electronics

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May • 1951

TESTING AIRBORNE MAGNETOMETERS . . . . CO
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May, 1951 — ELECTRONICS — Vol. 24, No. 5

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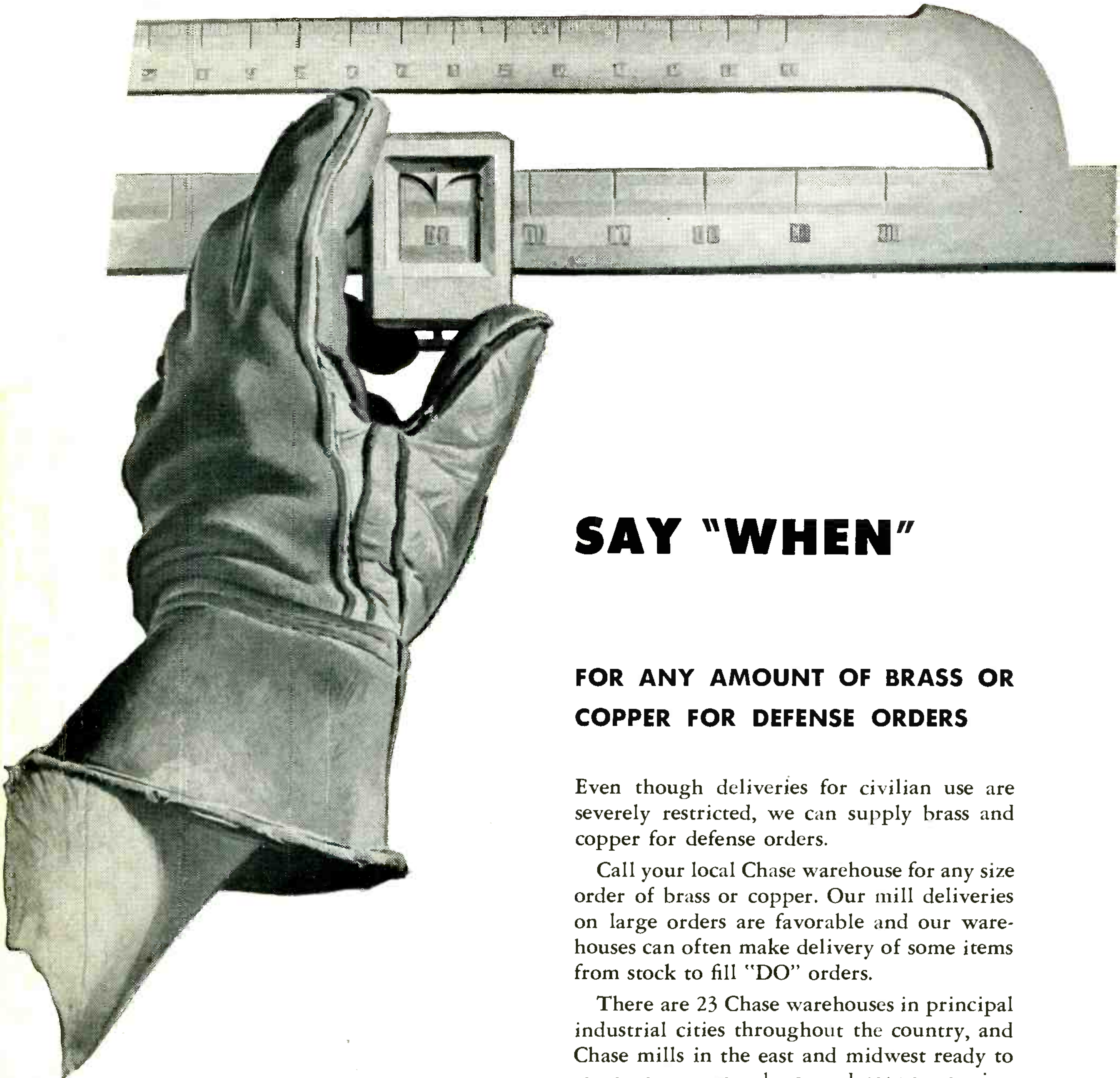

