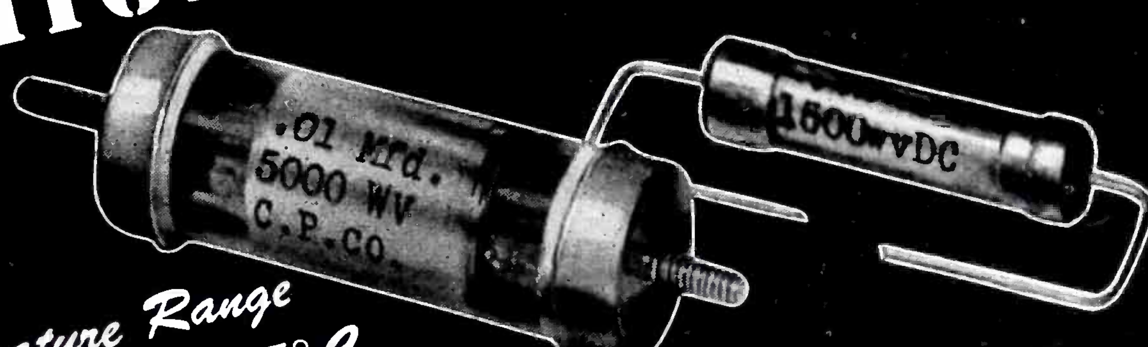
V-T Voltmeter

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. The type 1800-A vacuum-tube voltmeter supersedes the type 726-A. It can be used to measure either d-c or frequencies up to 500 megacycles. A probe used with a variety of fittings has a minimum capacitance

PLASTICON* ASG Silicone-Filled GLASSMIKES

1-3/8 x 3-1/2

FOR HIGHER VOLTAGES



Extreme Temperature Range from Minus 60° C to Plus 125° C

From 600 to over 30,000 Volts

Modern functionally designed capacitors. Metal ferrules are soldered to silver bands fused to each end of heavy-walled glass tubes. This vacuum tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.

Applications

- **For low and medium power coupling and bypass circuits where mica capacitors have previously been required**
- **Television and Oscilloscope Circuits**
- **Vibrator Buffer and Arc Elimination**
- **Geiger Counter and Instrument Capacitors**

Write for illustrated literature featuring our complete line of Glassmike Capacitors.

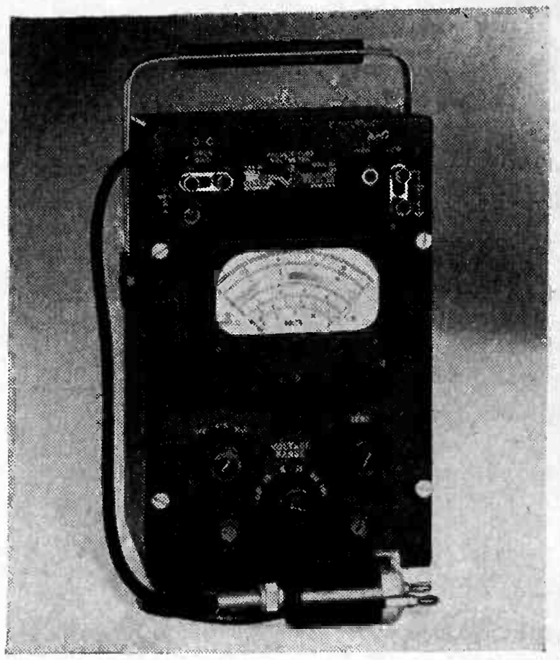
***PLASTICONS: Plastic-Film Dielectric Capacitors**

Order from your jobber: If he cannot supply you, order direct

CP

Condenser Products Company

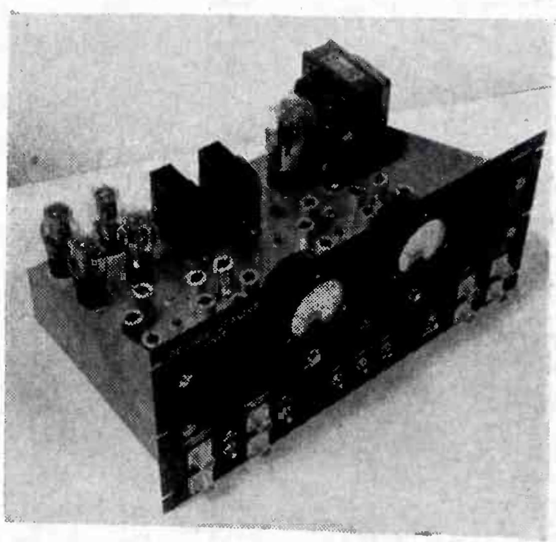
1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS



of 3.1 micromicrofarads and an input resistance at low frequencies of 25 megohms. The regulated power supply contained in the instrument is operated from the power lines.

Decade Counter

General Electric Co., Syracuse, N. Y. A new decade scaling unit for use with particle detectors will respond to impulses of 0.1 micro-



second duration separated by only 10 microseconds. Scaling factor of the type YYZ-1 unit is either 10 or 100, but can be used in cascade to provide factors of 1,000 or more.

Microvolt Meter

The Perkin-Elmer Corp., Glenbrook, Conn. An amplifier for the measurement of d-c and low-frequency a-c voltage in the microvolt range operates by changing direct voltages into 80-cycle alternating voltage by means of a vibrator. After this voltage has been ampli-

DIELECTRIC-HEATING ENGINEERS
wrote the specifications for this tube!

- ✓ High plate voltage to match high-impedance load.
- ✓ Low-wattage, low-current filament, for simple and economical transformer and circuit design.
- ✓ Up to 50 mc frequency at max plate input.
- ✓ Over 6 kw tube typical power output (Class C operation).
- ✓ Modern, compact tube and radiator construction, to conserve space when tube is mounted.

GL-5549

RATINGS

No. of electrodes	3
Type of cooling	forced air
Filament voltage	12.6 v
Filament current	56 amp
Max anode ratings:	
voltage	8,500 v
current	1.25 amp
input	10 kw
dissipation	4 kw
Frequency at max ratings	50 mc

New POWER TRIODE

General Electric's new GL-5549 triode bulls-eyes the target for power tubes for dielectric heating. Check all 5 key advantages above—then add (6) forced-air cooling for simplicity of installation, (7) a pure tungsten filament for more reliable high-voltage performance.

Substantial service life may be ensured by lowering the voltage of the GL-5549's tungsten filament during periods when no anode power is needed. Circuitwise, this easily is accomplished by using an auxiliary contact on the anode voltage contactor, to cut back the filament potential to 80 percent normal when the anode is "idle". The practice is especially useful in dielectric heating applications, which commonly operate on a low duty-cycle basis.

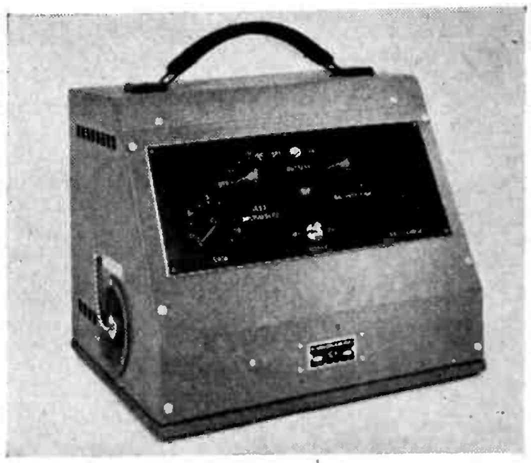
Type GL-5549 is the newest of a group of G-E power tubes for high-frequency heating—18 types in all—which is unexcelled in range, adaptability, and proven performance. G-E tube engineers gladly will work with you to select *the right tube* for your individual heating-equipment problem. Phone your nearest G-E office, or write *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

162-E10-8850

FIRST AND GREATEST NAME IN ELECTRONICS

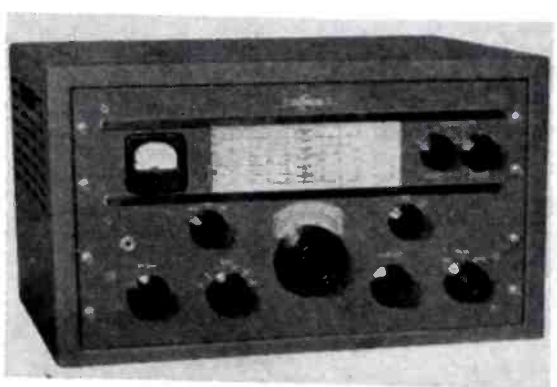
fied in a resistance-capacitance amplifier it is converted back to d-c through the synchronous action of other vibrator contacts. Because the output voltage can be used to



operate rugged meters or standard recorders, the amplifier is suitable for measuring circuits of radiation thermopiles, infrared spectrometers, and thermocouples.

All-Band Receiver

COLLINS RADIO CO., Cedar Rapids, Iowa. The 75A receiver is not a general communications receiver, having been designed for amateur band coverage from 80 to 10 meters. The straight-line tuning dial is cali-



brated directly in frequency. Circuitwise, the receiver includes a crystal filter, double conversion and self-contained power supply. It is completely described in a four page bulletin.

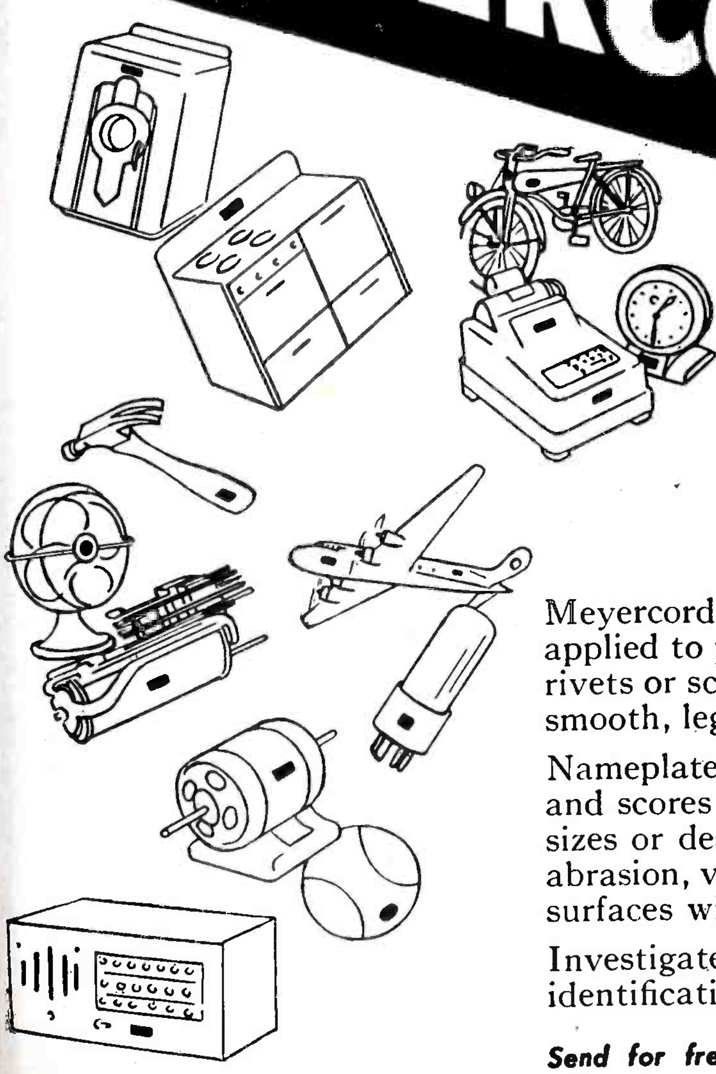
Improved B Battery

NATIONAL CARBON CO., 30 E. 42nd St., New York 17, N. Y. New 45-volt B batteries for use with electronic communications and industrial equipment are now available in smaller physical size. The new Mini-Max type battery displaces only 76.6 cubic inches as compared

Telling the World it's a REMINGTON

with

MEYERCORD DECALS



THE MODERN NAMEPLATE USED ON THOUSANDS OF PRODUCTS

Meyercord Decalcomania is a durable, flexible material that can be quickly applied to practically any commercial surface . . . at production line speeds. No rivets or screws. No sharp corners or edges. Simple, easy-to-use methods assure smooth, legible. lasting adhesion.

Nameplates, trademarks, operating instructions, lubrication guides, patent data and scores of other nomenclature can be reproduced in any number of colors, sizes or designs. Meyercord Decals are washable, resistant to acids, moisture, abrasion, vibration and hard use. They can be applied to concave, convex or flat surfaces with equal success.

Investigate Meyercord Decals, the modern stream-lined method of product identification used by manufacturers to save time and material cost.

Send for free MEYERCORD DECAL SELECTOR. Tells how and where to use Decals. Firm letterheads, please. Address Dept. 9-12

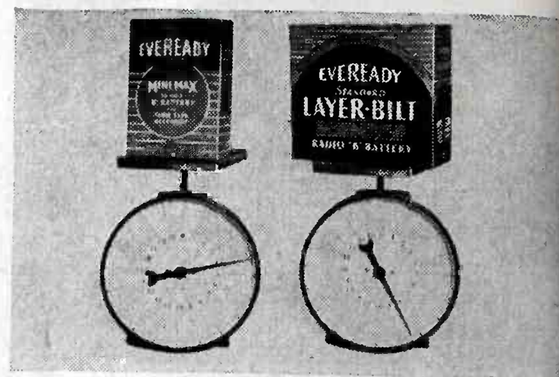
- IDENTIFY
- DECORATE
- ADVERTISE

your products with MEYERCORD DECALS

THE MEYERCORD CO.

World's Largest Decalcomania Manufacturer

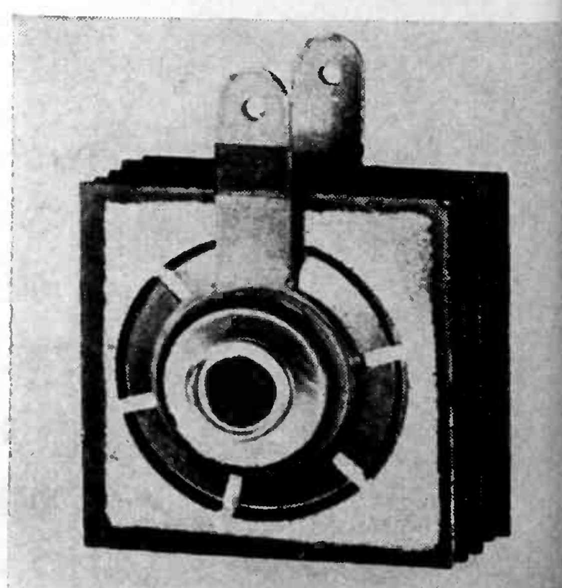
5323 WEST LAKE STREET • • • CHICAGO 44, ILLINOIS



with 179 for the older type and weighs 4 pounds 4 ounces as compared with over 8 pounds. Power capability and life of the new battery are the same as with the larger type.

Miniature Rectifier

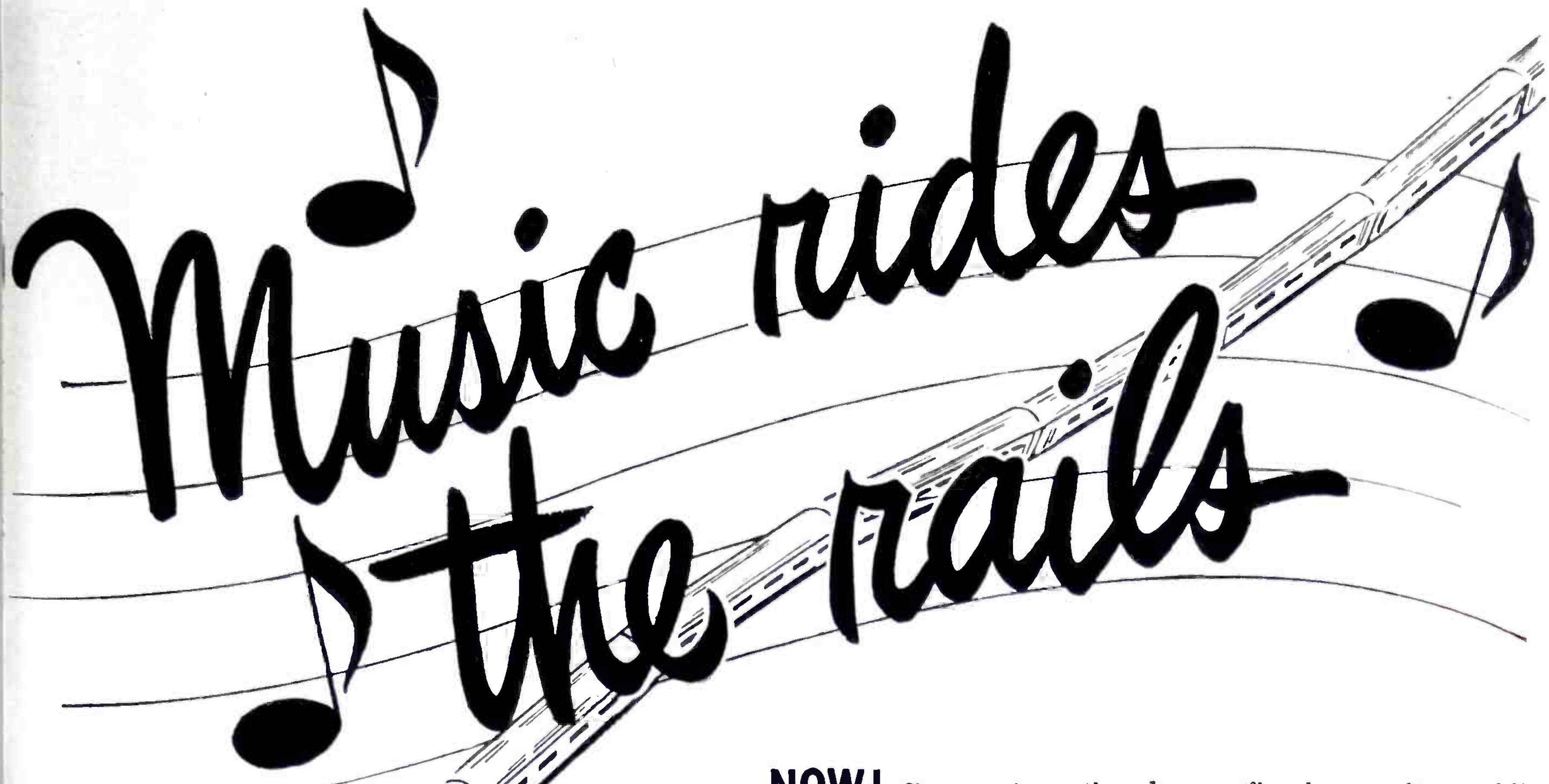
RADIO RECEPTOR CO., INC., 251 West 19th St., New York 11, N. Y. A new miniature five-plate selenium rectifier, type 5M1, has been designed to replace rectifier tubes in a-c/d-c portable radio receivers. The rectifier is used with a series



25-ohm resistor and a 40-μf capacitor. Maximum current is 100 milliamperes up to 35 C for input and output voltages of 130 volts.

Television Kit

TRANSVISION, INC., 144 Union Ave., New Rochelle, N. Y. Reminiscent of the early days of shortwave reception is the type of package offered for the television novice. A complete 17-tube television receiver with a 7-inch picture tube is offered in kit form. A bare minimum of tools is needed, but no testing equipment is required, since all dif-



NOW! Progressive railroads can offer the traveling public the same high quality of music and entertainment enjoyed in their passengers' own homes. With this new service, railroads can pave the way to greatly increased passenger train luxury and revenue.

In offering the first practical electronic program distribution system, Farnsworth has met the three basic requirements which railroad-conducted studies have shown necessary to high-quality rail-borne entertainment: (1) uniform, low-level sound distribution; (2) automatic compensation for varying ambient noise levels; (3) programs that passengers want to hear.

In the de luxe Farnsworth systems four channels are available for individual selection: popular or luncheon music; semi-classical or dinner music; radio programs; train announcements and travel talks. Also available are more simplified single- or dual-channel systems.

All Farnsworth systems are simple to install; operate automatically and unattended. Unitized construction permits instantaneous replacement of units without manual disconnection of a single wire. Other noteworthy features are: push-button precision crystal radio tuning and self-rewinding wire reproducing mechanisms.

Farnsworth Passenger Program Distribution Systems have been engineered by the same laboratories that gave the world its finest instrument for musical reproduction — The Capehart.

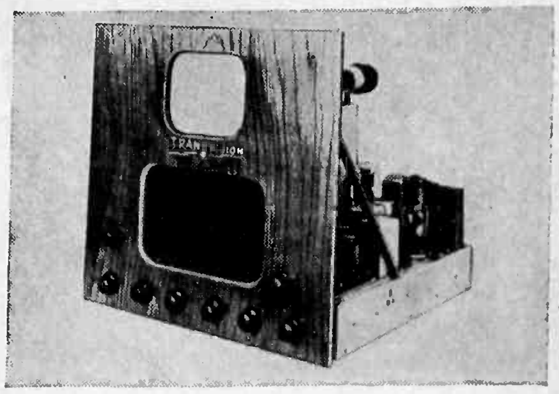
Farnsworth Television & Radio Corp., Dept. E-12, Fort Wayne 1, Indiana.

Now! Farnsworth brings top-quality music and radio entertainment to modern passenger trains!

Farnsworth

Television · Radio · Phonograph-Radio

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Traffic Control Systems for Rail and Highway • The Farnsworth Phonograph-Radio • The Capehart • The Panamuse by Capehart



ficult assemblies are prewired and tuned. Front panel and chassis with safety interlock, are supplied. A dipole antenna, 60 feet of lead-in cable, and a wooden mast are also included. Arranged for assembly by nontechnical television enthusiasts, the kit sells for $139.50, f.o.b. New Rochelle.