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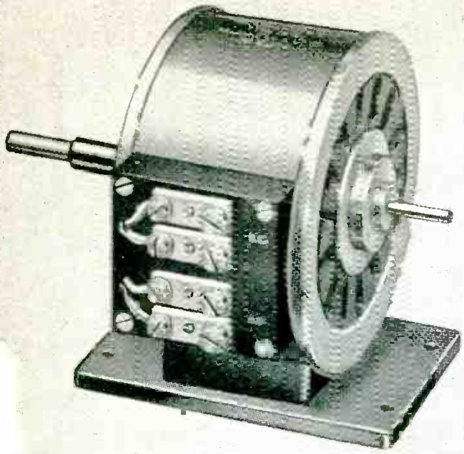
Phonic Motors and Timing Devices

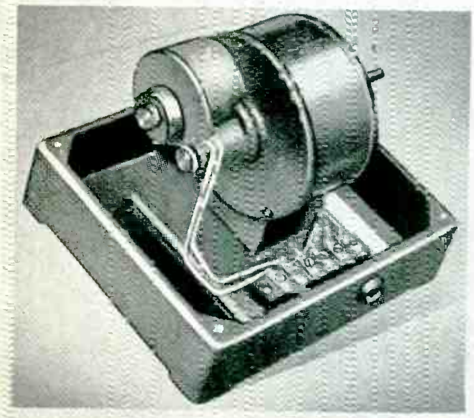


Designed for use at frequencies from 50 c/s - 2000 c/s. Phonic Motors of this type form the nucleus around which are built the timing devices illustrated on this page.

IN many branches of scientific work the need arises for a motor capable of a very high standard of constancy of speed. The frequency of the mains electricity supply is not normally controlled to better than one or two per cent., so that a mains-operated synchronous motor may be inadequate, and centrifugal governors, as used on gramophone motors, may not provide a sufficiently precise control. In such cases a phonic motor driven by an alternating current supply of high frequency stability may be employed. It is not perhaps generally realized that in their modern form such motors may be used to give quite a large torque, and are able to maintain synchronism despite the sudden imposition of relatively large inertia loads. Under steady-state conditions, "hunting" is almost entirely eliminated, and the constancy of rotational speed is almost entirely dependent on the frequency stability of the alternating current supply.

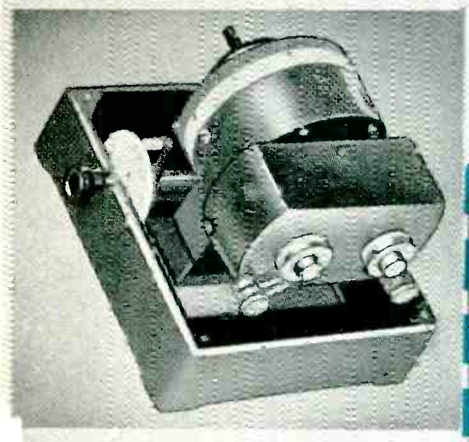
A precision quartz crystal controlled frequency of 100 kc/s may attain a frequency stability of the order of one part in 10^8. This frequency is then divided electronically to 1,000 c/s by means of regenerative dividers or locked multivibrators. In order to facilitate comparisons with time signals, or to use the frequency standard as a clock, it is necessary to derive a still lower frequency—preferably one cycle per second. Electronic division in the range 1,000 to 1 cycle per second, with high phase stability, is difficult, and the simplest and most reliable method is to drive a phonic motor from the 1,000 c/s source, and to fit mechanical contacts to suitably geared driven shafts. An added advantage is that by employing further gearing, more widely spaced signals may be obtained. Thus signals spaced at intervals of one sidereal second, or any other specified interval, may be obtained from an oscillator with a fundamental frequency of 100 kilocycles per mean time second. By means of a simple mechanical device, controlled changes in phase of the timing of the contacts are also possible.

MOTOR TORQUE



The Timing Device Type D-499-A provides an impulse of 1/10 second duration once every second when the motor is supplied with power at a frequency of 1000 c/s.

The Timing Device Type D-493-A provides an impulse of 1/10 second duration 61 times per minute and, in addition, an impulse of ½ second duration once per minute. A worm and wheel adjustment allows phasing correction.



Compactness

for resistors

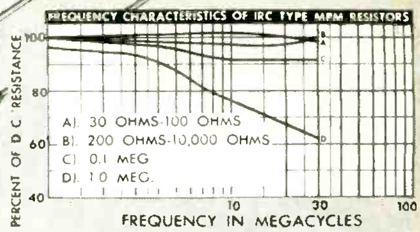
More and more components in less and less space! That's the manufacturer's dilemma as necessity shrinks the size of electrical and electronic instruments and equipment.

But compactness need not create bottlenecks —if you specify IRC *miniature resistors*. Years ago, we foresaw the trend to compactness and got ready for it. Now, with the widest line of resistor types in the industry, IRC can supply miniature components for almost any application.

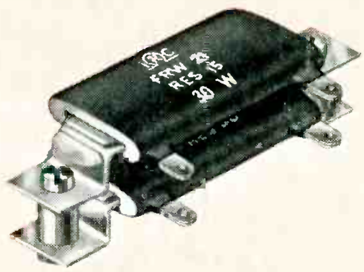
Only 15/16" in diameter, compact new IRC Type Q Controls adapt to a wide variety of small-space applications. Rugged construction features one-piece dual contactor of thin, high-stress alloy—simplified single-unit collector ring—molded voltage baffles—special brass element terminals that will not loosen or become noisy when bent or soldered. Salt-spray materials, when specified, protect against humidity; change in resistance is negligible even after long exposure. Noise level is low and Type Q Controls have unusual durability and efficiency. Coupon brings you full details in Catalog A-4.

is essential

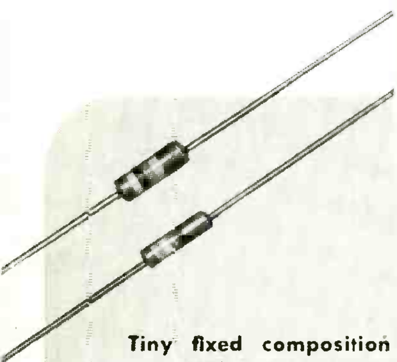
too!



Miniature MPM Resistors are ideally suited to high frequency receiver and similar applications. Frequency characteristics are outstanding, but absolute balance has been maintained with all other significant electrical characteristics. These are the same as in larger IRC Type MP Resistors. MPM's are constructed of solid steatite ceramic rods, to which a thin resistance film is permanently bonded. Changes due to humidity and aging are held to a minimum. Resistor body is 9/16'' long, and active resistance section only 3/8'' long. Send for complete information in Catalog F-1.



Higher space-power ratio than tubular wire wounds suits small, flat Type FRW fixed and adjustable wire wounds to voltage dropping applications in limited space. FRW's may be mounted vertically or horizontally, singly or in stacks. Non-magnetic mounting brackets extend through resistors—allow easy and economical mounting—aid in heat distribution along entire length—and transfer internal heat to chassis. Light-weight construction combines with exceptional mechanical strength and ability to withstand severe vibration. Bulletin C-1 gives full performance data.



Tiny fixed composition resistors—Types BTR and BTS—are only 13/32'' in body length. At 1/3 and 1/2 watts, respectively, these miniature units set new performance standards for fixed composition resistors. Advanced BT's easily meet the rigorous requirements of television—actually exceed JAN-R-11 Specifications! Balanced in every characteristic, BT's are especially well suited to high ambient temperatures. Power dissipation is excellent. Other Advanced Type BT's meet and surpass JAN-R-11 Specifications at 1 and 2 watts. Write for full particulars in Catalog B-1.