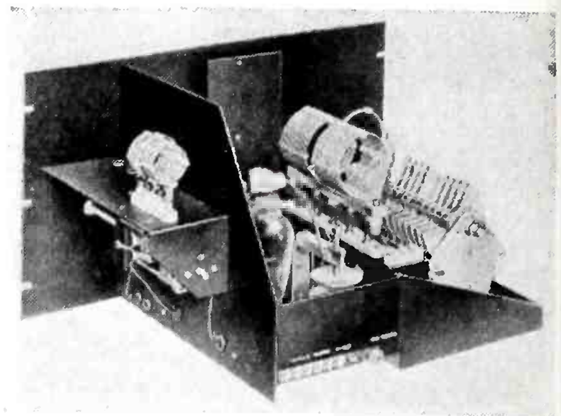
Metallized Capacitor

SOLAR MFG. CO., 285 Madison Ave., New York 17, N. Y. Solite paper capacitors are a new development using an aluminum film of negligible thickness deposited directly on the dielectric. Because of the self-healing characteristics which

guard against permanent short circuit after breakdown, the capacitors can operate at higher voltages. The new capacitors are physically small, have long life, low power factor, excellent r-f characteristics and are interchangeable with present standard capacitors when they are operated within published ratings.

Power Amplifier

JAMES MILLEN MFG. CO., INC., Malden, Mass. A packaged r-f power amplifier unit for use with amateur or other high-frequency equipment, the No. 90881 amplifier is wired for a pair of type 812 tubes, and contains grid and plate tank circuits as well as controls and meters. Plug-in inductors for the amateur



bands from 10 to 80 meters are furnished. The assembly is mounted on a 10½-inch relay rack panel.

Dynamic Tube Tester

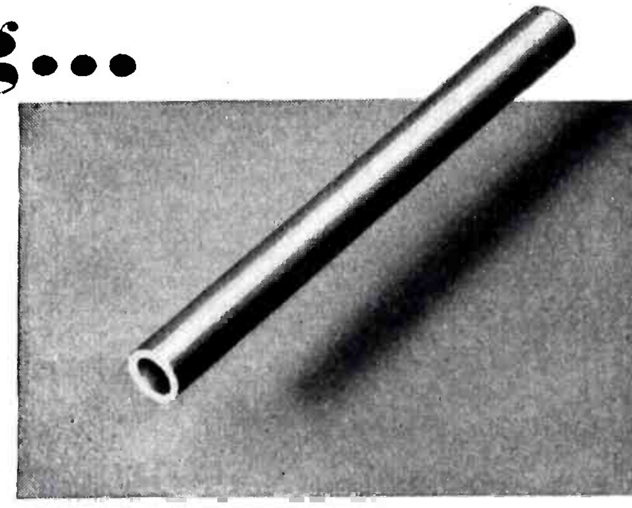
TRIPLETT ELECTRICAL INSTRUMENT Co., Bluffton, Ohio. The new model 2425 mutual conductance tube tester uses a calibrated measuring instrument that gives readings directly proportional to the value in

micromhos. Short, open, and gas tests can also be made. The instrument is contained in a metal carrying case 10x10x5¾ inches.

Regulated Power Supply

FURST ELECTRONICS, 800 W. North Ave., Chicago 22, Ill. The model 310-A regulated power supply is

When men in Electronics talk of Tubing...



they mean Superior

and, of course Nickel tubing

NICKEL
TO CATHODE SLEEVE SPECIFICATIONS IN SEAMLESS OR LOCKSEAM*

Other Industries too have come to know about Nickel and Superior now supplies this extraordinary metal day in and day out

Ask Superior Tube Company for information on Seamless and Weldrawn* Nickel

THE BIGGER NAME IN SMALL TUBING Superior

SUPERIOR TUBE COMPANY
ELECTRONICS DIVISION
Post Office Drawer 191 • Norristown, Pa.
Telephones Norristown 2070, Collegeville 3711

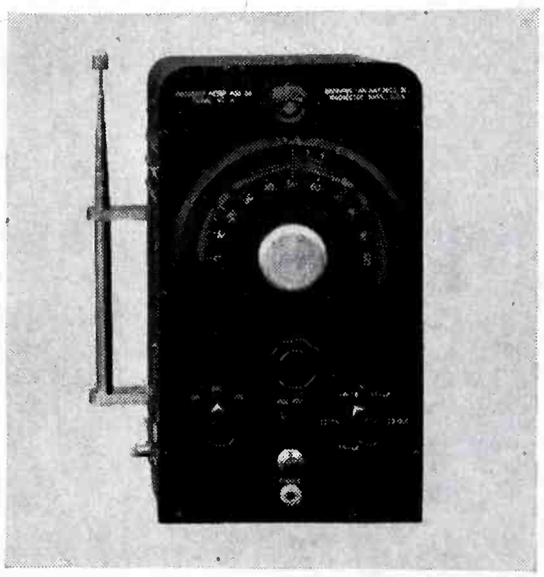
EXPORT DEPT.
13 E. 40th St., New York 16, N. Y.
Cable Address ARLAB

*Trade Marked U. S. Patents

arranged for testing a-c/d-c equipment and gives continuously variable voltage from the a-c power line directly, or through a rectifier that maintains voltage constant within 1 percent regardless of line or load variations. An a-c voltage of 1 ampere and d-c output up to 450 milliamperes are available. The model 310-B equipment does not include a-c controls or meter. Price of the 310-A unit is $330.

Frequency Meter

BROWNING LABORATORIES, INC., 742 Main St., Winchester, Mass. The model S-6 frequency meter covers the range from 100 kilocycles to 50



megacycles with an accuracy of plus or minus 0.025 percent. An internal crystal calibrator provides long-time accuracy. The equipment, operated from socket power, weighs 15 pounds.

Variable Equalizer

BURNELL & CO., 10 Van Cortlandt Ave., New York 58, N. Y. A new

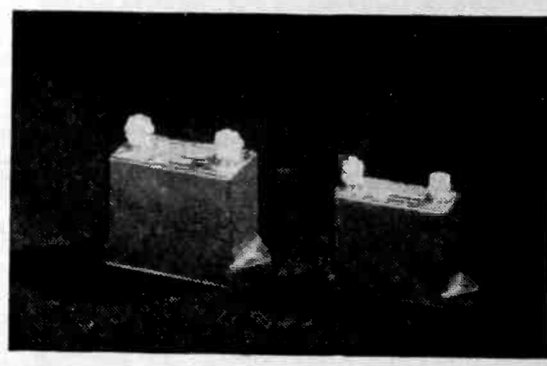
trol comprises the torque unit, amplifier, and control unit illustrated. The torque unit shaft responds to the position set by the control unit to an accuracy of 1 percent. One ounce-inch of operational torque results in 50 pound-feet of output torque.

VHF Tetrode

UNITED ELECTRONICS CO., 42 Spring St., Newark 2, N. J. The type 5562 graphite-anode beam tetrode can be used with full power output up to 120 megacycles. It has a thoriated tungsten filament operating at 6.3 volts. As a class C telegraph power amplifier or oscillator in typical operation, it uses 1,500 volts on the plate, can be driven with less than 4 watts, and has a power output of 135 watts.

Blocking Capacitors

GENERAL ELECTRIC CO., Schenectady 5, N. Y. New Lectrofilm capacitors in case styles 65 and 70



have been announced for radio-frequency blocking and bypass use. In the case 65 style four ratings from 0.0001 microfarad at 3,000 volts d-c are available. The case 70 styles have high voltage ratings. These capacitors are described in bulletin GEA 4295A.

Literature

Cables and Connectors. American Phenolic Corp., Chicago 50, Ill. A 12-page bulletin describes various sorts of transmission line and cable as well as cable fittings and connectors particularly useful at high radio frequencies. A separate

leaflet covers the new passenger car antenna.

Insulator Properties. American Lava Corp., Chattanooga 5, Tenn. Bulletin 245 describes AlSiMag electronic tube insulators and includes a table of mechanical and electrical properties of Steatite, Alumina, and Lava.

Oil Capacitors. The Capacitron Co., 849 North Kedzie Ave., Chicago 51, Ill. Type EC, CC, and BC oil-filled capacitors are high-voltage, high-capacitance units for power supply filtering and similar use. They are described in Bulletins 104 and 105.

Laboratory Apparatus. Boonton Radio Corp., Boonton, N. J. Catalog D contains information on Q meters, QX checkers, generators, accessories, and parts. A price sheet and ordering information are included in the 36-page catalog.

Wire Recorder. Radiotechnic Laboratory, 1328 Sherman Ave., Evanston, Ill. A two-pager covers their new wire recorder complete with built-in loudspeaker, timer, volume level indicator, and microphone with plug and cord.

Industrial Tubes. Westinghouse Electric Corp., Bloomfield, N. J. Industrial electronic tubes have been presented in families according to function in a readable 16-page pamphlet recently issued. The treatment of the subject and the display of information should prove helpful, particularly to industrial engineers who are not electronics experts. Ask for Catalog 86-020.

Relays. Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y. Complete engineering and ordering information is given in the 14 looseleaf pages of a folder issued recently on the line of a-c and d-c relays now available.

Crystal Accessories. Crystal Products Co., 1519 McGee St., Kansas City, Mo., has recently mailed out a 4-page list of crystals, holders, and ovens. A multiple holder is fea-

THE PROBLEM:

How to simplify modern electronic instruments ... get better control with fewer control units?

Cutaway view of the Helipot

THE ANSWER:

THE BECKMAN Helipot

(trademark of the HELIcal POTentiometer)

– almost 12 Times* the Resistance Control in Same Panel Space as Conventional Potentiometers!

ON PRODUCT after product the story is the same –the Helipot is revolutionizing potentiometer applications, simplifying control operations, and even making possible advanced electronic instruments impractical with other types of potentiometers. Widely used on precision electronic instruments during the war, the Helipot is an entirely *new* type of potentiometer which every electronic manufacturer and user should investigate.

HIGH LINEARITY—as a result of fulfilling large wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of one tenth of one percent—and even less!

WIDE RANGE—By coiling a long potentiometer slide wire into a helix, the Helipot provides many times the range possible with a single turn unit of comparable diameter and panel space.

PRECISE SETTINGS—Because of the many-times-longer slide wire, settings can be made with an accuracy impossible with single turn units.

LOW TORQUE—Of special interest for power-driven applications —the Helipot has unusually low torque characteristics. The 1 1/2" Helipot, for example, is available with a torque of only 1 inch/ounce.

Briefly, here's the Helipot principle ... whereas a conventional potentiometer consists of a *single* coil of resistance winding approximately 4" long, the Helipot has a potentiometer wire approximately 46"* long coiled *helically* into a case which requires *no more panel space* than the conventional unit. By means of a simple guide, the slider contact follows the helical path of the resistance winding from end to end as a single knob is rotated. Result...almost *twelve* times the amount of control – far greater accuracy, finer settings, greater range – *at no increase in panel space requirements!*

Let us study your potentiometer applications and suggest how the Helipot can be used – possibly already is *being* used by others in your industry – to simplify control operations, get greater accuracy and range, and increase the utility of modern electronic equipment. No obligation, of course. Write today outlining your problems.

***HELIPOTS ARE AVAILABLE IN 3 STANDARD SIZES:**

TYPE A—5 watts, incorporating 10 helical turns and a slide wire length of 46 inches, case diameter 1 3/4", is available with resistance values from 25 ohms to 30,000 ohms.

TYPE B—10 watts, with 15 helical turns and 140" slide wire, case diameter 3 1/4", is available with resistance values from 100 ohms to 100,000 ohms.

TYPE C—2 watts, with 3 helical turns and 13 1/2" slide wire, case diameter 1 3/4", available in resistances from 5 ohms to 10,000 ohms.

The Type B is also available in special sizes of 25 and 40 helical turns, with resistances ranging from 500 ohms to 300,000 ohms, and containing more than 100,000 change-of-resistance steps.

*Data above are for the standard Type A unit.

Send for the New Helipot Booklet!

THE Helipot CORPORATION, 1011 MISSION STREET, SOUTH PASADENA 2, CALIFORNIA

tured for four different crystals, any one of which can be selected by a rotary switch.

Thyratrons and Rectifiers. Chatham Electronics, 475 Washington St., Newark 2, N. J. Data sheets on 13 rectifier and thyratron tubes are loose-leaf bound into a paper cover. Characteristics, tube base connections, and maximum ratings are given for the industrial electronic tubes.

Crystals. Reeves-Hoffman Corp., 215 East 91st St., New York 28, N. Y. Various crystal units are pictured in a 4-page leaflet. Among the more unusual items are a postage-stamp unit less than an inch square and 3/16 inch thick, and a low-cost crystal designed for use in home broadcast receivers to insure foolproof pushbutton tuning.

Nylon Pickup. Astatic Corp., Conneaut, Ohio. The new Nylon 1-J crystal pickup cartridge is glowingly described in a 4-page brochure. Both chuck and needle are formed from Nylon, but the needle tip is sapphire. A special guard protects the unit from damage by careless handling.

Transformers and Reactors. Red Arrow Electric Corp., 100 Coit St., Irvington 11, N. J. A few sample units manufactured by the company are pictured in a 4-page leaflet that describes the types of transformers and engineering services available on order.

Deflection Yokes. The Telectron Co., 1988 East 59th St., Cleveland 3, Ohio. Magnetic deflection yokes and blocking oscillator transformers are described on a single-sheet bulletin. These television components can be used for replacement service of new equipment, owing to their standard method of construction.

Cathode Ray Manual. Allen B. Du Mont Laboratories, Inc., 2 Main Ave., Passaic, N. J. The Operating and Maintenance Manual for the type 274 oscillograph contains so much general information on the use of this and similar equipment

in the servicing of a-m and f-m equipment that it has been decided to make the 39-page manual available at a cost of 50¢ a copy; less in lots.

Miniature Tubes. Raytheon Mfg. Co., 60 E. 42nd St., New York 17, N. Y. Descriptive data and characteristics have been released on two miniature cathode-type r-f amplifier tubes 6BD6 and 12BD6 that have been designed to replace older tubes like the 6D6 and 6K7.

Noise Suppressor. Technology Instrument Corp., 1058 Main St., Waltham 54, Mass. The dynamic noise suppressor type 910-A, is completely described for prospective purchasers in a 7-page booklet recently made available.

Communications Equipment. Fred M. Link, 125 West 17th St., New York 11, N. Y. An illustrated file folder containing a leaflet serves to bring us up to date on mobile f-m communications equipment, main stations, antennas, and other necessary paraphernalia manufactured by this company.

House Organ. Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill. The Motorgram is published by this manufacturer of fractional horsepower motors, and will be of interest to engineers engaged in electronic work involving motors.

Wave Guide Fittings. De Mornay-Budd, Inc., 475 Grand Concourse, New York 51, N. Y. An 18-page profusely illustrated catalog of standard microwave components has just been released. Mechanical and electrical characteristics, including drawings, are presented for each element.

Ballast Bulletin. JFD Mfg. Co., 4117 Fort Hamilton Parkway, Brooklyn 19, N. Y. A new 4-page bulletin has been announced for free distribution listing a complete line of ballast resistors for a-c and d-c receivers.

F-M Brochure. Radio Engineering Laboratories, Inc., 35-54 Thirty-

Sixth St., Long Island City 1, N. Y. Bulletin 5015 details the faciiities, accomplishments, and aims of this pioneer manufacturer of f-m equipment.

Wire Wound Resistors. International Resistance Co., 401 North Broad St., Philadelphia 8, Pa. Type FRW flat wire wound resistors have a higher space-power ratio than standard tubular wire wounds and they lend themselves to assembly in stacks and gangs. Write for the 4-page descriptive bulletin.

Chemical Wire Stripper. Division Lead Co., 836 W. Kinzie St. Chicago 22, Ill. Cold removal of Formex or Formvar, and all baked insulations can be accomplished by chemical means using Divco solvents. Technical bulletins outline the process. Other pages describe the company's rosin-core solder and rosin flux remover.

Cable Bulletins. General Electric Co., Schenectady 5, N. Y. Flamenol is the title of a 16-page, four-color bulletin (GEA-4352) that tells the story of manufacture and use of this particular type of conductor. Flamenol Mine-Telephone Cable is described in a companion two-page bulletin, GEA-3612B.

Voltage Controls. Superior Electric Co., 713 Laurel St., Bristol, Conn. Bulletin 150 replaces all other bulletins and describes the complete Superior line of powerstats, automatic voltage regulators, and remote positioners.

Microphones. Electro-Voice, Inc., Buchanan, Mich. Bulletin No. 131 describes the Cardyne cardioid dynamic microphone and Catalog No. 101 presents the complete line of the company's products. An interesting feature of the 19-page catalog is an index identifying microphone types by application so that selection of the proper unit is facilitated.

Time Switches. Automatic Temperature Control Co., Inc., 34 East Logan St., Philadelphia 44, Pa. Two pages of a 4-page leaflet are devoted

to six practical examples of time-switch usage in industry. The various units are illustrated.

Control Devices. Ward Leonard Electric Co., Mount Vernon, N. Y. Bulletin 100,000 just issued is available without charge. It describes all manner of electric control devices such as midget relays, rheostats, time delays, and starters.

D-C V-T Voltmeter. Development Engineering Co., 1818 Ashland St., Houston, Texas. A catalog sheet has just been issued on the model SD-14 d-c vacuum tube voltmeter. The meter is of particular interest because of its small size and long battery life.

F-M Broadcasters. Federal Telephone and Radio Corp., Newark 1, N. J. Complete with circuit diagrams, specifications, and illustrations, Federal's latest publication on its 1 and 3 kilowatt f-m broadcast transmitters for the 88 to 108 megacycle band has recently been printed.

Communications Receivers. The Hallicrafters Co., Chicago, Ill. Two receivers, model S-38 and S-40, tune from 540 kilocycles to 32 megacycles and 540 kilocycles to 43 megacycles respectively in four bands. The SX-42 gives continuous coverage from 540 kilocycles to 110 megacycles on either a-m or f-m. These receivers and some antennas are described in an 8-page folder.

Television Antenna. Andrew Co., 363 East 75th St., Chicago 19, Ill. A 2-page technical data sheet, complete with graphs, describes the Di-Fan television and f-m broad band antenna.

Small Gears. Gear Specialties, 2635 W. Medill Ave., Chicago, Ill. A request on company stationery will bring a copy of the 4-page catalog bulletin that tells about small gears and their applications.

Snap-Action Switches. Micro-Switch, Freeport, Ill. Manual safety switches are featured in Data Sheet No. 38, comprising two loose leaf pages printed on both sides.

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

PICAO considers radar for world airlines; new IRE officers; television fanfare; review of OSRD history – "Scientists Against Time"

National Electronics Conference is Well Attended

THIS YEAR'S National Electronics Conference at the Edgewater Beach Hotel, Chicago, Oct. 3-5, drew an attendance of approximately twenty-five hundred for the sessions and exhibits. A total of 65 technical papers were presented, along with demonstrations which included the infrared sniperscope.

The papers presented at the Conference will be published in the "Proceedings of the 1946 National Electronics Conference", priced at $3.50. Orders should be sent to E. H. Schulz, Secretary, National Electronics Conference, Technology Center, Chicago 16, Illinois. Some copies of the 1944 "Proceedings" may still be available at $3.00 each. No show was held in 1945, due to wartime travel restrictions.

Officers for 1946 National Electronics Conference. Rear, left to right: C. A. Emery of Westinghouse, vice-president; Louis T. Rader of Illinois Institute of Technology, vice-president; A. B. Bronwell of Northwestern University, executive vice-president. Seated, left to right: J. E. Hobson of Armour Research Foundation, chairman of board of directors; E. H. Schulz of IIT, secretary; W. O. Swinyard of Hazeltine, president; R. E. Beam of Northwestern University, vice-president

U. S. Demonstrates Radio Aids to Air Navigation

IN RESPONSE to a suggestion by the Provisional International Civil Aviation Organization (PICAO), the British, U. S., and Australian governments have presented demonstrations of the various air navigation and communications systems now used or in process of development. The British demonstrations were conducted in and about London for PICAO delegates from Sept. 9th to 30th, after which the group was flown to New York for demonstrations at LaGuardia Airport and the CAA overseas communications center at Sayville, Long Island Oct. 7 and 8, thence to Indianapolis for a carefully planned series of lectures, demonstrations, and exhibits from Oct. 10 through the 23rd. Army planes flew the worldwide group of delegates back to New York City for an inspection of Airborne Instrument Laboratories and demonstrations of loran Oct. 25-26, after which the official delegates comprising the Special Radio Technical Division of the PICAO Air Navigation Committee convened in Montreal, Canada Oct. 30 to determine which systems will be specified for international adoption.

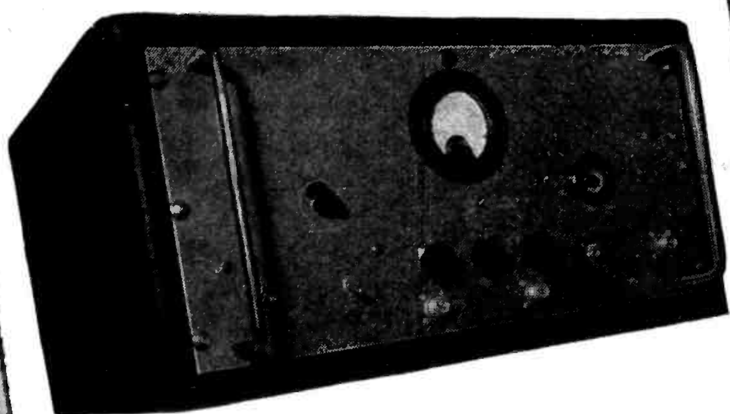
Navigation equipment demonstrated on the U. S. program as

Bendix airport surveillance system, employing high-definition search radar as an auxiliary to GCA and an aid to traffic control. Center frequency is 2,880 mc, and antenna rotation rate is 30 rpm. This equipment was demonstrated to PICAO delegates at Indianapolis

being now in use or ready for use falls into four categories: (1) long-range navigation, for overseas flights and long land flights as over the North Pole—loran and low-frequency omnidirectional range; (2) short-range navigation, as between airports of a given country or short over-water flights—vhf omnidirectional range, distance-measuring equipment, radio compass, automatic direction finder, pulse alti-

Lavoie

UHF PRECISION INSTRUMENTS

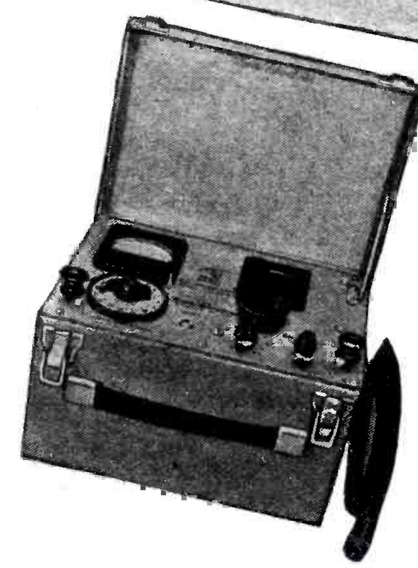


HARMONIC FREQUENCY GENERATOR

PROVIDES harmonic output voltages in 10 or 40 mc series with crystal-controlled accuracy.