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- ☐ Flat FRW Resistors
- ☐ Advanced BT Resistors
- ☐ MPM Resistors
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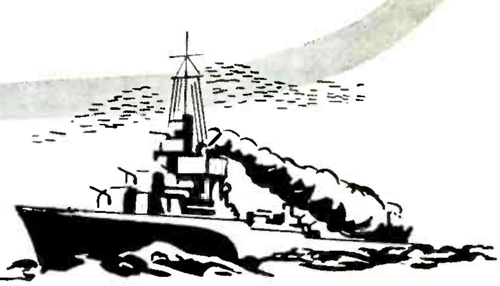
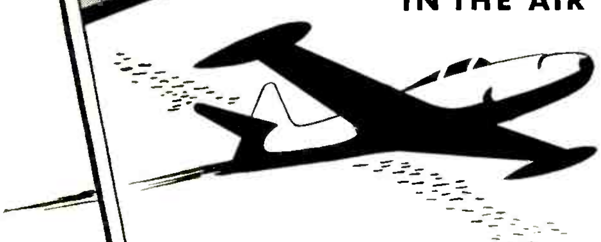


ON THE SEA

ON LAND



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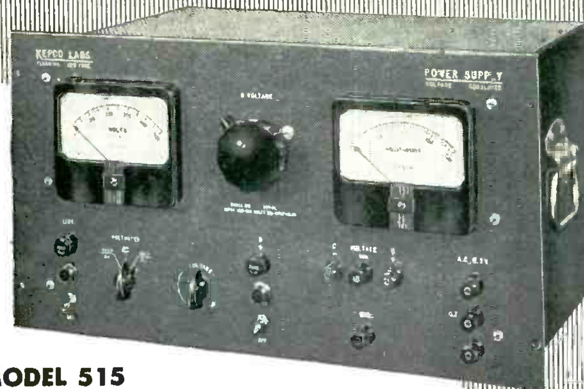

MODEL 515

B SUPPLY: 0-500 volts, 200 Ma.
REGULATION: ½% for both line and load variations.
RIPPLE: 5 millivolts.
OUTPUT IMPEDANCE: 2 ohms.
C SUPPLY: 0-150 volts, 5 Ma.
REGULATION: 10 millivolts for line 105-125 volts.
½% for load at 150 volts.
RIPPLE: 5 millivolts.
FILAMENT SUPPLY: 6.3 volts AC, 10 Amp., CT.

This unit is available with a 300 Ma. B Supply; with or without C Supply.

MODEL 510

Model 510 features TWO COMPLETELY INDEPENDENT REGULATED POWER SUPPLIES.
OUTPUT DC FOR EACH SUPPLY: 200-500 volts, 200 Ma.
REGULATION: ½% for both line and load variations.
RIPPLE: 5 millivolts.
OUTPUT IMPEDANCE: 2 ohms.
OUTPUT AC FOR EACH SUPPLY: 6.3 volts, 6 Amp., CT.

The supplies may be connected for series, parallel, or bucking operation.

MODEL 315

B SUPPLY: 0-300 volts, 150 Ma.
REGULATION: ½% for both line and load variations.
RIPPLE: 5 millivolts.
OUTPUT IMPEDANCE: 2 ohms.
C SUPPLY: 0-150 volts, 5 Ma.
REGULATION: 10 millivolts for line 105-125 volts.
½% for load at 150 volts.
RIPPLE: 5 millivolts.
FILAMENT SUPPLY: 6.3 volts AC, 5 Amp., CT.

MODEL 245

OUTPUT DC: 200-500 volts, 200 Ma.
REGULATION: ½% for both line and load variations.
RIPPLE VOLTAGE: 5 millivolts.
OUTPUT IMPEDANCE: 2 ohms.
OUTPUT AC: 6.3 volts, 6 Amp., CT, unregulated.

MODEL 103, MULTIPLE POWER SUPPLY

TWO B SUPPLIES: 0-300 volts, 75 Ma. each, 150 Ma. when paralleled. Ripple 10 millivolts. Unregulated.
ONE C SUPPLY: Minus 50 volts to plus 50 volts, 5 Ma. Ripple 5 millivolts. Unregulated.
ONE FILAMENT SUPPLY: 6.3 volts AC, 5 Amp.

MODEL 600

Model 600 features TWO INDEPENDENT REGULATED POWER SUPPLIES.
OUTPUT DC FOR EACH SUPPLY: 0-500 volts, 200 Ma.
REGULATION: ½% for both line and load variations.
RIPPLE: 5 millivolts.
OUTPUT IMPEDANCE: 2 ohms.
OUTPUT AC FOR EACH SUPPLY: 6.3 volts, 10 Amp., CT, unregulated.

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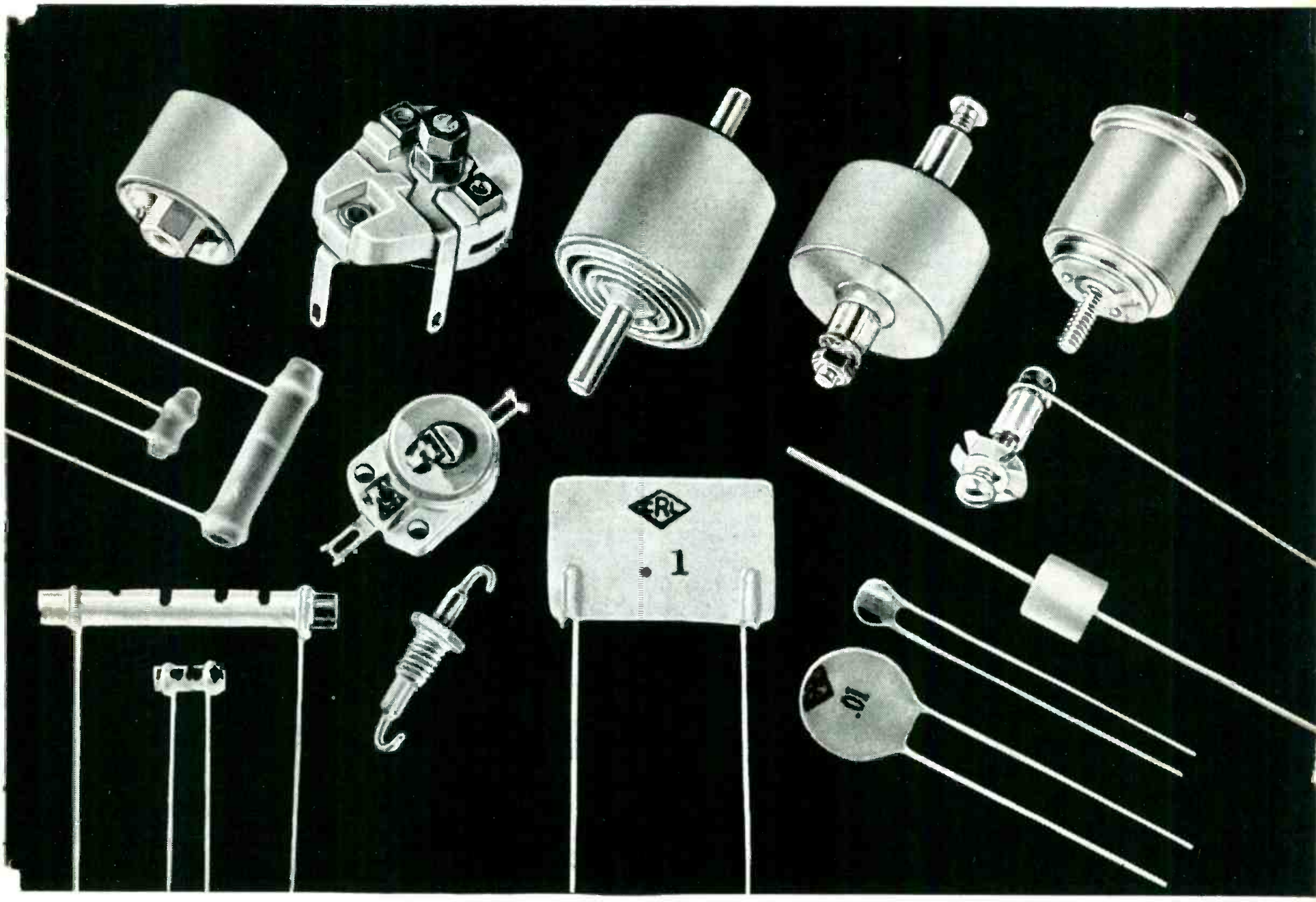