SELECTS 10 or 40 megacycles series by means of front panel switch.

USED FOR calibration of receivers, wavemeters, or (with Beat Detector built into instrument) for calibration of oscillators and signal generators. May also be used in conjunction with a low-frequency communications-type receiver to determine UHF oscillator drift. A mixer unit is available for this application.



PRECISION FREQUENCY METER

Completely portable Accuracy 0.1% Models available from 100 to 2000 megacycles with 2 to 1 frequency coverage on each model.

RECOMMENDED FOR:

- Production testing
- Measurement of oscillator drift
- Independent alignment of transmitters and receivers
- Precise measurements of frequencies

FULL DETAILS ON REQUEST

L U H F

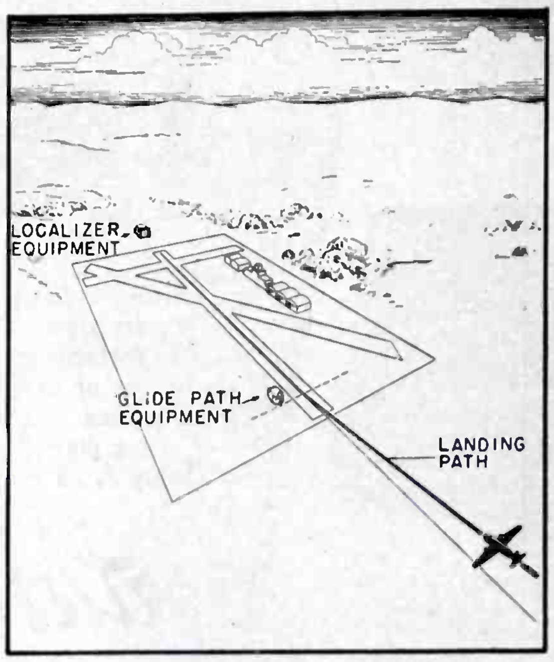
Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

Specialists in the Development and Manufacture of UHF Equipment

meter; (3) instrument approach and landing during conditions of poor visibility or low ceiling—CAA instrument landing system, ground-controlled approach, and microwave instrument landing system; (4) air traffic control at airports, to convert random arrivals into orderly landings with minimum delay under all weather conditions—search radar, vertical separation indicator, and



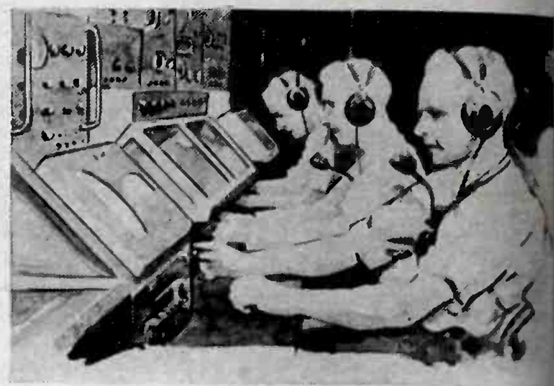
Perspective of typical airport, showing locations of the two units employed in Sperry microwave landing system

air traffic control system. A fifth category, covering complete navigation systems or individual equipments intended for future use, was also given consideration. Details of some of the systems follow.

The low-frequency omnidirectional range provides continuous indication of azimuth without ambiguity through 360 degrees about a transmitting station operating in the 50-400 kc band, and employs a 300-cycle subcarrier for production of the f-m component whose phase is a function of azimuth. One 400-watt station is in operation at Indianapolis, and several 10-kw stations will be in operation in U. S. coastal regions by July 1, 1947.

Loran is a pulsed type of radio transmission in the band 1,800 to 2,000 kc, providing pinpoint navigation data over reliable ranges of 700 nautical miles by day and 1,400 by night. Accuracy of range determination from the baseline joining two loran transmitters is better than 1 percent. The U. S. government is now operating 35 transmitting stations throughout the world, with four more ready for use if needed, and 9 others are being operated by Great Britain and Canada, all on a 24-hour schedule. The RCA AVR-26 airborne loran receiver weighs approximately 35 lb.

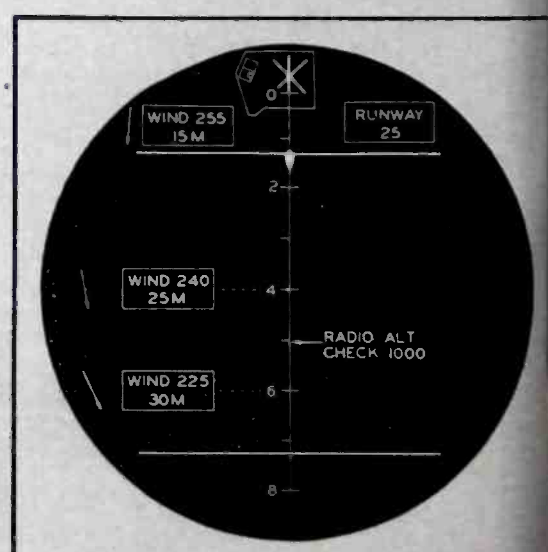
The CAA vhf omnidirectional range operates in the 112-118-mc band for short-range navigation,



In GCA three operators seated before scopes on the ground observe the position of an incoming aircraft with respect to glide path and azimuth markings on the screen, and bring the pilot down to contact with the runway through fog entirely by radioed voice instructions

using a 10-kc subcarrier. A number of stations have already been established on the Chicago-New York route.

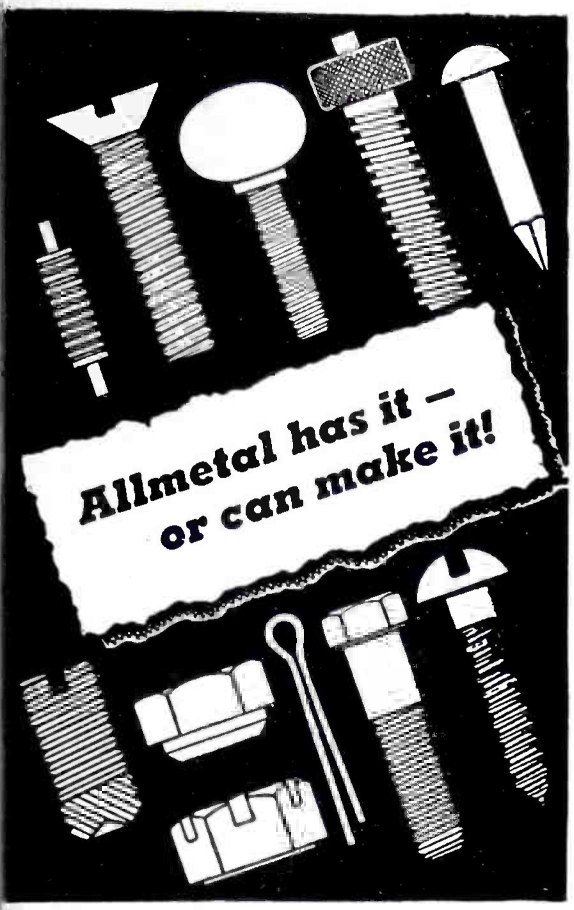
Radio pulse distance-measuring equipment was demonstrated by CAA, Hazeltine Electronics Corp. and Federal Telecommunication Laboratories, Inc. Operation is on 1,000 mc. Use with omnidirectional ranges gives the pilot of an aircraft a continuous indication of distance and direction from a range. Only experimental models are now in use. A transmitter in the aircraft sends a continuous flow of r-f pulses



In RCA's proposed Teleran system, a picture like this might be sent to the pilot by television during final approach. His aircraft is a spot moving on a map (between 0 and 2). Any other planes within area of map would also show

to the ground beacon, which retransmits similar pulses in reply. The time between transmission of a pulse by the aircraft and recep

What type of STAINLESS FASTENER do you need?



Prompt delivery from the largest stock in the nation!

Screws . . . nuts . . . washers . . . pins . . . Allmetal carries the largest stock in the country of stainless steel fasteners and screw machine parts. We also have facilities for heading, tapping, drilling, reaming, slotting, turning, stamping, broaching and centerless grinding . . . and we work not only with stainless and monel, but also with duralumin, aluminum, brass, bronze, or any other non-corrosive metal. All parts produced to close tolerances. Write for our catalog today. Allmetal Screw Products Co., 33 Greene St., New York.

Send for FREE CATALOG

This new, 83-page catalog helps you select the correct size and type of non-corrosive fastening device for any particular job. Includes stock sizes, specials that can be made, engineering data, etc. Make request on company letterhead.

ALLMETAL SCREW PRODUCTS CO.
33 Greene Street, New York 13

SPECIALISTS in STAINLESS FASTENERS

specify NORTHERN

It's your custom molder's responsibility. He must make the part right . . . or the product is wrong! When you specify Northern you gain the advantage of more than 37 years of experience in producing plastics for all type assemblies. You are assured of precision and uniformity for your plastic part, which means quicker, cleaner assembly . . . a better all-over job.

Northern INDUSTRIAL CHEMICAL CO.

38 Years of Plastic Molding Experience

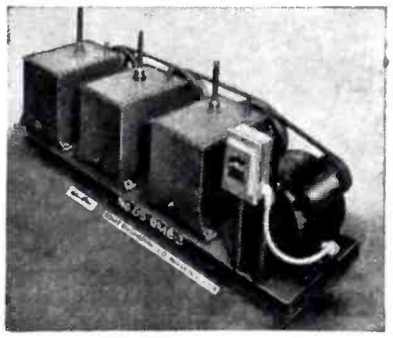
7-11 ELKINS ST., SO. BOSTON 27, MASS.

EISLER EQUIPMENT*

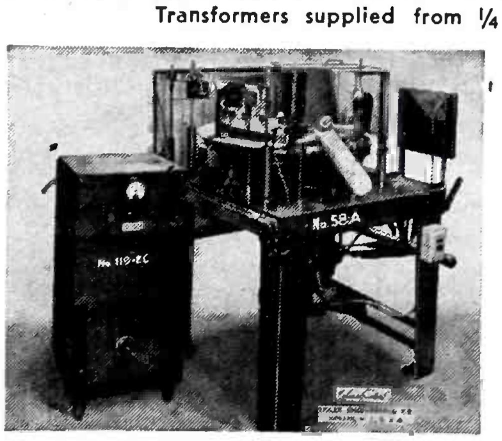
. . . COMPLETE AND DIVERSIFIED FOR EVERY PHASE OF ELECTRONIC MANUFACTURE!

TRANSFORMERS of all types — furnace, distribution, power phase changing, air, oil, induction, water cooled, plate, filament and auto-transformers. Filter chokes and inter-phase reactors.

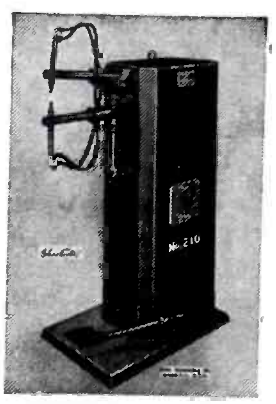
Transformers supplied from 1/4 to 300 KVA.



EISLER Compound Vacuum Pump.



24 Head Radio Tube Exhausting Machine.



EISLER Spotwelders from 1/4 to 250 KVA.

*EISLER machines are in use and in production by 99% of all American radio tube and incandescent lamp manufacturers and throughout the world.

CHAS. EISLER
EISLER ENGINEERING CO.
751 SO. 13th ST. (Near Avon Ave.) NEWARK 3, NEW JERSEY

tion of its reply pulse is measured electrically and indicated to the pilot on a meter calibrated in miles.

The CAA instrument landing system (ILS) consists of a runway localizer in the 108-111 mc band, a glide-path transmitter in the 328.6-335.4 mc band (third harmonic of localizer), and 75-mc marker beacons. Sideband frequencies are 90 and 150 cycles. A variation uses a 10-kc subcarrier that is frequency-modulated at 60 cycles to indicate on-course for the localizer by phase comparison. These ILS systems can be hooked up with the autopilot for automatic approach control.

The Sperry microwave version of ILS operates on 2,650 mc, with 600 and 900 cycle modulation. The system is now in the preproduction stage,

The ground controlled approach system (GCA) presented by CAA is a combination of search and precision scan radar units that permits operators on the ground to talk a plane down by radio. No special equipment is needed in the airplane, but ground equipment is complex and requires three to five operators. The Navy has adopted GCA as standard for all its airfields in this country and overseas, and will man 39 units this winter. A GCA unit will soon be installed at LaGuardia Field for use of commercial aircraft. The Navy has made 65,000 GCA landings, 469 of which were under actual instrument conditions. No plane making its final landing approach under instrument conditions has had an accident while under control of Navy GCA.

Traffic Control at Airports

Use of high-power 10-cm search radar at an airport enables control tower crews to see on a screen the positions of all aircraft within up to 30 miles of the airport, for guidance in directing traffic and monitoring holding patterns of planes waiting to land. A video mapping system permits simultaneous production of maps on the screen, showing runways, obstructions, beacon and marker locations, and airport locations in correct relation to planes in the air. Moving target indication (MTI) may be added to subdue ground clutter in the vicinity of the radar antenna by increas-

NEWS! YOUR 1947 RADIO ENGINEERING SHOW

to be at

GRAND CENTRAL PALACE

March 3-6

NOT at the 34th Street Armory. We outgrew that place and were lucky enough to get space at Grand Central Palace . . . the biggest exhibition hall in New York, for the biggest radio engineering show in history!

Admission to Grand Central Palace and all lectures free to members of The Institute of Radio Engineers. $3.00 admission for non-members.

Have you made your plans yet to attend the show?

(Incidentally, better make hotel reservations well in advance!)

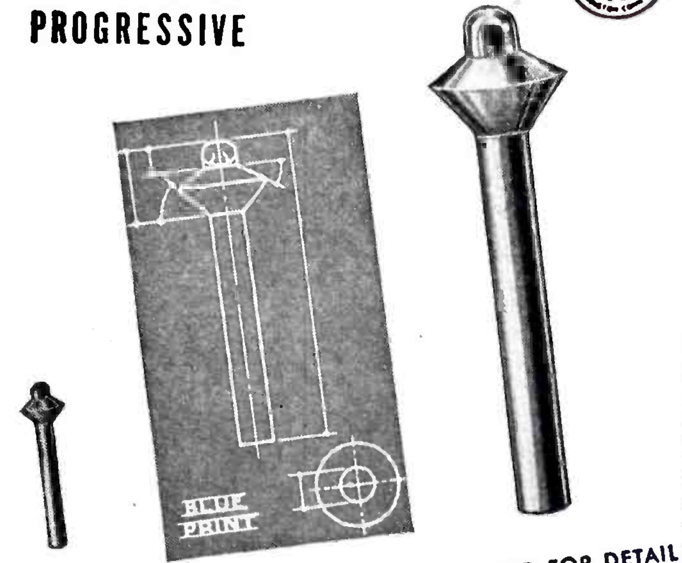
Wm. C. Copp, Exhibits Manager

THE INSTITUTE OF RADIO ENGINEERS

1 E. 79TH ST., N. Y. 21   Circle 6-6357

ANOTHER SPECIAL BY PROGRESSIVE

QUALITY PROMCO BRAND



CATALOG SHOWS DOZENS MORE

Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.

The PROGRESSIVE MFG. CO.

50 NORWOOD ST.   TORRINGTON, CONN.

Find Out Now About ★ STAR ★ CERAMICS

There are many kinds for special uses, such as applications calling for resistance to electricity, heat, moisture, chemicals or weathering agents. There are more than a score of formulas in actual production at one time in our factory.

Send for "A Brief Survey of Technical Characteristics of molded Ceramic Products." It is right to the point.

★

The STAR PORCELAIN CO.

Electronics Dept.

Trenton 9, N. J.

SPECIALIZED Skill in METAL

CABINETS · PANELS · CHASSIS · RACKS

with Beautiful Chrome Trim

PAR-METAL PRODUCTS CORPORATION

32-62—49th STREET

LONG ISLAND CITY 3, NEW YORK

Export Dept.: Rocke International Corp.
13 East 40 Street, New York 16

The time-tested Par-Metal line presents superior features of styling, design, and construction. True to policy, Par-Metal continues to *specialize in Electronic Housings* exclusively...and is therefore able to offer leadership in value. Compare! *Write for Catalogue.*

ing the contrast between desired and undesired indications.

The CAA vertical separation indicator for airport traffic control employs an airborne transmitter controlled by an aneroid cell between limits of 148 and 154 mc so that frequency is a linear function of the altitude of the airplane. A panoramic-type receiver-indicator on the ground shows by means of pips on a calibrated scale the altitudes of all planes within range that are equipped with the special transmitters. A similar indicator in the airplane is calibrated between minus 1,500 feet and plus 1,500 feet to show only pips of planes at approximately the same altitude.

In anticipation of traffic heavier than 30 to 40 flights per hour along a route, The Teleregister Corporation of New York City has developed a system of automatic aids for obtaining position reports from planes en route and sending instructions automatically to planes.

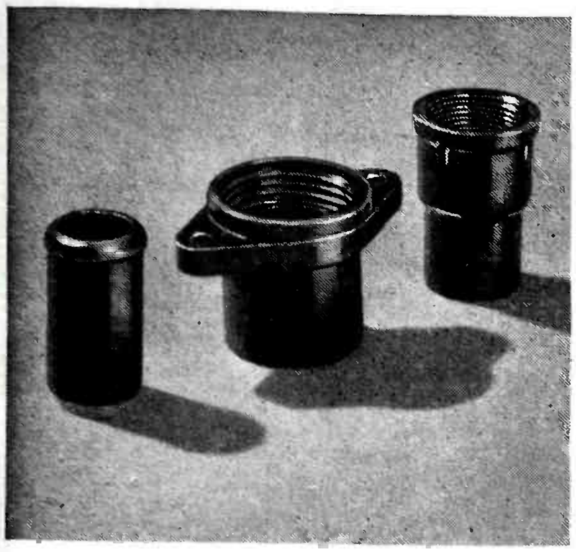
Systems for Future Use

Lanac, standing for Laminar Navigation Anti-collision System, is a complete integrated all-weather flying system proposed by Hazeltine Electronics Corp. for future use. It includes navigation, fixed-obstacle avoidance, anticollision by lamina segregation, traffic surveillance by ground observers, and instrument approach. It will operate in the 1,000-mc band, using an airborne challenger and replier and a ground challenger, beacons, and cathode-ray display.

Navar consists essentially of a 1,000-mc distance-measuring equipment (DME) serving simultaneously as a Racon (airborne responder beacon) to assist ground radars. Ground equipment includes an S-band search radar and a 1,000-mc responder for the DME. A complete demonstration by Federal Telecommunication Laboratories is expected early in 1948.

Teleran is a combination of ground radar, airborne transponders, and television transmission from ground to aircraft, proposed by Radio Corporation of America for air navigation, traffic control, collision prevention, instrument landing, talk-down landing, automatic landing, automatic flight, etc. The pilot sees on his television

PILOT LIGHT
Socket Housings
Compression Molded Plastics



Custom Molded . . . to meet specific requirements . . . by an experienced organization . . tooled for the production of plastics parts for electrical or general applications. Inquiries acknowledged promptly.

Midwest Molding and Manufacturing Co.

335 NORTH WHIPPLE ST. • CHICAGO 12, ILL.

Model 2450
ELECTRONIC TESTER

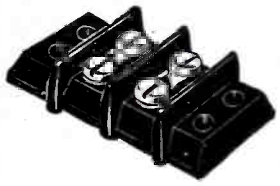
There's never been a tester like this!

Here's a tester with dual voltage regulation of the power supply DC output (positive and negative), with line variation from 90 to 130 Volts. That means calibration that stays "on the nose"! That means *broader service* from a tester that looks as good as the vastly improved service it provides. This model includes our Hi-Precision Resistor which outmodes older types. Detailed catalog sheets on request. Write today.

Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

JONES BARRIER TERMINAL STRIPS



2-142

2-142-¾W

2-142-Y

Bakelite Barriers placed between Terminals increase the leakage path and prevent direct shorts from frayed wires at Terminals. Terminals and screws are of nickel plated brass. Insulation is of BM 120 molded Bakelite.

Illustrated are three types: Screw Terminals, Screw and solder Terminals and Screw Terminal above panel with solder Terminal below. For every need.

Six series cover every requirement: No. 140 — 5-40 screws, No. 141—6-32 screws, No. 142—8-32 screws, No. 150—10-32 screws, 151—12-32 screws and No. 152—¼-28 screws.

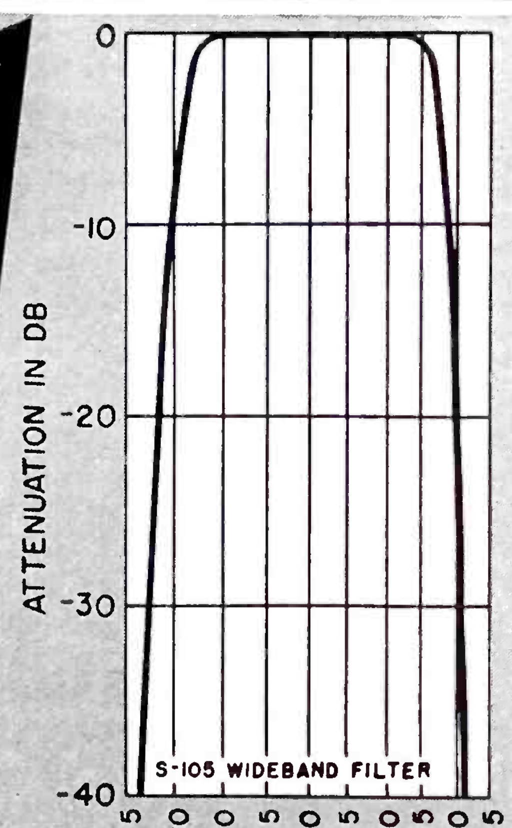
These sturdy Terminal Strips will not only improve your electrical connections but will add considerably to the appearance of your equipment. A truly modern Terminal. Write today for catalog No. 14 listing our complete line of Barrier Strips in addition to other Electrical Connecting Devices.

HOWARD B. JONES DIVISION
CINCH MFG. CORP.
2460 W. GEORGE ST. CHICAGO 18

TOROIDAL COIL FILTERS

. . . are the answer to any network problem

- SHARP CUT-OFF
- LOW INSERTION LOSS
- HUM PROOF
- COMPACT
- HIGH STABILITY



Actual measurements taken on Toroidal Coil Filter manufactured by Burnell & Co.

Toroidal Coils

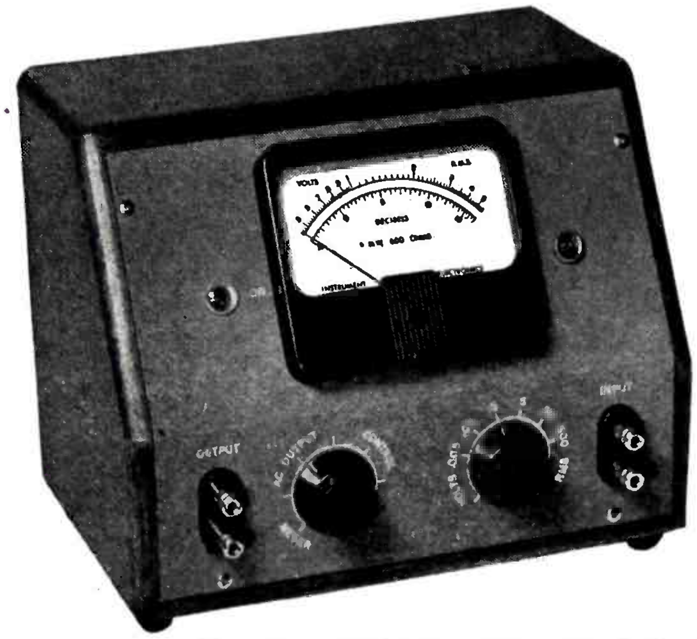
Inductance—1 MHY to 3 HYS
Frequency—300 cy. to 30,000 cy.
"Q"—55 at 1000 cy.; 150 at 3000 cy.

Ask to be put on mailing list for complete catalogue of coils and filters.

Burnell & Co. Designers and Manufacturers of Electronic Products

10-12 VAN CORTLANDT AVE. EAST, BRONX 58, N. Y., SEdgwick 3-1593

LOGARITHMIC AC VOLTMETER —WIDE BAND AMPLIFIER—



Advanced Design gives you a sensitivity and frequency response never before obtained.

No other Voltmeter offers all these advantages

- Range .0005 to 500 volts
- Frequency 5 CPS to 2.0 MC
- Logarithmic voltage scale
- Linear DB scale
- Input 2 Megohm 15 MMF
- Accuracy ±2%
- Stability ±1% 105 to 125 V.

Ideal for Audio, Supersonics, Lower Radio Frequency Spectrum. Measures Stage Gain, RF and IF Amplifiers on Broadcast Receivers.

Write For Complete Information

Instrument Electronics

42-17 Douglaston Parkway **Douglaston, L. I., N. Y.**

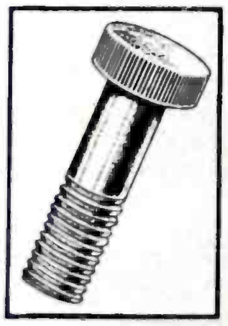
SLASH SCREW COSTS 86%
By Means Of Special Developments

KEENE, N. H. (Special)—Modern methods applied to screw manufacture were cited today as responsible for the incredible saving of 86% in screw costs for a customer of the New England Screw Company of this city. Figures show that the customer was paying $3.75 a thousand for screws from another source and that New England Screw furnished the same product for only 53c.

The customer first approached New England Screw when they became dissatisfied with deliveries and service from another manufacturer. Already far behind in production, they had little hope of catching up, much less of saving any money.

"Our delivery schedules had to be set so high," recalled the president of New England Screw, "they didn't dream we could maintain them. But we did! And saved them 86% in the bargain!"

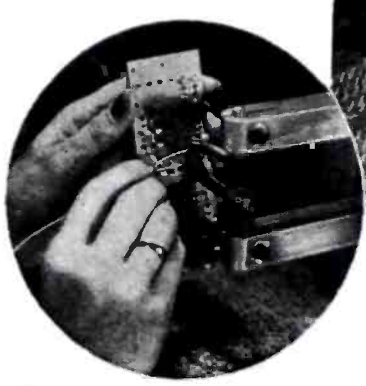
One of the many special screws made by this firm is shown in the illustration at the left. New England Screw has been making standard and special screws and headed shanks for over 50 years, and their modern manufacturing methods are described in an interesting catalog which will be sent to any company requesting it. Engineers of any manufacturer using screws or headed shanks are invited to consult with their Engineering Department which will gladly co-operate.



NEW ENGLAND SCREW CO.
KEENE, NEW HAMPSHIRE

High-Speed Precision WELDING...

of light gauge non-ferrous metals



This photograph shows a typical assembly operation in a radio parts plant... welding 0.025″ dia. nickel plated copper wire to light gauge brass clips mounted on a bakelite panel. Scores of manufacturers of these and other types of delicate non-ferrous metal assemblies are now doing a better job in less time at lower cost... with the RAYTHEON Condenser Weldpower. Changing from slow, costly soldering operations or use of too-large, too-costly bench welders, these users find the RAYTHEON 56 m.f.d. and 200 m.f.d. units are accurate, fast, economical. Write for detailed information. Ask for Bulletin DL-W-507.

RAYTHEON MANUFACTURING COMPANY
Industrial Electronics Division, Waltham 54, Mass.
Sales Offices: Atlanta • Boston • Chicago • Cleveland
Louisville • New York

RAYTHEON
Excellence in Electronics

RADIONIC EQUIPMENT CO.
170 Nassau St., Dept. 4012, New York 7, N. Y.

Please send me a FREE copy of your 1947 Catalog. I understand it has thousands of items illustrated, described and priced and will be a great help to me in my search for "hard-to-find" radio equipment.

Name ....

Address ....

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

screen only data pertinent to his position and altitude. Flight tests are scheduled for 1947.

Shoran is a short-range navigation system employing a form of radar for accurate positioning of an aircraft. A transmitter in the plane sends out a pulse that triggers two fixed stations, which in turn transmit pulses to a receiver and timer in the plane.

New IRE Officers

NEW PRESIDENT of the Institute of Radio Engineers for 1947 is Dr. W. R. G. Baker, vice-president of General Electric Co. in charge of

W. R. G. Baker, new IRE president

electronics. He will take office shortly after the first of the year, succeeding F. B. Llewellyn of Bell Telephone Laboratories.

The vice-president for 1947 will be Noel Ashbridge, deputy director-general of British Broadcasting Corp., London.

Three new directors were elected to serve for 1947-1949: Murray G. Crosby, consulting engineer with Paul Godley Co., Upper Montclair, N. J.; Raymond F. Guy, radio facilities engineer with National Broadcasting Co., New York; Raymond A. Heising, patent engineer with Bell Telephone Laboratories, New York.

Television Conference

A RECORD CROWD for television, officially recorded as 1,200 for the banquet, attended the Second Television Conference and Exhibition of the Television Broadcasters Association, held at the Waldorf-Astoria hotel in New York City Oct. 10 and 11. Despite flickering screens, ghost images, unexplained fadeouts, blurred images, and high prices (in relation to screen size and prewar figures) for the few receiver models shown, many of those who attended are enthusiastically heralding the Conference as the second rebirth of commercial television. Conspicuous by its absence was Columbia Broadcasting System, whose color television system has caused much controversy. An ad saying simply "Compliments of a friend", printed in six colors in the official program booklet, aroused much conjecture.

In recognition of their work in developing the image orthicon, Dr. Albert Rose, Dr. Harold Bell Law, and Dr. Paul K. Weimer of RCA Laboratories, Princeton, N. J., were presented with awards at the TBA Second Television Conference and Exhibition. This tube freed television from limitations arising from previous necessity for high-intensity illumination

J. R. Poppele, president of TBA, declared that the Conference and Exhibition will provide conclusive evidence that television is ready to proceed on a greatly expanded commercial basis and that the new industry is well on the way to becoming one of the most important in the nation.

Radio Production Figures

PRODUCTION OF 3,242 television receivers in September highlights that month's production figures as released by RMA. Other figures show a drop from the all-time production record established in August. Total September RMA

FREEDOM FROM BREAKDOWN

ROWE NO. 7 PERMANENT MAGNETIC DRIVER UNIT

A long lasting unit that provides extra power with a minimum of break-downs and replacements. Overcomes the many annoyances that long have been troublesome to sound engineers.

The 3 lb. 4 oz. ALNICO heavy duty magnet . . . . the one-piece metal diaphragm with voice coil mounted thereon . . . . the heavy gauge steel and brass parts are just a few of the refinements in design and construction. Write for circular 84 which gives complete details.

ELECTRONICS DIVISION

ROWE Industries

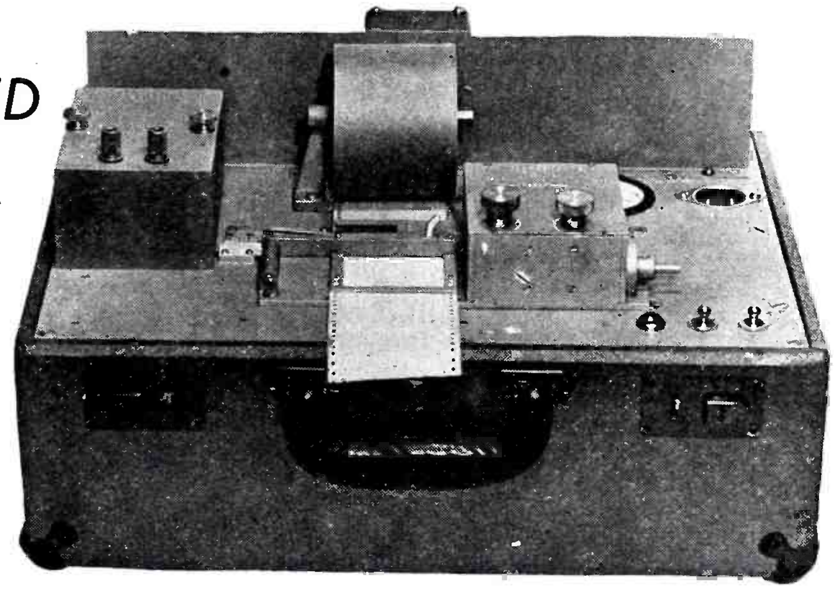
3120 MONROE ST., TOLEDO 6, OHIO

FOR MEASUREMENTS OF

• REVERBERATION TIME • DECAY OF SOUND

• SOUND INTENSITY • LOUDNESS

HIGH SPEED RECORDER MODEL PL with interchangeable input potentiometers



THE GRAPHIC RECORDER FOR THE MODERN ACOUSTICAL ENGINEER

Ask for Literature from the Designers & Manufacturers

SOUND APPARATUS CO.

233 BROADWAY • NEW YORK 7, N. Y.

MORE HEAT PER POUND OF WIRE with KANTHAL RESISTANCE ALLOY*

Kanthal Alloy A-1 allows continuous service temperature of 2462° F. with resistivity of 872 Ohms/C.M.F. at 68° F.

* WIRE, RIBBON OR STRIP

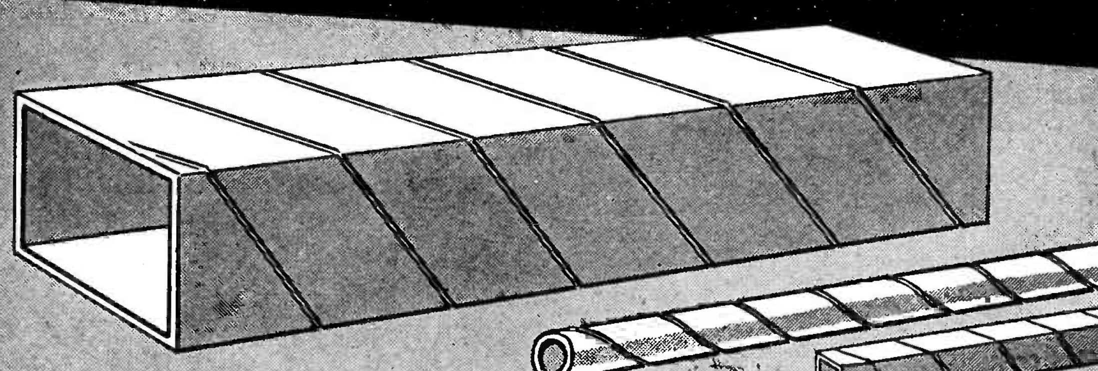
The Kanthal Handbook, comprising 115 pages of complete technical reference material covering all data on the properties, fields of application, and design considerations of the Kanthal alloys, will be sent upon request to engineers writing on company letterheads.

WIRE PRODUCTS — Jelliff — SINCE 1880

THE C. O. JELLIFF MFG. CORP.

SOUTHPORT — CONN.

Over 1000 Sizes



PARAMOUNT SPIRAL WOUND PAPER TUBES

SEND FOR ARBOR LIST OF OVER 1000 SIZES

Convenient, helpful listing of over 1000 stock arbors. Includes many odd sizes of square and rectangular tubes. Write for Arbor List today. No obligation.

Square • Rectangular • Triangular Round and Half-Round

With a wide range of stock arbors . . . plus the specialized ability to engineer special tubes . . . PARAMOUNT can produce the exact shape and size you need for coil forms or other uses. *Hi-Dielectric, Hi-Strength.* Kraft, Fish Paper, Red Rope, or any combination, wound on automatic machines. Tolerances plus or minus .002". Made to your specifications or engineered for YOU.

Inside Perimeters from .592" to 19.0"

PARAMOUNT PAPER TUBE CORP.

616 LAFAYETTE ST., FORT WAYNE 2, IND.

Manufacturers of Paper Tubing for the Electrical Industry member-company production was 1,323,291 sets, of which 105,344 were radio-phonograph consoles and 17,541 were sets with f-m bands. All but a few of the television sets were direct-viewing video-radio-phonograph combination types. The CPA estimate for September was 1,500,000 sets, as compared to 1,700,000 for August.

Television Station Status

ACCORDING TO an FCC release, as of Sept. 25, 1946 there were 6 licensed television stations rendering broadcast service, 31 outstanding construction permits authorizing new stations, 14 applications designated for hearing and awaiting decision, 11 applications pending disposition of hearings in related cases, 10 applications pending receipt of information requested by the Commission, and 6 applications being processed.

MEETINGS TO COME

DEC. 2-7; NATIONAL POWER SHOW; Grand Central Palace, New York City.

DEC. 5-7; JOINT EMSA AND ASXRED WINTER MEETING; Mellon Institute of Industrial Research and Univ. of Pittsburgh, Pittsburgh, Pa.; sponsored by Electron Microscope Society of American and American Society for X-ray and Electron Diffraction; make dinner reservations with Dr. Max Lauffer, Univ. of Pittsburgh.

JAN. 27-31; ELECTRICAL ENGINEERING EXPOSITION; held concurrently with AIEE winter convention; 71st Regiment Armory, New York City.

MARCH 3-6; IRE WINTER MEETING; Hotel Commodore, New York City, with Radio Engineering Show at 34th Street Armory.

BUSINESS NEWS

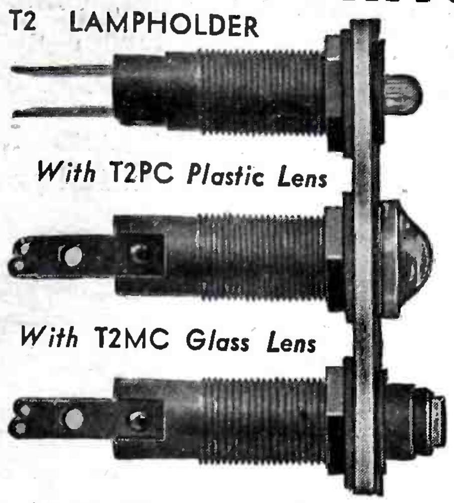
STROMBERG-CARLSON CO., Rochester, N. Y., has leased the five-story Mayer block in Erie, Pa. for the manufacture of table model radios and undisclosed new products.

SPECIAL PRODUCTS CO., Silver

KIRKLAND Pioneer
INDICATING LAMPS

TYPE T2 UNITS

T2 LAMPHOLDER



T2 lampholder, molded of bakelite, holding lip, dia. 11/16". Tip of lamp bulb protrudes sufficiently to be removed from front of panel without use of special tool.

Very low current consumption bulb (0.038 max. amp. on 24 volts). Series resistor of small size on 120-220-440 volts, etc.

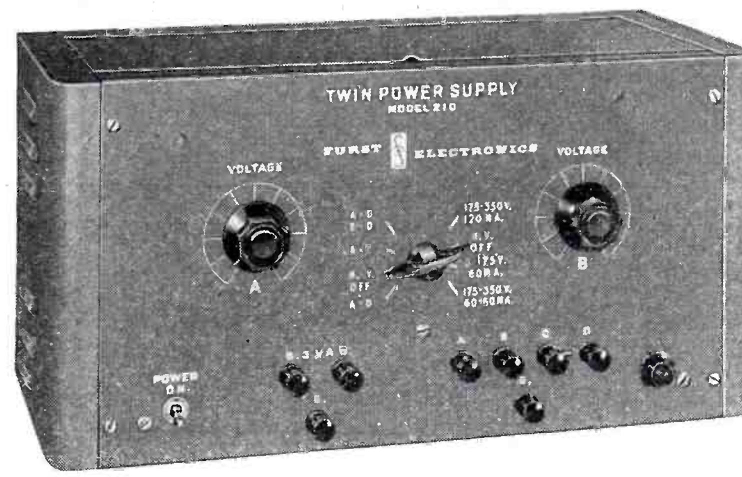
T2PC Lens-cap, molded in plastic.
T2MC Lens-cap, metal with glass lens.

WRITE TODAY FOR CATALOGUE

THE H. R. KIRKLAND COMPANY
8 King Street Morristown, N. J.

TWIN POWER SUPPLY

Electronically Regulated for precise measurements



Two independent sources of continuously variable D.C. are combined in this one convenient unit. Its double utility makes it a most useful instrument for laboratory and test station work. Three power ranges are instantly selected with a rotary switch:

175-350 V. at 0-60 Ma., terminated and controlled independently, may be used to supply 2 separate requirements.
0-175 V. at 0-60 Ma. for single supply.
175-350 V. at 0-120 Ma. for single supply.

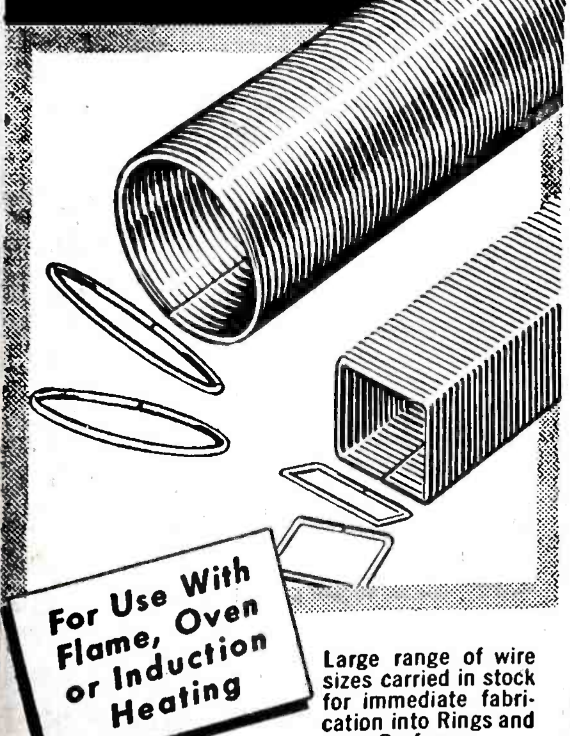
In addition, a convenient 6.3 V.A.C. filament source is provided. The normally floating system is properly terminated for external grounding when desired. Adequately protected against overloads.

- **Output voltage variation less than 1% with change from 0 to full load.**
- **Output voltage variation less than 1 V. with change from 105 to 125 A.C. Line Voltage.**
- **Output ripple and noise less than .025 V.**

Twin Power Supply Model 210 Complete $115.00 F.O.B. Chicago
Dimensions: 16" x 8" x 8" Shipping Wt. 35 lbs.
(Other types for your special requirements)

FURST ELECTRONICS
800 W. NORTH AVENUE, CHICAGO 22, ILLINOIS

- **SOFT SOLDER RINGS AND PREFORMS**
- **SILVER SOLDER RINGS**
- **COPPER BRAZING RINGS**



Large range of wire sizes carried in stock for immediate fabrication into Rings and Preforms.

ELECTRONIC SPECIALTIES MANUFACTURING COMPANY
127 North Main Street, Elkhart, Indiana

Align Yourself with ARCTURUS —The Oldest Name in Radio Tubes!

Here is your chance to secure those hard-to-get tubes you need. Standard Arcturus places at your disposal a diversified supply of tubes of every type and description — both War Assets Administration surplus and regular stock. Every tube is subjected to rigid testing and servicing, including packaging.

The supply of some types is limited. To get the Standard Arcturus monthly announcements of available types of War Assets Administration surplus tubes, clip the coupon below and mail it *at once* with a complete list of your requirements.