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Centralab ceramic capacitors provide a permanence never before achieved with old-fashioned paper or mica condensers. The ceramic body provides imperviousness to moisture, plus unmatched ability to withstand any temperatures normally encountered in electrical apparatus. What's more, ceramics make possible tremendous savings in space; many Centralab ceramic capacitors are ⅕th the size of ordinary capacitors. This is particularly important where new design requirements call for less bulk. You can rely on Centralab ceramic capacitors for close tolerance, high accuracy, low power factors, and excellent temperature compensating qualities. Compare Centralab Ceramic capacitors for small size, wide range of ratings, variety of types and top quality characteristics. Compare their price. The results will show you why you'll standardize on Centralab — first in the field of electronic ceramics.

WANT MORE INFORMATION? **SEE NEXT TWO PAGES** →

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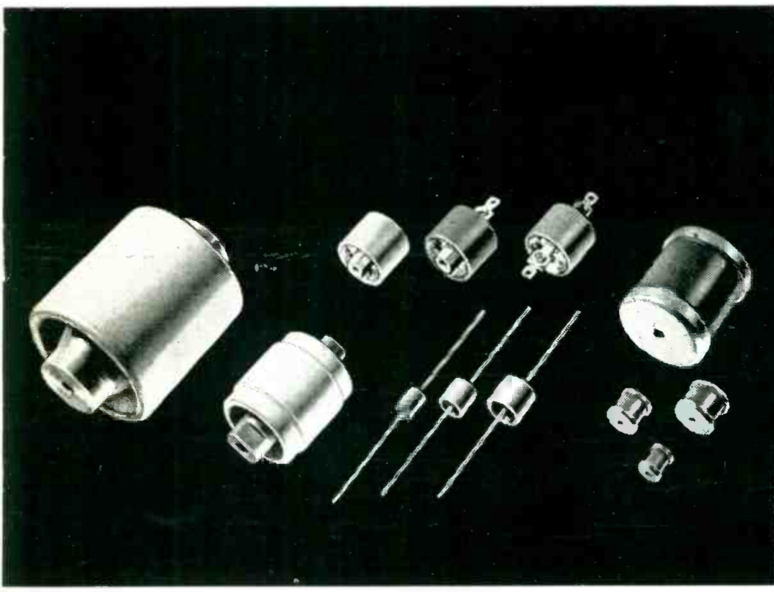
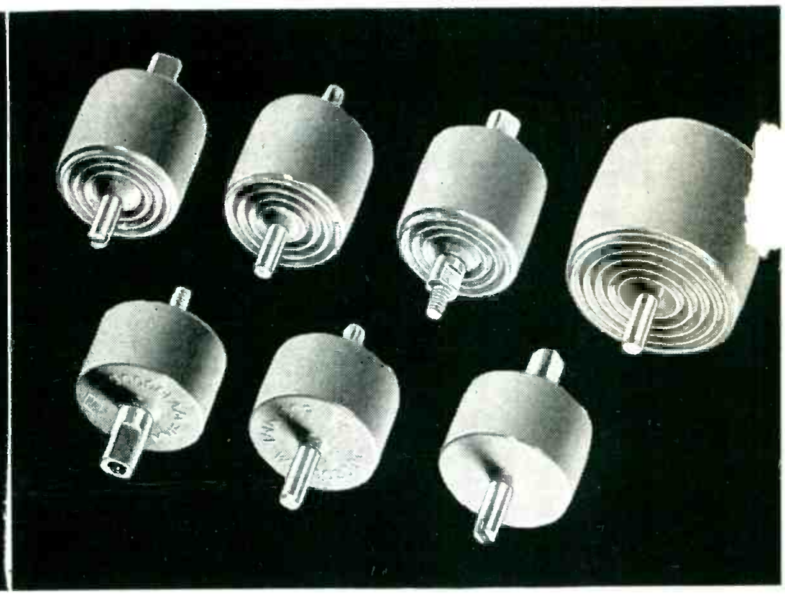