ARCTURUS
"KNOWN THE WORLD OVER"
STANDARD ARCTURUS CORPORATION
NEWARK 4, N. J.
WAR ASSETS ADMINISTRATION AGENCY
Contract No. WAS (p) 146

FILL IN & MAIL TODAY

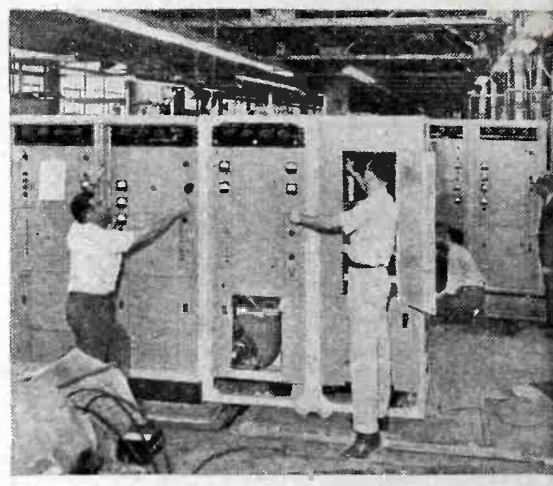
Standard Arcturus Corp., 101 Sussex Ave., Newark 4, N. J.
Please send me monthly lists of available W.A.A. tubes.

Name ....
Company ....
Address ....
.... E-12

Spring, Md. announces its entry into the industrial photo relay field with units designed and engineered by G. W. Rhein.

ASCO CORP., Cleveland, Ohio, has moved to a new and larger plant at 17702 Waterloo Road.

FEDERAL TELEPHONE AND RADIO CORP. announces it is in full produc-



First Federal 10-kw f-m broadcast transmitter undergoing final tests before shipment to radio station WELD in Columbus, Ohio

tion on both 3-kw and 10-kw f-m transmitters.

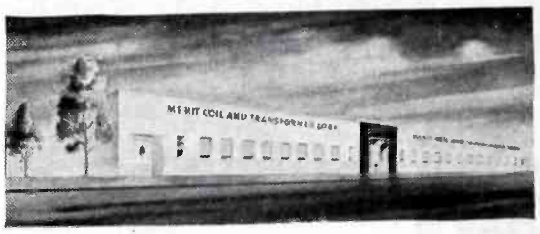
TRIAD TRANSFORMER MFG. CO., Los Angeles, Calif. has been formed by L. W. Howard and O. D. Perry, and has taken over the inventory and equipment of Electronic Components Co. The new firm will specialize in short orders and special transformers for the electronic field.

CARTER MOTOR CO., Chicago, Ill., is now relocated in its own greatly enlarged quarters at 2644 N. Maplewood Avenue having four times the previous floor area.

NAVY development contracts for guided missiles were held by the following firms as of about Oct. 15: Aerojet Engineering Corp.; Bell Aircraft Corp.; Bendix Aviation Corp.; Camden Eastern Marine Co.; Consolidated-Vultee Aircraft Corp.; Curtiss-Wright Corp.; Electronic Associates, Inc.; Experiments, Inc.; Farnsworth Television & Radio Corp.; General Tire and Rubber Co. of Calif.; Hercules Powder Co.; Merrill Engineering Co.; North American Aviation, Inc.; Radio Corporation of America; Standard Oil Development Co.; Submarine Signal Co.; Sylvania Electric Products, Inc.; United Aircraft Corp.; and Wilmotte Mfg. Co. This list is necessarily imcomplete as contracts

are constantly being wound up and new ones entered into. The Army may also be issuing guided missile development contracts, but has not disclosed the type of product involved in its contracts.

MERIT COIL & TRANSFORMER CORP., Chicago, Illinois, has begun work on a new addition that will approximately double the present capacity of the main plant.



Merit Coil & Transformer Corp. plant as it will appear after completion of new addition early in 1947

PERSONNEL

LEWIS W. CHUBB, director of Westinghouse Research Laboratories, was awarded the John Fritz Medal and certificate by four engineering societies—ASCE, AIMME, ASME, and AIEE—"for pioneering genius and notable achievements during a long career devoted to the scientific advancement of the production and utilization of electrical energy".

SAMUEL G. LUTZ has been appointed chairman of the Electrical Engineering Department of the College of Engineering, New York University. In 1940 he was project engineer in charge of speech secrecy systems at Naval Research Laboratory. He directed important countermeasures work for the Navy in 1943, and in December 1944 was made head of the Measurements and Direction Finding Section of NRL.

WALTER B. SCHULTE, founder and president of Micro Switch Corporation, now a division of First Industrial Corporation, Freeport, Illinois, is retiring Dec. 15, and will be succeeded by William W. Gilmore, executive vice-president.

ROBERT M. BENNETT, Jr. has been appointed chief engineer of St. Louis Microphone Co., St. Louis, Mo.

RALPH A. GALBRAITH, contributing author to the MIT staff book,

"Principles of Radar", has been appointed professor of electrical engineering and chairman of the department at Syracuse University, Syracuse, N. Y.

RAY C. BIERMAN becomes senior electrical engineer at Webster-Chicago Corp., Chicago, in charge of development work on wire recorders, amplifiers, and other electronic devices. He was formerly chief engineer with Permoflux Corp., Chicago.

R. C. Bierman

H. K. Skramstad

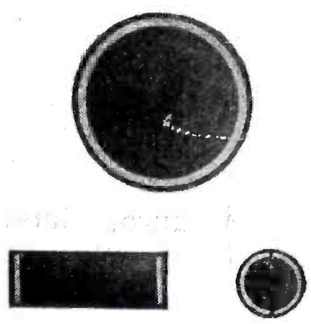
H. K. SKRAMSTAD is now chief of the Guided Missiles Section of the National Bureau of Standards, which developed the radar-guided BAT glide bomb in cooperation with OSRD, MIT, and the Navy Department. Dr. Skramstad played a key part in the development of the BAT, which was the first fully automatic guided missile to be successfully used in combat by any nation.

DALE POLLACK, formerly vice-president in charge of engineering with Templetone Radio Mfg. Corp., announces the opening of his office and laboratory at New London, Conn., specializing in frequency-modulation development and research.

DONALD G. FINK, editor of ELECTRONICS, was on Oct. 30 elected to the board of directors of McGraw-Hill Book Co., New York, N. Y.

ROBERT WILSON, now a professor in the physics department of Harvard University, was elected chairman of the Federation of American Scientists, an organization of 3,000 scientists seeking public understanding and world control of atomic energy under international law. Dr. Wilson was director of the Nuclear Physics Research Division

BRADLEY
PHOTO ELECTRIC CELLS



Unmounted Cells

The shapes of Luxtron photocells vary from circles to squares, with every in-between shape desired. Their sizes range from very small to the largest required.

In addition to the unmounted cells shown here, Bradley also offers cells in a variety of standard mountings, including plug-in and pigtail types.

For direct conversion of light into electric energy, specify Bradley's photocells. They are rugged, lightweight and true-to-rating.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.
32 Meadow St. New Haven 10, Conn.

"Alnico" permanent magnets

Specializing in the production of highest quality Alnico Magnets in all grades including new triple strength No. 5.

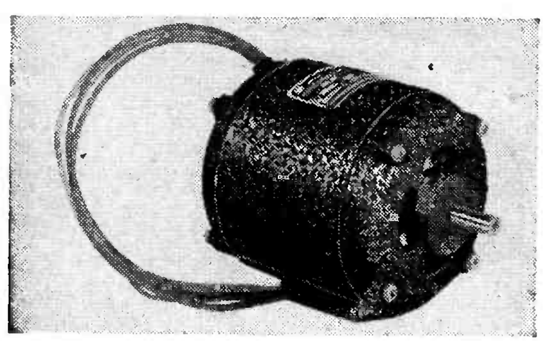
Production material checked to assure highest uniform quality of product.

Castings made to customer's special order on the basis of sketches or blue prints furnished.

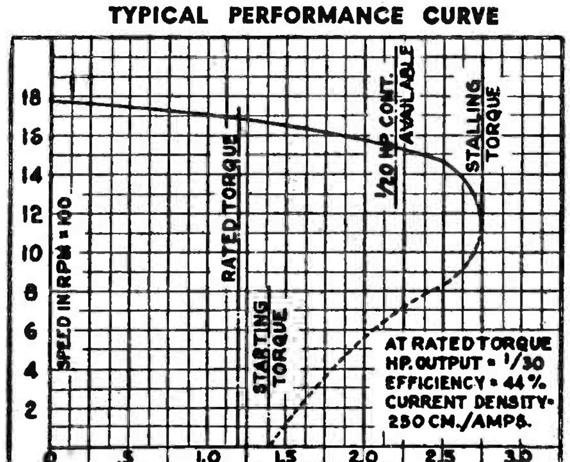
Information and suggestions furnished on request.

GENERAL MAGNETIC CORPORATION
MANUFACTURERS OF HIGH COERCIVE MAGNETIC ALLOYS
10001 ERWIN AVENUE
DETROIT 5, MICHIGAN

NEW MODEL



ELINCO TYPE ALP
TYPICAL PERFORMANCE CURVE



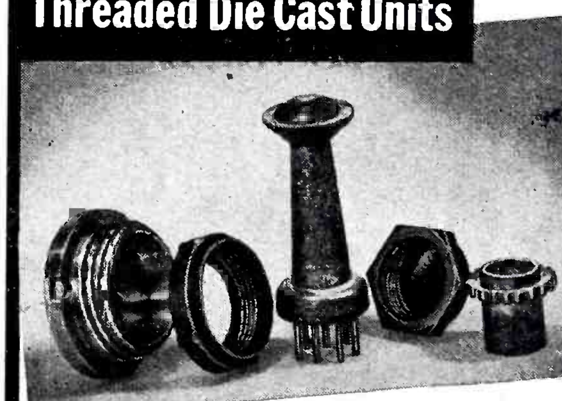
Type ALP-191; 110 volt 60 cyc. single-phase Capacitor start & run; Motor Capacitor Value 4.25 Mfd. Curve #235.

Elinco ALP Frame Motors are 3⅜" x 4-5/16" capacitor start and run, two and four pole AC motors, internal fan cooled. Continuous duty rating—as induction motor to 1/30 h.p. at 1700 r.p.m.; as synchronous motor to 1/60 h.p. at 1800 r.p.m. Substantially higher ratings are available at speeds of 3400 and 3600 r.p.m. respectively. Also, higher rating for intermittent duty.

Write for Temporary Bulletin 46-A

ELECTRIC INDICATOR CO.
STAMFORD, CONNECTICUT

★STAR
Specialists in Internal and External Perfect Threaded Die Cast Units



Intricate parts of 100% rust-proof Zinc alloy.
Accurate to specification. Held to tolerances of .005.
Threads require no machining.
Ideal for instrument, small machine and minute electronic parts.

Producers of the Two Vital Aids to Manufacturers of Miniature Tube Radios.
JE-10 STAR MINIATURE SOCKET WIRING PLUGS.
JE-13 STAR MINIATURE TUBE PIN STRAIGHTENERS.

Write for complete information.

STAR EXPANSION PRODUCTS CO.
(INCORPORATED)
147 Cedar St. New York 6, N. Y.

at the Los Alamos, New Mexico laboratory of the Manhattan District Project.

WILLIAM A. HIGINBOTHAM, past chairman of the Federation of American Scientists, will remain in Washington as executive secretary of the Federation. He worked on radar at MIT Radiation Laboratory early in the war, and was later head of the Electronics Group in the Los Alamos laboratory that developed and tested the first atomic bomb.

LADISLAUS L. MARTON received the appointment as principal physicist in the Electronics Section of the National Bureau of Standards, and will initiate a program of research on basic theory and applications of electron and ion beam devices. He was previously on the faculty staff of Stanford University, where he headed the Division of Electron Optics.


L. L. Marton


B. Adler

BEN ADLER has been appointed vice-president in charge of engineering at Transmitter Equipment Mfg. Co., New York City. He was formerly chief facilities engineer at American Broadcasting Co.

CARL W. MULLER has been made vice-president and general manager of Sorensen & Co., Inc., Stamford, Conn. He received the Civilian Meritorious Award for wartime work designing instruments for the Army Air Forces.

WILLIAM N. GREER has moved his offices to San Juan, Porto Rico, where he will continue the practice of general communications engineering.

ALCIDE PROSDOCIMI has been elected vice-president in charge of the International Division of Solar Mfg. Corp., New York City.

NEW BOOKS

Scientists Against Time

By James Phinney Baxter, *3rd, President of Williams College. Atlantic—Little, Brown, Boston, Mass.,* 1946, 473 *pages*, $5.00.

Dedicated "To the Scientists of the United Nations who gave their lives in the cause of freedom," this official history of the Office of Scientific Research and Development tells of the plans, the hopes, the endless experiments, the day-and-night labor under pressure and secrecy that lay behind the ultimate success of our scientists in outstripping the enemy.

This history of the mobilization of civilian science for war was initiated by Dr. Vannevar Bush who, in February 1943, persuaded Dr. Baxter, then deputy director of the Office of Strategic Services, to undertake the job. The author was given access to the official records of the Army, the Navy, and OSRD; he visited laboratories, attended service demonstrations of the new weapons, and interviewed many scientists.

Here for the first time is the full story of how we started with the formation of OSRD in June 1940; how Anglo-American radar finally surpassed the German; how new weapons were developed to meet each new emergency. The book is divided into six parts, the last of which is appropriately devoted to the atomic bomb.

Part I is 118 pages of fascinating orientation, covering the roles of submarine, naval, amphibious, air, and land warfare in relation to each other on the various battlefronts, along with the relation of science to strategy in wartime.

Part II is essentially electronic, contains 134 pages (the longest section in the book), and presents in sequence the roles played by radar and loran, radar countermeasures, contributions to subsurface warfare, new devices for air warfare, rockets, fire control, and proximity fuzes.

Of less interest to electronic readers but equally fascinating in context are Part III on chemistry and the war, Part IV on military medicine, and Part V on men and machines.

Here is a book that can stand for

all time as an authenic scientific history of World War II. True, there will be highly specialized volumes reporting on specific projects in minute detail, such as the MIT Radiation Laboratory series, but for most readers this well-prepared and comprehensive history will suffice; furthermore, even those waiting for the detailed volumes will find this book extremely valuable in its presentation of the overall picture. Here each OSRD project in turn is taken up, including many that were relatively unknown and only recently released from secrecy. Here too are equally interesting stories of the many projects abandoned for one reason or another, such as the Pelican—a depth bomb that was dropped from a plane and followed a radar beam produced by the plane so as to give automatic homing on a ship or submarine target. The Navy's verdict here was "no operational use".

An appendix gives among other things the number of contracts held by principal industrial and nonindustrial contractors with OSRD and the total dollar value of contracts held by each company. The index is comprehensive. The foreword is by Vannevar Bush, whose own words aptly express the undercurrent theme of the book:

"But it tells also of something that is more fundamental even than this diversion of the progress of science into methods of destruction. It shows how men of good will, under stress, can outperform all that dictatorship can bring to bear—as they collaborate effectively, and apply those qualities of character developed only under freedom."

The achievements of scientists working voluntarily against time, as presented in this book, constitute a tremendous argument for permanent worldwide peace. The implication is obvious, that no agressor can expect to survive for long if this army of scientists is ever called up again to fight for freedom.—J. M.

The Gas-Filled Triode

By G. WINDRED, *Hulton Press, Ltd., London,* 1946, 72 *pages,* 2/6.

CHARACTERISTICS AND USES of gas tubes are simply presented for

those unfamiliar with the subject. Although this monograph contains no new material, it does present concisely and clearly all the essential facts about the tubes and their more usual applications including rectification, inversion, and motor control. The presentation is qualitative, design equations and typical values being seldom given. The discussion includes gas tetrodes. —F. R.

The Diffraction of X-Rays and Electrons by Free Molecules

By M. H. PIRENNE, *Cambridge University Press and The Macmillan Co.,* 1946, 160 *pages.*

THIS RESUME of one of the advanced physical methods of studying the microcosm presents the experimental evidence and the theoretical inferences built thereon in a logical order without resorting to obscuring mathematical treatments. The discussion is an addition to the Cambridge Series of Physical Chemistry.—F. R.

LEGAL NOTICE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

Of Electronics, published monthly (semi-monthly in June) at Albany, N. Y., for October 1, 1946.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared J. A. Gerardi, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publishers of Electronics and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the name and address of the publisher, editor, and business manager is: McGraw-Hill Publishing Company, Inc.; Editor, Donald G. Fink; Managing Editor, W. W. MacDonald; Business Manager, W. B. Blood, all of 330 West 42nd Street, New York 18, N. Y.

2. That the owner is: McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York City. Stockholders holding 1% or more of stock: James H. McGraw; James H. McGraw, Jr.; James H. McGraw, Jr., Curtis W. McGraw and Edwin S. Wilsey, Trustees for: Harold W. McGraw, James H. McGraw, Jr., Donald C. McGraw and Curtis W. McGraw, all of 330 West 42nd Street, New York City; Edwin S. Wilsey and Curtis W. McGraw, Trustees for James H. McGraw, 3rd, Madison, New Jersey; Curtis W. McGraw, Donald C. McGraw, both of 330 West 42nd Street, New York City; Mildred W. McGraw, Madison, New Jersey; Grace W. Mehren, 536 Arenas St., La Jolla, Calif.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

J. A. GERARDI, Secretary.
McGRAW-HILL PUBLISHING COMPANY, INC.

Sworn to and subscribed before me this 24th day of September, 1946.

[SEAL] ELVA G. MASLIN.
(My commission expires March 30, 1948.)

ADDITIONS and CORRECTIONS

to the

JUNE 1946-1947 ELECTRONICS BUYERS' GUIDE

The following listings are to be used in conjunction with the June 1946—1947 ELECTRONICS BUYERS' GUIDE for information on manufacturers' names, addresses, and products omitted or incorrectly listed in that issue. Product classification numbers and names are the same as used in the June Guide.

19. RAILROAD COMMUNICATION SYSTEMS

General Electric Co., Schenectady, N. Y.

31. ELECTRIC PHONOGRAPHS and RECORD PLAYERS

General Electric Co., Bridgeport, Conn.
Rexon, Inc., 295-5th Ave., New York 16, N. Y.

36. RADAR RECEIVERS

General Electric Co., Syracuse, N. Y.

38. TRANSMITTERS

General Electric Co., Syracuse, N. Y.

41. AM PORTABLES

General Television & Radio Corp., 2701 No. Lehmann St., Chicago 14, Ill.

56. AIRCRAFT RECEIVERS

General Electric Co., Syracuse, N. Y.

67. MARINE RECEIVERS

General Electric Co., Syracuse, N. Y.

72. TELEVISION RECEIVERS

General Electric Co., Bridgeport, Conn.

86. TELEVISION SYSTEMS, INDUSTRIAL

General Electric Co., Syracuse, N. Y.

129. HUMIDITY CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

140. PRESSURE CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

145. SMOKE DENSITY COMBUSTION and CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

147. TEMPERATURE CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

149. TIMING CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

208. MOISTURE METERS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

209. pH METERS, RECORDERS and COMPARATORS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

255. DIATHERMY ACCESSORIES

Wappler, Inc., 27 W. 24th Street, New York 10, N. Y.

261. ELECTRIC WAVE GENERATORS

Wappler, Inc., 27 W. 24th Street, New York 10, N. Y.

285. BRIDGES

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

340. GALVANOMETERS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

361. THERMOCOUPLE METERS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

439. ANTENNA KITS

General Electric Co., Syracuse, N. Y.

477. METAL CABINETS

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

485. SHIELDED CABLE

Precision Tube Co., 3828 Terrace St., Phila. 28, Pa.

488. CANS

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

495. MICA FIXED CAPACITORS

General Electric Co., Syracuse, N. Y.

518. AUDIO and POWER CHOKES

Empire Coil Co., 238 Huguenot St., New Rochelle, N. Y. (Audio)

533. RELAY and SOLENOID COILS

Empire Coil Co., 238 Huguenot St., New Rochelle, N. Y.

596. FASTENERS and FASTENING DEVICES

duPont de Nemours & Co., Inc., E.I., Explosive Rivets Div., Wilmington 98, Del.

656. RODS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

657. SCREW MACHINE PARTS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

658. SHEETS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

660. FIBRE STAMPINGS and PUNCHINGS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

666. FIBRE INSULATION TUBES

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

670. PLASTIC INSULATION TUBES

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

675. CERAMIC INSULATORS

General Electric Co., Syracuse, N. Y.

716. METAL STAMPINGS, Small

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

823. RIVETS

duPont de Nemours & Co., Inc., E.I., Explosive Rivets Div., Wilmington 98, Del.

840. TUBE SHIELDS

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

853. INSTRUMENT HAIRSPRINGS

Instruments Specialties Co. Inc., 254 Bergen Blvd., Little Falls, N. J.

854. PRECISION SPRINGS

Instruments Specialties Co. Inc., 254 Bergen Blvd., Little Falls, N. J.

857. STRAIN RELIEFS

Walker Co., George, 118 Amsterdam Ave., Passaic, N. J.

897. TERMINAL STRIPS

Langevin Co., Inc., The, 37 West 65th St., New York 23, N. Y.

901. AUDIO and POWER TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.
Empire Coil Co., 238 Huguenot St., New Rochelle, N. Y. (Audio)

902. AUTO-TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.
Langevin Co., Inc., The, 37 West 65th St., New York 23, N. Y.

907. MICROPHONE TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.

909. MINIATURE TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.

911. PULSE TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.

927. BASES

National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.

936. GRIDS and SUPPORTS

National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.

944. BALLAST TUBES

Kuthe Labs. Inc., 150 Summit Street, Newark 4, N. J.

959. RECTIFYING TUBES

Electrons Inc., 127 Sussex Ave., Newark, N. J.

964. THYRATRONS

Electrons Inc., 127 Sussex Ave., Newark, N. J.

976. TURNTABLE UNITS

Rek-O-Kut Co., 146 Grand St., New York 13, N. Y.

977. VALVES, SOLENOID

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

1008. ELECTROSTATIC AIR CLEANERS

Raytheon Mfg. Co., Electronic Equip. Div., Waltham 54, Mass.

1019. METAL BOXES

Walter Co., S., 144 Centre St., Brooklyn 31, N. Y.

1036. FANS AND BLOWERS

Smith Mfg. Co., F. A., P. O. Box 509, Rochester 2, N. Y.

1078. FABRIC INSULATION

Varflex Corp., N. Jay St., Rome, N. Y.

1080. FIBERGLAS INSULATION

Varflex Corp., N. Jay St., Rome, N. Y.

1091. SCREWDRIVERS and SMALL INSULATED TOOLS

Standard Pressed Steel Co., Jenkintown, Pa.

1099. CUTTING HEAD MACHINES

Rek-O-Kut Co., 146 Grand St., New York 13, N. Y.

1116. WIRE STRIPPING MACHINES

Lead-All Products Co., 24 E. 21st St., New York 10, N. Y.

1123. BERYLLIUM and BERYLLIUM ALLOYS

Beryllium Corp., The, Reading, Pa.

1128. COEFFICIENT METALS

Carpenter Steel Co., Reading, Pa.
Magnetic Metals Co., Camden, N. J.

1134. HIGH PERMEABILITY ALLOYS

Carpenter Steel Co., Reading, Pa.
Magnetic Metals Co., Camden, N. J.

1135. LAMINATED METAL PRODUCTS

Magnetic Metals Co., Camden, N. J.

1144. NICKEL & NICKEL ALLOYS

Carpenter Steel Co., Reading, Pa.
Magnetic Metals Co., Camden, N. J.

1153. STAINLESS STEEL

Carpenter Steel Co., Reading, Pa.

1154. STEEL

Carpenter Steel Co., Reading, Pa.

1155. STEEL ELECTRICAL

Carpenter Steel Co., Reading, Pa.

1158. THERMOSTATIC BI-METALS

Carpenter Steel Co., Reading, Pa.
Magnetic Metals Co., Camden, N. J.

1208. RESISTANCE THERMOMETERS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

1211. METAL and ALLOY TUBING

Carpenter Steel Co., Kenilworth, N. J.

1213. NICKEL TUBING

Carpenter Steel Co., Kenilworth, N. J.

1215. STEEL TUBING

Carpenter Steel Co., Kenilworth, N. J.

NAME and ADDRESS CORRECTION or CHANGE

Bradley Laboratories, 82 Meadow Street, New Haven, Conn.
Tibbetts Industries, Inc., Camden, Maine

A NOTE FROM THE EDITORS

The above list of additions and corrections together with the one published in the November Issue bring the 1946–1947 Electronics Buyers' Guide fully up to date on the basis of information now available. No further monthly listings will be published for use in conjunction with the 1946–1947 Guide. All pertinent directory information received in the months ahead will be held for publication in the 1947–1948 Guide (coming June 1947).

Manufacturers of electronic components, equipment, and allied products are urged to watch for the questionnaire which we shall send them shortly, requesting a complete list of the products they manufacture to be included in the 1947–1948 Buyers' Guide. Complete, accurate product listings by manufacturers are indispensable to us in the preparation of the Guide, and, wherever possible, product literature in the form of brochures, booklets, data sheets etc. should accompany the returned questionnaire. Careful completion of this questionnaire will help us greatly in producing an accurate and all-inclusive listing in the 1947–1948 Buyers' Guide.

CONTACTS
FOR THE FIELD OF ELECTRONICS

Strip Insulated Wires
QUICKER . . . BETTER
with *"Speedex"*
AUTOMATIC WIRE STRIPPER . . . Speeds Production

Strips Insulation from all types of wire—instantly, easily, perfectly Just press the handles and the job is done. Cuts wire too. Strips 800 to 1000 wires per hour. Available for all size solid or stranded wires —No. 8 to No. 30. List Price $6.00
Write Dept. E for Full Particulars

GENERAL CEMENT MFG. CO.
Rockford, Illinois, U.S.A.

FINE RIBBONS OF TUNGSTEN and MOLYBDENUM

Quality and accuracy in our fabrication of Tungsten & Molybdenum Ribbons have characterized our service to the Electronic industry.

A development of

H. CROSS Co.
15 Beekman St., New York 7, N.Y.

REX RHEOSTAT COMPANY, BALDWIN, L. I., N. Y.

PROTECTED & UNPROTECTED
RHEOSTATS
WITH LUBRICATED CONTACTS
ROTARY DRIVE RHEOSTATS
WITHOUT BACK LASH
PROTECTED & UNPROTECTED
ADJUSTABLE RESISTORS
UP TO 1000 WATT
PROMPT SHIPMENTS

PRECISE ELECTRONICS CO.
Manufacturer of
all types of COILS for radio and other electronic devices.
Wire cut and stripped to size.
614 West 49th Street New York, N. Y.
Telephone: Circle 5-9063

MICROMETER FREQUENCY METER for checking Transmitters from 100 Kc to 175 Mc. within 0.01 per cent

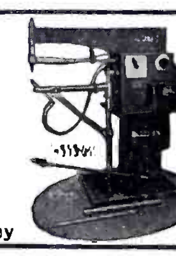
LAMPKIN LABORATORIES
Bradenton, Fla., U. S. A.

Miles FILMGRAPH
CONFERENCE, TELEPHONE, DICTATION
Permanent recorders & Instantaneous play-back machines for all industrial purposes. Safety film cost 5c per hour.
MILES REPRODUCER CO., INC.
812 B'way, Dept. E, New York, 3, N. Y.

We manufacture a complete line of equipment

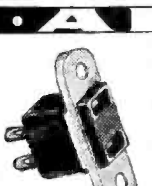
SPOT WELDERS, electric from ¼ to 50 KVA
TRANSFORMERS, special and standard types
INCANDESCENT LAMP manufacturing equipment
FLUORESCENT TUBE MAKING EQUIPMENT
ELECTRONIC EQUIPMENT, vacuum pumps, etc.
WET GLASS SLICING and cutting machines for laboratory use
GENERAL GLASS working machines and burners
COLLEGE GLASS working units for students and laboratory

AC ARC WELDERS from 100 to 400 Amps



EISLER ENGINEERING CO.
731 So. 13th St. (near Avon Ave.) Newark, New Jersey

ALDEN



No. 402AC

Here is the smallest possible A. C. power outlet to fit standard plugs. Rivets, eyelets or spot welds in place. Tabs provide for wrap around and fast soldering of wire. Mounting centers 1-1/8", takes only 1" clearance back of panel. Underwriters approved for 10 amp. @ 250V or 15 amp. @ 125V.
WRITE FOR ALDEN'S "BLUE-BOOK"
ALDEN PRODUCTS COMPANY
BROCKTON 64P, MASSACHUSETTS

Electron Tube Machinery
of every type, — standard, and special design

Specialists in Equipment for the manufacture of Radio Tubes, Cathode Ray Tubes, Fluorescent Lamps, Incandescent Lamps, Neon Tubes, Photo Cells, X-ray Tubes and other glass or electronic products, on production or laboratory basis.

Kahle ENGINEERING COMPANY
1307-1309 Seventh St., North Bergen, N. J.

---

18 YEARS IN RADIO

GET THIS *New* CATALOG By This Old Firm

Latest developments in radio and electronic parts and devices, newest ham gear, gadgets for experimenters, bargains in war surplus items.

FREE TO YOU
Mail the coupon below and get this new catalog FREE.

BURSTEIN-APPLEBEE CO.,
1012 McGee, Kansas City 6, Mo.
Send me FREE catalog advertised in Electronics.
I AM ____________
STATE CONNECTION IN INDUSTRY
NAME ____________
ADDRESS ____________
TOWN ____________ STATE ____________

RADIO BOOKS BY MAIL OVER 125 TITLES IN STOCK
SAME-DAY SHIPMENT ON 98% OF ALL MAIL ORDERS. Books of nearly all radio publishers. If you don't know price, send deposit and we'll ship C.O.D.
SEND STAMP FOR CATALOG TO **EDITORS AND ENGINEERS, Ltd.**
1303 Kenwood Road • Santa Barbara, California

High Speed Production Of Quality R. F. Coils and Sub-Assemblies, For Discriminating Manufacturers
Clippard INSTRUMENT LABORATORY, INC.
1125 Bank Street, Cincinnati 14, Ohio

MERRYLECTRONIC XMAS
Engineers think that Santa works for Sun Radio. That's their only explanation for the surprising way in which we supply hard-to-get radio - electronic parts & equipment. Find out for yourself. Call Sun today!

SUN RADIO & ELECTRONICS CO., Inc.
ESTABLISHED 1922
122-124 DUANE ST. NEW YORK 7, N. Y. BArclay 7-1840

Make it a HABIT . . . to check this page—EACH ISSUE
THIS CONTACTS SECTION supplements other advertising in this issue with these additional announcements of products and services essential to efficient and economical operation in the field of
ELECTRONICS

SEARCHLIGHT SECTION

EMPLOYMENT • BUSINESS • OPPORTUNITIES • EQUIPMENT—USED or RESALE

UNDISPLAYED RATE:
15 cents a word, minimum charge $3.00. (See ¶ on Box Numbers.)
POSITIONS WANTED (full or part-time salaried individual employment only), ½ above rates.
PROPOSALS 75 cents a line an insertion.

INFORMATION:
BOX NUMBERS in care of any of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads.
DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:
The advertising rate is $9.00 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request
AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. E

NEW ADVERTISEMENTS received by 10 A. M. December 10th will appear in the January issue, subject to limitation of space available.

WANTED
SUPERVISORY ENGINEER
Company specializing in the development of electro-mechanical equipment has a permanent supervisory position open for Engineer—experience in electro-mechanical development and design. Location: Minneapolis — St. Paul, Minnesota

P-260, Electronics
520 North Michigan Ave., Chicago 11, Ill.

POSITIONS VACANT

ASSOCIATE PROFESSOR Of Electrical Engineering. Education: M.S. degree in E.E. with specification in Electronics. Teaching experience required. Industrial or military experience desirable. Salary $3200.00 to $3600.00 for nine months school year depending on age and experience. Write: Department of Electrical Engineering, North Dakota Agricultural College, Fargo, North Dakota.

INSTRUCTORS to teach Radio Engineering, must have B.S. Degree in E. E. or Physics, or equivalent; 5 years experience in commercial electronics works. Knowledge of Microwaves desirable. Write giving full details regarding education and experience to Personnel Dept., Spartan School of Aeronautics, Tulsa, Oklahoma.

EMPLOYMENT SERVICE

SALARIED POSITIONS $2,500-$25,000. This thoroughly organized confidential service of 36 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 278 Dun Bldg., Buffalo 2, N. Y.

POSITIONS WANTED

SALES ENGINEER: Experienced engineer earnestly desires changing from dealing with circuits, slide rules and test apparatus to more direct contacts with people and personalities, i.e. position in sales engineering field. Thoroughly acquainted radio equipments and components; qualified from personality and appearance standpoints. Prefer N.Y.C. area or western U. S. PW-263, Electronics, 330 W. 42nd St., New York 18, N. Y.

(Continued on page 312)

WANTED
ELECTRONIC ENGINEER
Electronic Engineer, preferably under 30 years of age wanted for Research Department of Caterpillar Tractor Co., manufacturers of Diesel Engines, Tractors and earthmoving equipment. Applicant should be an Electrical Engineering graduate and have practical knowledge of laboratory electronic instrumentation, design and application.

Please state qualifications, education, training and experience so that an interview can be arranged.

All applications will be carefully considered and acknowledged. Please address:

CATERPILLAR TRACTOR CO.
PEORIA, ILLINOIS

WANTED
Prominent Aircraft Company, Eastern United States needs men with following qualifications:

Experienced engineers with Bachelor's, Master's, Doctor's degrees in Electrical Engineering, Physics, Mathematics. At least two years experience in design and development of radar and television systems, automatic computers, servomechanisms, target seekers, etc., required. Positions open for preliminary and detail design, research, and development of guided missiles under Army and Navy contracts.

Starting salary commensurate with experience. Address

P-243, Electronics
330 West 42nd St., New York 18, New York

AUDIO ENGINEER
Available Now
19 Years Diversified Experience
DISC RECORDING EQUIPMENT & SYSTEMS
AUDIO TEST EQUIPMENT
MINIATURE AUDIO SYSTEMS
HIGH QUALITY AUDIO FREQUENCY SYSTEMS FOR MANY PURPOSES
Design Administration

A practical and effective worker, willing and capable of taking charge of a product from start to market.

PW-262, Electronics
330 West 42nd St., New York 18, N. Y.

AVAILABLE JANUARY 1, 1947
Executive Electronics Engineer
RESEARCHER—DESIGNER
Age 41, married, 3 children.
Salary $10,000-$12,000, any place in U.S.A.
Lt. Comdr. USNR, released April 28, 1946

Sole inventor 18 patents, including 1808738, 2077768, 2080575, 2102911, 2108410, 2164019, 2168071, 2346868, 2358534. Co-inventor others.

For 15 years, Chief E.E. in charge Res. & Dev., midwest manufacturer speed-control systems.

Weak at calculus and chemistry; strong at mechanics, electronic circuitry, servo-mechanism, instrumentation, design for production.

Worked on development Night-Fighter Radar at M.I.T.; then Aircraft Radar Officer on carrier in combat; then 18 mo. BuAer. Armament Division, developing systems for combining Radar with Fire-Control, Turret-Control, and Bomb-sights.

Continuously retained since, "Consulting" on product development and market survey. Successful at Sales Engineering and at getting along with people. Prefer to accept the lower pay that goes with security, research, and less necessity to "win friends and influence people."

W. R. PERRY
171-37, 46th Ave., Flushing, N. Y.

WANTED
ENGINEER-EXECUTIVE
We need a top-flight executive to direct the engineering efforts of our young, expanding electronic manufacturing organization.

P-267, Electronics
330 West 42nd St., New York 18, N. Y.

Additional Employment Advertising on Pages 312 & 313

WANTED
PHYSICISTS

Large Oil Company in the East with long established Research and Development Division has openings for men with experience in experimental or theoretical physics.

A rapidly growing physical research group is doing fundamental and applied research in radiation, nuclear, electronics, general physics, and geophysical prospecting.

Real opportunities exist for top flight men to grow with this expanding organization which is committed to long term research.

Salaries are high and based on education and experience. Our own personnel know of this ad.

P-227, Electronics
330 West 42nd St., New York 18, N. Y.

POSITIONS WANTED
(Continued from page 311)

QUALIFIED RADIO Engineer desires connection as Assistant Chief Engineer, Administrative, Project, Liaison, Sales Engineer or equivalent responsible position. Prefer television or UHF/VHF activities. Eight years background research, developmental, production phases auto radios, RF coil and tuner design, FM, radar countermeasures, D/F systems, recording-reproducing equipment. Age 31; married; personable; ability to direct overall responsibilities of developmental and production projects. Location N.Y.C. area or western U.S. PW-264, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONICS TRAINEE on job preferred. 3 years experience with U. S. Navy. Eric Browner, 3132 Perry Ave., Bronx, New York. Telephone: Olinville 2-2144.

BUSINESS OPPORTUNITY

LOUDSPEAKER for custom and domestic sound installations (see Electronics for February, 1946) with performance comparable to large theater types now developed through pilot model and limited production stages including patent protection, needs plant, market development and organization beyond my means. Would consider forming, joining, or being joined by existing organization or individuals to form team to exploit this and other ideas. Write: Paul W. Klipsch, Hope, Arkansas.

Available

HEARING AID ENGINEER

Intensive Experience on

HEARING AIDS
STETHOSCOPES
AUDIOMETERS
TEST EQUIPMENT
PSYCHO ACOUSTICS

With a good record in every step from product development, production problems, administration, to technical publicity for the finished product.

PW-266, Electronics
330 West 42nd St., New York 18, N. Y.

Engineers

Broadcast Radio receiver Project Engineers, Television receiver Project Engineers and Mechanical Engineers experienced in broadcast receiver engineering methods. Excellent opportunity for advancement in a growing engineering department.

Reply giving full details to

Personnel Manager
BENDIX RADIO
Division of Bendix
Aviation Corporation
Baltimore 4, Maryland

ELECTRICAL ENGINEERS
(SENIORS)

SEVERAL POSITIONS OPEN FOR MEN WITH UHF EXPERIENCE

MECHANICAL ENGINEERS
(SENIORS)

SEVERAL POSITIONS OPEN FOR MEN WITH RADAR DESIGN EXPERIENCE

ALLEN B. DU MONT LABORATORIES, INC.
2 Main Avenue, PASSAIC, N. J.

Aircraft Corporation, old established firm has openings for the following technical personnel:

Engineering Technical Writer—B S Degree in Aero Engr. or Mech. Eng. Experience in report writing necessary.

Industrial Engineer—25 to 30 years old with 3 to 5 years experience in Administrative Engineering with Industrial Organization.

Two Electrical Engineers or Physicists, M S Degrees or better preferred. One with at least four years experience in research or development of television or microwave receivers, the other with equivalent experience on microwave antennas and/or systems.

Two Applied Physicists—M S or Ph D Degrees, one with at least 3 years experience in Electronics and/or Instrument Design, the other with equivalent experience as an experimental physicist with high vacuum experience.

Two Mathematicians—M S or Ph D Degree with five years experience in Research and Development Problems.

P-261, Electronics
520 North Michigan Ave., Chicago 11, Ill.

WANTED
ELECTRONIC MANUFACTURERS' SALES REPRESENTATIVES

Manufacturer of Industrial Electronic equipment including motor control, desires additional sales representation in industrial areas.

Applicants should be acquainted with Electronic circuits and will first spend considerable time at factory to study equipment.

RW-259, Electronics
520 North Michigan Ave., Chicago 11, Ill.

SALES ENGINEERS
Wanted
by large radio parts manufacturer

Will be trained for territorial office managementships. Good appearance, pleasant personality and desire to learn overall sales and business management are essential, but none need apply who lack the prime requisite of practical broadcast receiver design engineering experience. In reply give historical background, nationality and salary requirement.

SW-131, Electronics
330 West 42nd St., New York 18, N. Y.

ATTENTION ENGINEERS

Experienced engineers with Bachelor's, Master's or Doctor's degrees in Electrical Engineering, Communications, Radio, Physics, Mathematics. At least two years experience in design and development of radar and television systems, electronic navigational systems, automatic computers, servo-mechanisms, etc., required.

Specialists in High Frequency transmitters, receivers, antennas, aircraft electronic components particularly desired.

Starting salary commensurate with experience. Exceptional opportunity for the right men.

Write

McDONNELL AIRCRAFT CORPORATION
Lambert-St. Louis Municipal Airport,
BOX 516 ST. LOUIS (21) MISSOURI

New England
SALES REPRESENTATIVE

Desires connection with high quality manufacturers in electronic fields.

Long experience in all phases of electronics.

MORRILL P. MIMS COMPANY
M. P. Mims, W5BDB/1
43 Leon St. Boston 15, Mass.

Pacific Northwest
Manufacturers' Representative:

Want to represent national lines electronic and electric equipment. Excellent contact with industrial trade, jobbers and marine outlets with service organization for lines represented.

RA-258, Electronics
68 Post Street, San Francisco 4, Cal.

NATIONAL DISTRIBUTION AVAILABLE

For Manufacturers who make products suitable for sale to Radio, Electrical, Electronic Jobbers and Industrials. We have a complete sales staff for national and export distribution. Reply with samples or description of product.

RA-228, Electronics
330 West 42nd St., New York 18, N. Y.

Electronic Engineering Service

Research Design Development
in ELECTRONICS
and APPLIED PHYSICS
for industry and laboratory

SUBMIT YOUR PROBLEMS

SENTINEL LABORATORIES
1019-23 Appletree St. Philadelphia 7, Pa.

INSTRUMENTS

Complete repair, rebuilding services on panel, switchboard, portable indicating meters.

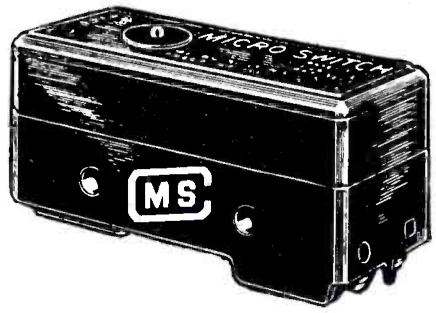
Take advantage of these services by a company equipped to turn out high quality work.

A competent staff and modern laboratory assure dependable and continuous performance.

Backed by 20 years' experience in the instrument field.

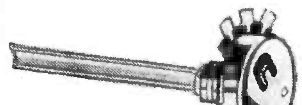
PRECISION ELECTRICAL INSTRUMENT CO.
146 Grand Street New York 13, N. Y.

Selected Government Parts from Wells' Vast Stock!



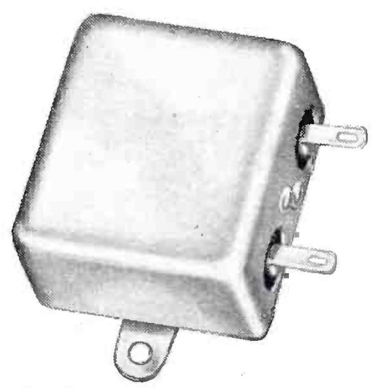
MICRO SWITCHES

We can make immediate delivery of a wide variety of Micro-Switches, G.E. Switchettes, Acro, C-H and MU. Prices are well below the market. List upon request.



VOLUME CONTROLS

Send us your requirements on volume controls. Our stock consists of the most popular makes in values from 100 ohms to 5 megohms. New list ready.



BATHTUB CONDENSERS

All famous makes of oil-filled bathtub condensers are represented in our huge stock. Single and dual types range from .05 to 4 Mfd. at working voltages from 200 to 600. Write or wire for list.

All material is guaranteed to be of top quality and our prices always represent definite savings. Our engineering staff is qualified to suggest substitutions if necessary.

4717-U West Madison Street
Chicago 44, Illinois

WELLS SALES, INC.

HAZELTON INSTRUMENT CO.
Electric Meter Laboratory
Electrical instruments, Tube Checkers and Analyzers repaired
War surplus meters converted for civilian use.
140 Liberty St., New York, N. Y.
Tel. BArclay 7-4239

SLIDE RULE SHORT CUTS

Positive Location of the Decimal Point. EASIER AC and DC calculations QUICKER
6 x 9 inches; decorative cover; 12-pt. type.
Second Edition—$1.50 postpaid

W. P. MILLER
536 "F" Street, San Diego 1, California

Will Buy or Trade
Any Size
PLAIN ENAMEL
MAGNET WIRE

NEW ENGLAND TRANSFORMER CORP.
47 McGrath Highway Somerville 43, Mass.

WANTED

To purchase or license patents on patentable ideas on Transformers.

Particularly interested in ideas pertaining to Transformers and reactors for use with fluorescent lamps.

Advance Transformer Company
1122 W. Catalpa Avenue
Chicago 40, Illinois

METERS
AND INSTRUMENTS

VOLTMETERS	BRIDGES (Wheatstone)
AMMETERS	MEGOHMMETERS
MICRO AMMETERS	RHEOSTATS
OHMMETERS	VARIABLE TRANSFORMERS
FREQ. METERS	RELAYS

ELECTRO-TECH Equipment Co.
119 Lafayette St., New York 13, N. Y.

FOR SALE

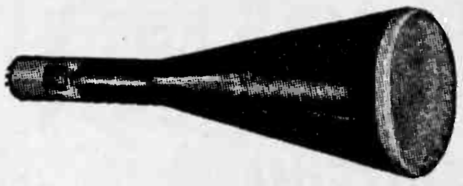
10—7½ KVA Air Cooled, Completely enclosed Transformers; primary 220/440 Volts, 60 cycles, 3 phase (12 terminals); secondary 3240/5600 Y volts with taps at 2440/4230 Y volts (7 terminals including neutral). *Dielectric test* — 2000 volts from primary to ground. 16000 volts minimum from secondary to primary and secondary to ground.

Brand new, immediately available, attractively priced.

MARCUS TRANSFORMER CO., INC.
32-34 Montgomery Street
Hillside 5, New Jersey

NEW CATHODE RAY TUBES

Made by North American Philips



Tube	Type Approx. List	Your Cost
3BP1	15.00	3.95
3FP7	27.00	3.35
5BP1	20.00	4.95
5BP4	27.00	5.95
5CP1	45.00	4.95
5CP7	48.00	6.00
5FP7	32.00	4.25
5JP2	48.00	13.50
HI POWER XMTR TUBES		
837	2.80	1.50
872A	7.50	3.50
705A	22.50	7.50
241B-WE	85.00	50.00
861	155.00	95.00

OHMITE WIRE WOUND RHEOSTATS

Model H 250 Ohms 25 Watt	.98
Model H 125 Ohms 25 Watt	.98
Model J 1800 Ohms 50 Watt	1.25
Model K 3000 Ohms 100 Watt	1.98
Model L 250 Ohms 150 Watt	2.25
Model L 100 Ohms 150 Watt	2.25
Model N 22 Ohms 300 Watt	3.00
Model P 1200 Ohms 225 Watt	2.75

Other ratings in stock in ohmite, Clarostate and Dejar. Inquire—

A. C. RELAYS

DPDT 10a contacts. 115v/60 cps. coil Allied	$1.79
SPST 5a, ac: 115v cont. 115v/60 cps.	1.49
SPDT contacts; 5a coil rated 115v/60c	1.39
DPDT 115v/60c. cont. rating 5a @ 50v	1.69
DPST Telephone type; 2p, 1 cl; 1 open; cont. rating, .5a @ 50v, coil rating 3.5 ma (@ 12K ohms) 1000 vac	1.05
DPDT Steatite Insulated 10A Silvered Contacts. Made by Leach	1.95

SPECIAL ITEMS

Visors for 5 inch 'scopes	$.75
Broadcast band Push-button tuning units inductive, capacitive types	2.98
Swinging choke: 2.5Hy @ 375 ma; 10 hy @ 75 ma	@ 3.95
Mallory 500 mf @ 200 vdc in Bakelite case	1.95
Cardwell Split-Stator type PK-200-QD. 200-30 mmf per section. Special Hi-Volt with .2" spacing	9.95
Johnson type 500D35. 500-35 mmf. .08" spacing. (Listed at 11.75)	4.75
Antenna loading coil, Heavy duty with six (6) variable taps. 6¾" x 4¾" dia.	2.95
Band generator type GN-45B. Output: 6v-3a/500v-.14a rated speed 60 cps.	5.95
Matched pair precision resistors 6.33 megs.	1.50

POWER SUPPLY for LM-18 freq. meter. Output: 290v @ 20 ma; 13v @ 600 ma. Input: 105-125v @ 60 cps; 260 ma; 27.6 W. with type 84 reectifier tube; shock mounted. Complete with input and output plugs..$14.75

HI-VOLT plate transformer, made by Amertran 115v-60 cycle input. Secondary is 6200v-ct-700 m.a. $39.95

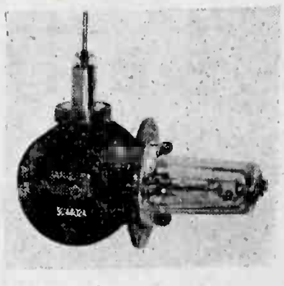
6 HY. 700 M.A. CHOKE............$7.95

All merchandise guaranteed. Mail orders promptly filled. All prices F.O.B. New York City. Send Money Order or Check. Shipping charges sent C.O.D.

SEND FOR FLYER

COMMUNICATIONS EQUIPMENT CO.
131E Liberty St., New York 7, N. Y.
Telephone WH 4-7658

MICRO WAVE —EQUIPMENT



MAGNETRONS!! Westinghouse type 2J32 (JAN.) just released. This is the first large lot of MAGNETRONS to flow into the civilian market! The 2J32 is designed for 10 cm. operation. Rated at 300 kw peak pulse power. Complete information supplied. Brand new, packed in individual protective cartons. The 2J32 is listed at $200. OUR PRICE.............$25.50

3J31 1 CM MAGNETRONS just received. OUR PRICE $20.00

KLYSTRON oscillator tubes. 2K25/723-ab. designed for 3 cm. operation. New. Packed individually. Listed at $38.00. OUR PRICE $7.75

30 MC I.F. AMPLIFIER with 2-6AC7's. Uses 723 a/b. 3 CM wave guide input. 21 IN XTAL Detector with 6AC7 Tubes.................$10.00

Thermistor Beads, for use with UHF and Micro-Wave Equipment, list @ $3.00; in separate sealed containers D-170396 .... @ .95 each

3 CM WAVE GUIDE SECTIONS

1 B24 T-R tubes for 1 Cm. Unit in stock.

Silver Plated Directional Couplers with a 20 DB drop with:

A. Straight Wave Guide section 6" long...	@ $3.95
B. 15° bend in wave guide 15"	@ 5.90
C. 30° bend in wave guide 10" long	@ 4.75
D. 90° bend in wave guide 15" long also 90° bend in coupler	@ 6.50
A. Six inch section silver plated wave guide with 90° twist	@ 2.95
B. 2½ foot silver plated with 90° bend (2" radius)	@ 5.50
C. 150° bend, with 90° twist 3¼" radius with pressurizing nipple and coax coupler	@ 3.95

All merchandise guaranteed. Mail orders promptly filled. All prices F.O.B. New York City. Send Money Order of Check. Shipping charges sent C.O.D.

COMMUNICATIONS EQUIPMENT CO.
131 E. Liberty St., New York City 7, N. Y.
Send for Flyer Tel. WH 4-7658

REMLER
Agent for

WAR ASSETS ADMINISTRATION

(Under Contract No. 59A-3-48)

. . . to handles and sells a wide variety of

ELECTRONIC EQUIPMENT

released for civilian use

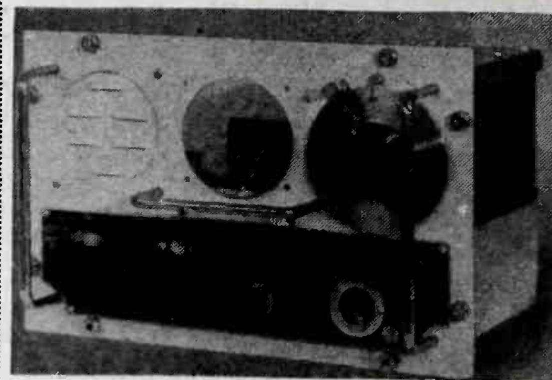
Write for Bulletin Z-1A

REMLER COMPANY LTD.
2117 Bryant St. San Francisco 10, Calif.

REMLER
Since 1918

Pioneers in Electronics and Plastics

New Incomplete
Navy Oax Sonar Units



Each unit consists of the following:

1—4" Jensen PM4S Speaker

1—Power Transformer, 115 volt 60 cycle input, output 315-O-315 volts at 70 MA, 6.3 volts center tapped at 3.5 ampere, 5 volt at 3 ampere

1—Single variable condenser, 312 MMF with clock wise increase characteristics

1—Input Transformer

1—Output Transformer

1—Crowe 4" Dial

1—National Vernier Drive

1—IRC Attenuator, 100,000 impedance 3 DB per step to 57 DB, Type B-31P

9—Octal Sockets

2—2" Skirted knobs

1—DPST Toggel Switch

1—3 deck, 2 pole, 5 position each wafer switch.

1—Fuse post

The unit was designed to use 1,6SJ7; 1,6SN76T; 1,6U66T; 1-5Y36T; 1,UR-150/30

NO TUBES SUPPLIED WITH UNIT

Has a large quantity of assorted resistors, mica condensers, bathtub condensers, potentiometer, connectors, etc.

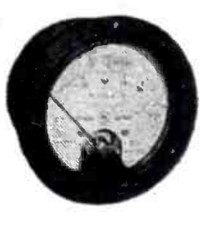
Priced at
ONLY $7.50 F.O.B., N. Y. C.

MARITIME SWITCHBOARD
336 Canal Street New York 13, N. Y.

SURPLUS NEW METERS

D. C. METERS
MICROAMMETERS, GALVONOMETERS

McClintock, 3½" square, 0-50 ua mvt., spec. scale $4.50
Gruen, 2½", 0-100 ua mvt., Black scale with markings —8 to +6 DBM and 0-100, 2000 ohms resist. $3.50
Weston, 506, 2½", 0-150 microamp Black scale $3.95
Marion, 2½", 200 microamp undamped mvt., spec. sc. $3.50
Marion, 3½", 0-200 ua 68 ohms resistance, undamped mvt. $4.95



G. E., DO-41, 3½", 200 MICROAMP Mvt., SPEC. SC. KNIFE EDGE POINTER, COMP. WITH PAPER V-O-M.A. SCALE $6.00

W.E., 3½", concentric style, 0-200 microamp $4.00
G.E., DO-41, 3½", 0-500 microamp mvt. scale 20 K.V., comp with paper V-O-M-A. scale $4.95
G.E., DW-55, 2½", 0-500 microamp scale 0-10 .... $3.95
Simpson, 125, 2½", 0-500 microamp scale 0-15, 0-600 volts $3.50

D. C. MILLIAMMETERS

W.H., RX-35, 3½" square, 0-1 M.A., 55 ohms, internal resistance, complete with paper V-O-M.A. scale. $4.95
G.E., DW-41, 2½", 1 M.A. $3.95
G.E., DO-40, 3" ring mtd, 2.5-0-2.5 & 25-0-25 M.A., dual range, zero center $1.95
Gruen, 2½", 3 M.A. movement scale 0-30, 450 & 300 volts M.A. $2.00
Simpson 25, 3½", 5 M.A. movement Zero Right Scale—6 to 100 caption "DB" above 1 Microvolt. $3.00
Simpson 26, 3½", 0-15 M.A. $4.50
G.E., DO-53, 3½" square, 20 M.A. . $4.95
Simpson 3½", 0-200 M.A. $4.50
Marion, 3½", 0-200 M.A. $3.00
Burlington, 3½", 0-200 M.A. $2.75
DeJur Amsco, 3½", 0-100 M.A. $3.00
Weston 3½", 0-1000 M.A. $4.50

D.C. VOLTMETERS & KILOVOLT METERS

G.E., DW-41, 2½", 15 VOLT BLACKSCALE, 15 MARKINGS, NO CAPTION . . $2.50

W.H., SX-33, 2½", Sur. Mtd., 3-03 V, 200 r/v $1.25
Western Electric, 3½", Concentric Style, 0-75 volt D.C., 1000 r/v . . $3.00
Gruen, 2½", 150 volt $3.50
W.H., NX-35, 3½", 0-200 V, 1000 r/v $5.50
W.H., NX-35, 3½", 0-200 V, 1000 r/v mtd on 45 degree metal angle panel $6.00
W.E., 3½", 500 volt, 1000 r/v Concentric Style $5.00
Weston 301, 3½", 0-4 KV with ext prec resist $7.95
W.H., NX-35, 3½", 15 K.V. comp. with 1000 r/v ext prec resist L.P. $160.00
Your Cost $16.00
W.H., NX-35, 3½", 20 K.V. comp with 100 r/v ext prec resist L.P. $210.00
Your cost $21.00

D.C. AMMETERS

Triplett, 3½", 0-15 amp $4.00
Weston 506, 2½", 200 amp. with ext shunt $9.50
G.E., DO-41, 3½", 200 amp. with ext shunt $12.50

RADIO FREQUENCY AMMETERS

Weston 425, 3½", 0-500 M.A. R.F. . $7.50
G.E., DW-44, 2½", 0-1 A.R.F.. Black scale $3.50
Weston 425, 3½", 0-1 Amp R.F. ... $7.50
G.E., DO-44, 3½", 1.5 Amp $6.50
Weston 507, 2½", 0-1.5 A.R.F. Black scale, Metal case $2.95
Weston 507, 2½", 3 Amp bk sc. ... $3.50
Simpson 2½", 3 Amp, expanded at lower part of scale $3.50
Weston 640, 4½", Surf Mtd, 0-3 A.R.F. $9.50

A.C. VOLTMETERS

G.E., AW-42, 2½", 0-10 V.A.C. ... $3.95
G.E., AO-22, 3½", 1000 cycle, 50 volts, mtd on metal angle bracket with 6' Tyrex leads & clips $2.50
G.E., AO-22, 3½", 150 volt $5.50
G.E., AO-22, 3½", 0-150 V.A.C. black scale $3.50
W.H., NA-35, 3½", 150 volt $5.50
Triplett 332, JP, 3½", 0-150 V.A.C. metal case $4.50
Triplett 232, 2½", 250 volt $4.95

A.C. AMMETERS

W.H., NA-35, 3½", 0-50 amp. A.C. $4.50
Simpson, ½" square case 60 amp S.C. $3.50
Triplett, 3½", 0-75 Amps A.C. $3.50
G.E., AO-22, 3½", 80 Amp S.C. $3.50

AIRCRAFT METERS

G.E., 2½", Aircraft type, 0-30 Amps. D.C. black scale, luminous mkgs with internal shunt $1.50
G.E., 2½", Aircraft type, 0-60 Amps. D.C. black scale, luminous mkgs with external shunt $2.25
G.E., 2½", Aircraft type, 0-60 Amps & 0-30 Volts D.C. black scale, luminous mkgs with external shunt. $3.00
G.E., 2½", Aircraft type, 0-120 Amps D.C. black scale, luminous mkgs with external shunt $2.75
W.H., 2½", Aircraft type, 0-30 volt D.C. bk. sc. lum mkgs, 5 M.A. movement 6000 ohm resist $1.25
W.H., 2½", Aircraft type, 0-150 volt A.C. bk sc lum mkgs, suitable for use from 25 to 125 cycles $1.50

PORTABLE A.C. AMMETERS
Surplus New
WESTON MODEL 528

DUAL RANGE 0-3 Amp. and 0-15 Amp. full scale for use on any frequency from 25 to 500 cycles. The ideal instrument for all commercial, industrial, experimental, home, radio, motor and general repair shop testing. Comes complete with a genuine leather, plushlined carrying case and a pair of test leads. A very convenient pocket sized test meter priced at less than 50% of manufacturers list. Your cost ONLY . $12.50

SPECIAL METERS

Weston 301, Power Level Indicator, 625 Microamp 1.2 volt A.C. mvt, self cont rect, blank sc $6.00
Weston 301, 3½", 0-150 V.A.C. Rectifier Type, 1000 r/v A.C. ... $6.50
Weston 705, Sensitrol relay 100 microamp, Solenoid reset, S.P. norm closed $7.50
G.E.., miniature, 1½" square, 1 M.A. 100 ohm mvt, 10 divis sc, bk sc. . $2.75
G.E., DW-46, 2½" DB-10+5, 6 M.W. 600 ohms zero DB=1.90 volts $4.50
G.E., Totalizing hour meter, 3½" 5 Digits, 99,999 hrs. 115 volt 60 cycle $4.95
J.B.T., 3½", Frequency Meter, 58-62 cycle, 5 reed $4.00
J.B.T., Type 33FP Portable Frequency Meter, 380-420 cycles, 100-130 volts, 9 vibrating reeds, complete with leather case & test leads. $9.00
Marion, 2½", ring mtd "S" meter made for National Co. 1 M.A. mvt scale "1-9 S units 0-40 D.B. above S 9" $3.50
Roller Smith, miniature, 1½" sq 1.37 M.A. mvt, spec bk sc $2.50
Roller Smith, miniature, 1½" sq 2 M.A. mvt, with 2' lead & plug jack 0-10 div sc $2.50

PRECISION RESISTORS

±1% Accuracy-Wire-Wound-1 M. A., Weston, G.E., 1 R C on Sprague

1.0 Meg 1 KV $1.50
1.5 Meg 1.5 KV $2.00
2.5 Meg 2.5 KV $2.50
5.0 Meg 5.0 KV $5.00
20.0 Meg 20.0 KV $16.50

All meters are white scale in round, flush, bakelite cases, unless specified otherwise.
Add sufficient money on parcel post orders, excess will be refunded.

MARITIME SWITCHBOARD • **Worth. 4-8217. 336 Canal St., N. Y. 13, N. Y.**

"TAB"

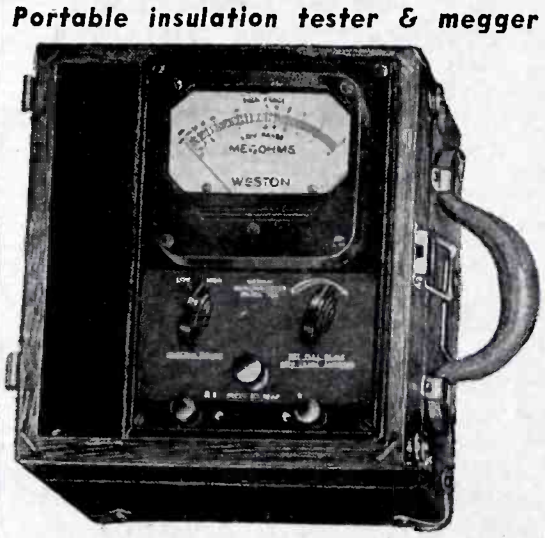
That's A Buy

NEW GUARANTEED PARTS

SOLA constant V transf 95 to 125V-250VA/60 cy ($52) $19.00
Buss & Littlefuses 3AG/250ma(LP25c) 48 for.. 1.00
WE 200 microamps 3½" Rd Bkl case (21)..... 4.95
SIMPSON one ma 3½" Rd Bkl case.......... 3.95
WESTGHSE AN IND DUAL 200 microamp MTR ($70).................... 4.50
WESTON—GE—10 plus 6DB 500/600 ohmL... 3.95
WESTON 476 Sq 3" B'Case 15VAC ($10)...... 4.25
WESTON 506 Rd 2½" B'Case 250ma ($8.50)... 3.00
WESTON—GE or eq. 0-1 ma 2½" meter ($10) 2.95
GE One ma/100ohms DNI Miniature 1½" mtr.. 2.95
GE 2.5 & 25 ma zero ctr Galvo DO40 B'Case.. 3.95
WSTGHSE Six digit elapsed Time Indicator NH35 .... 4.95
GE-DW41-2½" B'C 2000V/1000 ohms V & Multiplier ....$ 8.95
GE-WD44-2½" B'C one Amp RF meter........ 3.95
Friez Barometric 14000 ohm Var resist #AS500045 .... .97
Transformer 500 ohm line to Voice Coil 6 ohms 1.40
Transf Line to Line 500, 333, 250, 200, 125, 50 ohms ± 1DB.................... 1.95
Condsr 0.5 mfd/600WVDC Bathtub 5 for..... 1.00
Condsr 10mfd/600WVDC (2/2.5mfd&5mfd) 2 for 2.50
Condrs 20mfd/600WVDC (1-2-3-4-5-8mfd) 2 for 5.00
Condsr 3mfd/330VAC/1000WVDC; 2 for..... 2.50
Condsr 2mfd/2000WVDC W&CD: 2 for 4.25
Condsr 3mfd/3000WVDC 2 for 5.00
Condsr 15mfd/330VAC/1000WVDC GE/PYR.. 2.95
Condsr 30mfd/660VAC (2 or 3 units) 8.10
Condsr 2mfd/5500WVDC WSTGHSE.......... 10.00
Condsr 0.5mfd/1500WVDC/TLA upright 2 for.. 1.15
Condsr oil 2mfd/600WVDC TLA 2 for........ .79
Condsr oil 2mfd/12500WVDC WSTGHSE 25.00
Condsr oil 1mfd/25000WVDC WSTGHSE 75.00
Collins 6Hy/1.2amp/12500Vwkg Cased CHT... 16.00
Socket CINCH Disheptal ($5.90) mica B..... .49

WESTON MODEL 796

Portable insulation tester & megger



New NAVY termination. Tests insulation & resistance up to 200 megohms, test potential 350 to 500 VDC. Resistance 0-20-200 megohms .5 & 5 megohms center scale. 4" sq. 50 micromampmtr less batteries, test leads & carrying case (LP$100) $16.95 with carrying case $24.75: Parts for 500 V-AC supply $9.

WE 16mfd/400WVDC oil 2 for....................$ 2.35
16 ft. Ext cord hvy duty SJ Male & Fem plugs 1.00
Millen 12515 Condsr Var 150mfd/3000V & W.L. Resis. plaque N.I.................... 1.95
Dynamic mike & Transf complete new........ 1.95
IRC WW 100000ohm/40watt .65 ea, 2 for...... 1.00
WE Crystals 1N22, 23, 26 four 1.50
RCA 808 new S.C. (L.P.7.75) 2 for 5.00
829B/3E29 new gtd & socket.................. 4.50
872A new gtd & sockets 2 for 5.75
GE 446A/2C40 RCA Lighthouse tube ($11).... 6.95
6AK5 JAN new (LP$4), 1.25, 2 for........... 2.00
TBY Vibrapack & storage battery new 9.95
Condsr kit qty silver mica; 50 for 2.00
Condsr kit 100 BT½ & 1W; 50 to 2 meg...... 2.50
Control Kit type ABJ; 50 to 2 meg: 10 for..... 2.50
Kurman 1000kc Hummer op 6-8V ($9) .... .97
Collins transformer mfged Chicago Transf Co. Pri 56/60 cy. 105, 110, 115, 120, 125V inpt; Sec. 1100 VCT/212ma cased & Two 10hy/250ma/100ohm GE chokes & Two 3mfd/330VAC 1000VDC Pyranol condsrs Gt'd new worth $40 ....$9.50
Same but primary 115V&230V50/60 cy........$10.50
115V/60 cy pri; 2.50V/1.75A 6.5V/8A, 5V/3A, 6.5V /.6 & RK60 ....$4.50
RAYTHEON cased 840VCT/110ma, 530VCT/21ma, 5V/3A, 5V/3A, 6.3V/1A, 6.3V/6A, 115V/60 cy pri & Two 10hy 110ma hermet' cased chokes & oil condsr. 2/2.5mfd & 5mfd $5.95
Cased Hermatically sealed transformer pri 50/800 cys-105/125 & 80V Sec 1000VCT & 300/110ma. 6.3V/4.5V, 5/3A, 6.3V/.65A, 6.3V/.65, 6.3/1.25-A & two cased H'sealed 10hy./110ma Chokes & two condsr. 3mfd/330VAC/1000VDC Pyranol..$7.95
Thermador cased SC Rated cont. 3800VCT/6KW/2.7 Amps Primary 200, 210, 220, 230, 240, 440, 50/60 cys ($365) $45.00
GE line trans. 200V/50/60cys. sec 117/112/103/93 V-7 Amp $20.00

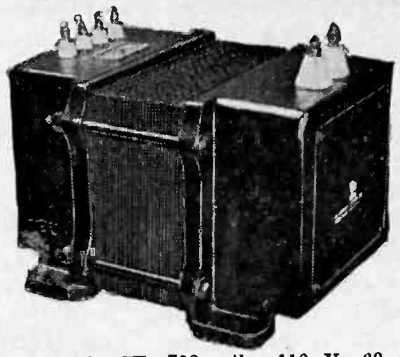
$2 Min. order FOB N.Y.C. Add Postage all orders and 25% deposit. WHitehall 3-3557. Send for catalog 300. Specialists in International Export, School, College & Industrial trade. Money Back Guarantee.

"TAB," Dept. E 12
SIX CHURCH STREET NEW YORK 6, N. Y.

SPECIAL BUY IN

TRANSFORMERS

PLATE TRANSFORMER



Value **$150**

SPECIAL **$39.95**

Immediate Delivery

6200 Volt CT—700 mils, 110 V. 60 Cy. tapped primary 2 KVA Amertran, size 11"x14"x10". Weight 150 lbs. Freight prepaid to any part of the Continental U.S.A.
We also carry a complete line of electronic and communication equipment. Send money order or check. Write for our latest bulletin I B.

Write or Wire to
NIAGARA RADIO SUPPLY CORP.
160 Greenwich St., New York, N. Y.
BOwlingreen 9-7993

Available Immediately

NOT WAR SURPLUS

3 gang Variable Condensers—
Radio Condenser Co.

AM Section—Total Capacity—378 mmf.
Minimum Capacity—10.8 mmf.

RM Section—Total Capacity—25 mmf.
Minimum Capacity—7.8 mmf.

Quantity 2880—$2.50 each

Type 7AG7 Tubes—Sylvania
Quantity 9600—$0.57 plus tax

Loctal Sockets—Amphenol 88-8XT
Quantity 14,900—$0.05 each

BROWNING LABORATORIES, INC.
WINCHESTER, MASS.

AVAILABLE IMMEDIATELY

1—20 kw Westinghouse High Frequency Heating Equipment (R. F. Generator). Standard design. Power supply unit identical to that used in Dielectric Heating, Radio Broadcast, Induction Heating. Practically new equipment—used very little. For complete details write—F. V. Drake, Purchasing Agent.

COLUMBIAN ROPE COMPANY
Genesee Street Auburn, New York

TEST EQUIPMENT FOR SALE

Standard Instrument Incremental Bridges Model #500. For measuring iron core inductances from 1 to 500 volts at 400 cycles. Calibrated from .05 to 100 henries D.C. load current variable from 0 to 500 ma DC. Complete with instructions—At sacrifice price.

GENERAL TRANSFORMER CORPORATION
1250 West Van Buren St. Chicago 7, Ill.
Chesapeake—3500

BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., Inc.
65-67 East 8th St. New York, N. Y.

SURPLUS EQUIPMENT SALE

Ferris model 18B microvolter, 20-150 megacycles, in good order......$125.00
RCA beat frequency audio oscillator, 30-15000 cps, in good order.. $40.00
Measurements model 78B, R.F., Signal generator, 2 bands, good working order $45.00
3" Radar indicator scope, ID-93/APG-13A complete with 3 BP1 and 9 tubes, black crackle finish case, new, 115V, 400 Cps........ $25.00
Radar receiver BC 1068, range 150-205 mc, 14 tubes, 115V, 60 cps... $35.00
Radar receiver BC 406, 205 mc, 15 tubes, 115V, 60 cps $25.00
GE pyranol capacitors:

1 mfd,	15000	WVDC	$25.00
2 mfd,	4000	"	5.00
.15 mfd,	4000	"	1.50
.05 mfd,	2500	"	.75

Button silver micas, 50, 400, 500 micro-microfarad, 500 V, dc...10¢ each
IN 23 B diode crystals...........70¢ each

ELECTRO-IMPULSE LABS.
SHREWSBURY, NEW JERSEY

SPECIALS IN TUBES

IMMEDIATE DELIVERY

6AC7	8011
2x2	955
956	6B4G
5BP1	

Also large supply of other tubes.
All tubes new and individually boxed—JAN
Available in large quantities, Prices upon request.

Write or Wire to
D & D SUPPLY COMPANY
254 E. 54th St. Brooklyn 3, N. Y.
Phone: Dickens 2-4385

Delivery vs. Delay

KNOWING where to find some specific material, part or instrument may be the difference between DELIVERY and DELAY. If the advertisements in this issue do not cover your requirements, write

ELECTRONICS


Micro-Wave Equipment
CAPACITORS
HIGH VOLTAGE
TRANSFORMERS
2 KVA and 6 KVA Step Up-Step Down Transformers
All 50/60 Cycles. 2 KVA: 2 to 1 ratio. Step-Up—115 to 230 Volts or 230 to 460 Volts. Step-Down—460 to 230 Volts or 230 to 115 Volts.
Weight—96 lbs.
Ea. $28.00
6 KVA: 2 to 1 or 4 to 1 ratio. Step-Up—125/115 to 230 or 460 Volts. Step-Down—460 or 230 Volts to 125/115 Volts.
Weight—225 lbs.
Ea. $68.00
Ten and Over $65.00
W. E. Inerteen or GE Type 26F
W. E. INERTEEN or G.E. Type 26F681. 1 Mfd. — 7500 vdc. 1 to 49—
ea. $5.60
Lots of 50 or more—
ea. $4.90
W. E. INERTEEN 2 Mfd. — 5500 vdc. 1 to 49
ea. $6.20
Lots of 50 or more—
ea. $5.80
ELDICO OF NEW YORK INC.
4431 Douglaston Pkwy
DOUGLASTON, L.I. N.Y.
Bayside 9-8686
CATALOG "M"
Our new catalogue is now being distributed.
Have you received yours?
A request on your letterhead will bring it to you.
Eldico INC. OF NEW YORK
44-31 DOUGLASTON PARKWAY Douglaston, N. Y.

INDEX TO ADVERTISERS

INDEX TO ADVERTISERS

SEARCHLIGHT SECTION

(Classified Advertising)

Index to electronics Volume XIX

January to December issues, inclusive, 1946

Cumulative Index (April 1930—December 1944) available at 75 cents

McGraw-Hill Publishing Company

330 West 42nd St., New York City, 18

• Illustrated

H

I

L

M

N

O

P

Q

* Illustrated

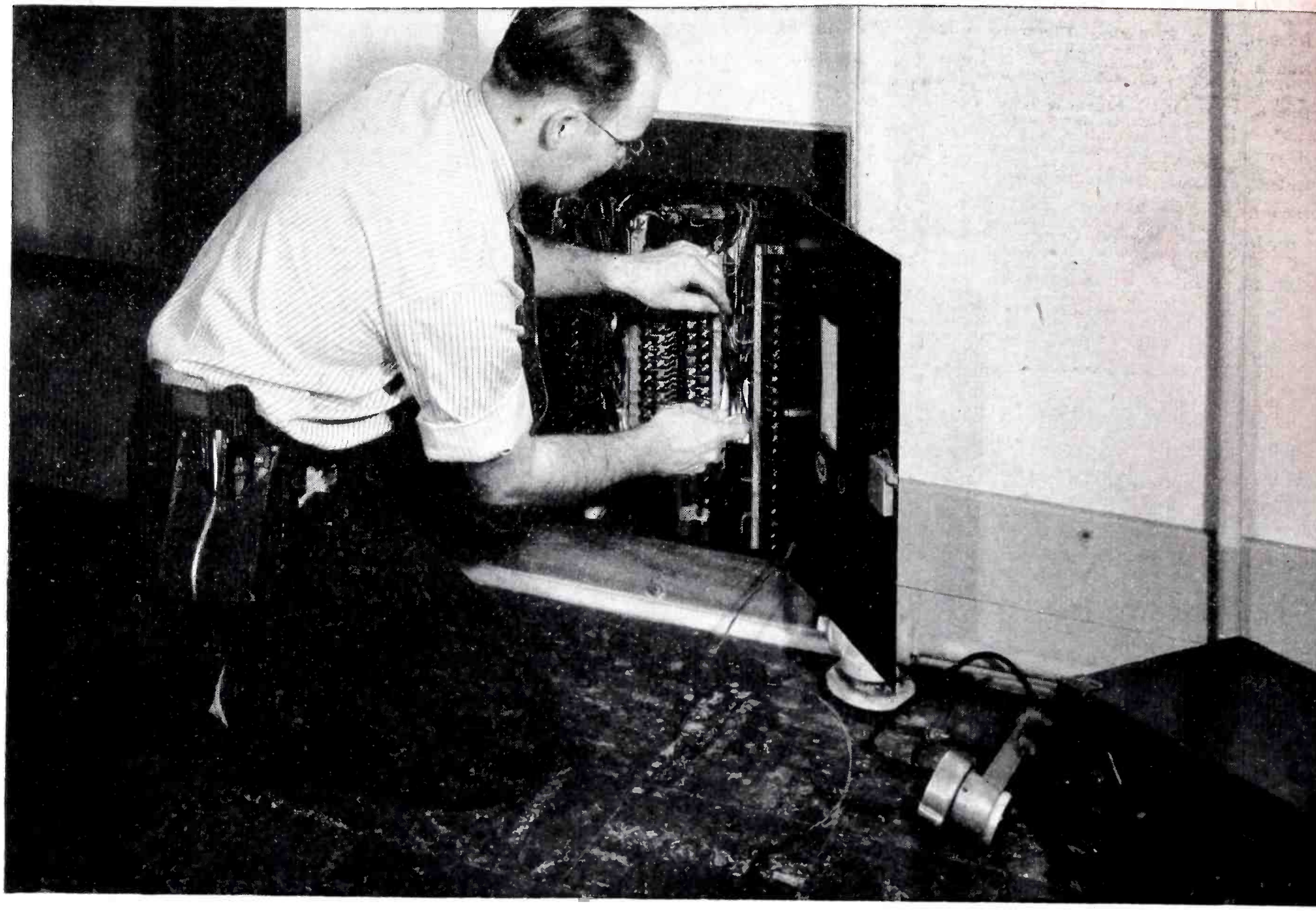
R

S

AUTHORS' INDEX

• Illustrated

• Illustrated



Station wire insulated with GEON makes hit with 'phone men

Some advantages apply to all types of manufacturing and construction

HERE are a few of the advantages of telephone station wire insulated with GEON: it strips fast, clean, easily; it's smooth, not sticky, easy to handle; the colors are clean and bright.

Then add the fact that the excellent electrical properties of insulation made from GEON permit a thinner coating. That means lighter weight, more conductors per conduit, or smaller holes to be drilled during construction.

In addition, insulation made from GEON is self-extinguishing—won't support flame. It resists most normally destructive agents such as ozone, oils, acids, air, aging, abrasion, water, and many others.

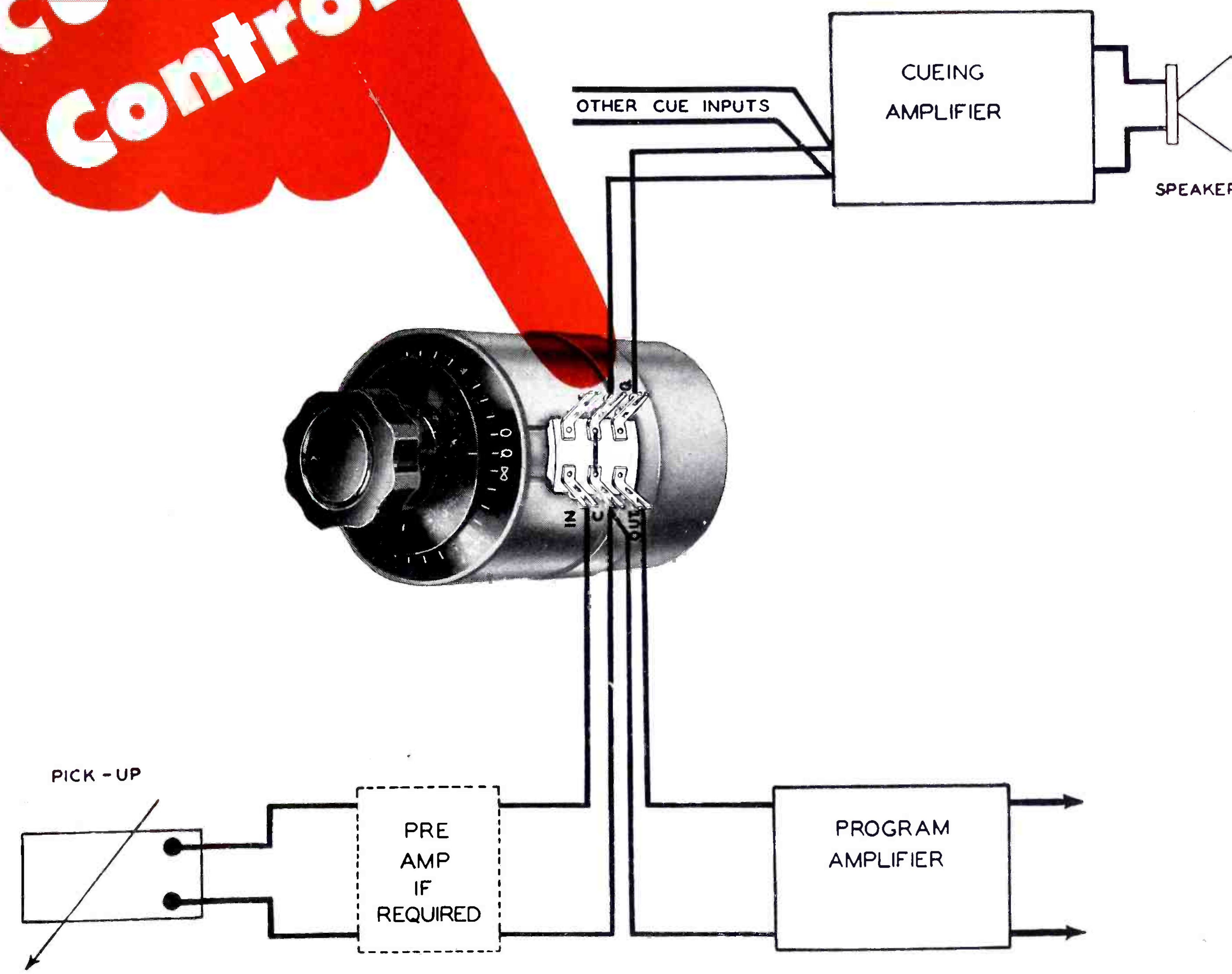
GEON's applications range from spaghetti for radio hookup wire to heavy insulation for buried service entrance cable. That's why we urge you to specify wire insulated with GEON the next time you order from your supplier. For information about special applications please write Dept. F-12, B. F. Goodrich Chemical Company, Rose Bldg., Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

Geon
Polyvinyl Materials

B. F. Goodrich Chemical Company A DIVISION OF THE B. F. GOODRICH COMPANY

Direct Cueing Control

without auxiliary switches



DAVEN ATTENUATORS *with Built-in cueing controls*

are now available . . .

DAVEN attenuators may now be obtained with a cueing control. Auxiliary switching mechanisms are no longer required to cue recordings, transcriptions and remote or network programs.

The control itself will serve to transfer the program material to a separate cueing amplifier. Provision is made at the extreme attenuation position for connecting the incoming signal to a cue circuit before "fading in" the signal. As a result, a program can be smoothly "brought in" at the right time without the operation of any additional switches. A lug on the terminal board is provided for connection to the cueing system.

The cueing feature may be supplied on any type of Daven attenuator. However, it is primarily recommended on those controls used for mixing, which are provided with a taper to infinity. For further details write to our Sales Department.

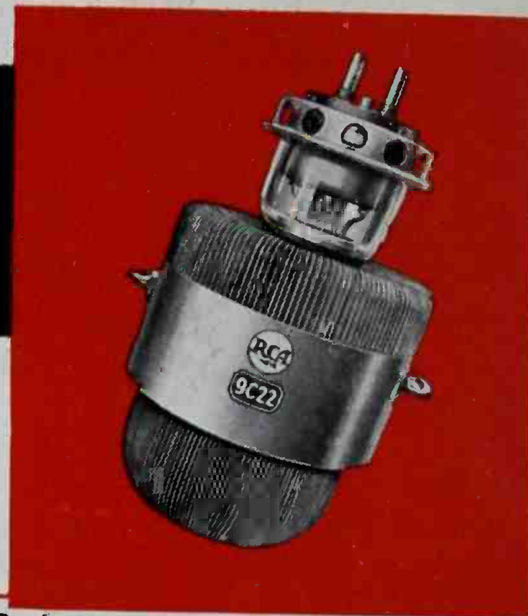
APPLICATIONS

- Broadcast Stations
- Recording Studios for Playback
- Wired Music Services
- Sound Film Industry
- Dubbing & Re-recording for Sound Effects

THE DAVEN CO.

191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

RCA PREFERRED TYPE POWER TUBES



QUICK-REFERENCE POWER-FREQUENCY TABLE

Type No.	Class	Maximum Input Power (Watts) CCS Unmodulated Class C Ratings at:											
		1.6 Mc.	7.5 Mc.	15 Mc.	25 Mc.	50 Mc.	75 Mc.	110 Mc.	150 Mc.	200 Mc.	250 Mc.	300 Mc.	600 Mc.
9C21	Triode	150000	150000	150000	105000								
9C22	Triode	100000	91000	80000	70000								
9C25	Triode	40000	40000	40000	40000	25000	25000	25000					
9C27	Triode	40000	40000	40000	40000	25000	25000	25000					
892	Triode	30000	22500	17000									
892R	Triode	18000	13500	10500									
889-A	Triode	16000	16000	16000	16000	16000	14000	11000	8000				
889R-A	Triode	16000	16000	16000	16000	13500	10000						
8D21*	Tetrode	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	
7C24	Triode	5000	5000	5000	5000	5000	5000	5000					
833-A	Triode	1800	1800	1800	1750	1500	1200						
6C24	Triode	1500	1500	1500	1500	1500	1500	1500	1500				
4-125A/4D21	Tetrode	500	500	500	500	500	500	500	500	425	335		
8000	Triode	500	500	500	500	400	300						
813	Beam Power	360	360	360	360	300							
8005	Triode	240	240	240	240	195							
828	Pentode	200	200	200	200	160	130						
811	Triode	155	155	155	155	155	125						
812	Triode	155	155	155	155	155	125						
826	Triode	125	125	125	125	125	125	125	125	125	125	100	
829-B*	Beam Power	120	120	120	120	120	120	120	120	120	105		
8025-A	Triode	75	75	75	75	75	75	75	75	75	75	75	75
815*	Beam Power	60	60	60	60	60	60	60	55	40			
807	Beam Power	60	60	60	60	60	50	40					
2E24†	Beam Power	40	40	40	40	40	40	40	33				
832-A*	Beam Power	36	36	36	36	36	36	36	36	36	32		
2E26	Beam Power	30	30	30	30	30	30	30	25				
802	Pentode	25	25	25	25	20	16						

*Twin type—input values per tube for push-pull operation.

†Recommended only for highly intermittent applications. Input values are ICAS ratings.

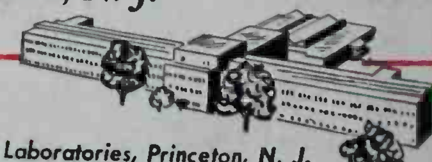
The accompanying table of ratings vs. operating frequency provides the design engineer with a simple and rapid means of choosing the most suitable RCA tubes to meet the power and frequency requirements of equipment in the design stages.

Technical Literature

Detailed data on all the types listed are provided in the RCA HB-3 TUBE HANDBOOK. Technical bulletins covering tube types in which you are interested will be sent on request.

Application Engineering Service

RCA tube application engineers will be pleased to cooperate with you in adapting these or any other RCA tube types to your equipment designs. Just write RCA, Commercial Engineering, Section D-6L, Harrison, N. J.



RCA Laboratories, Princeton, N. J.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA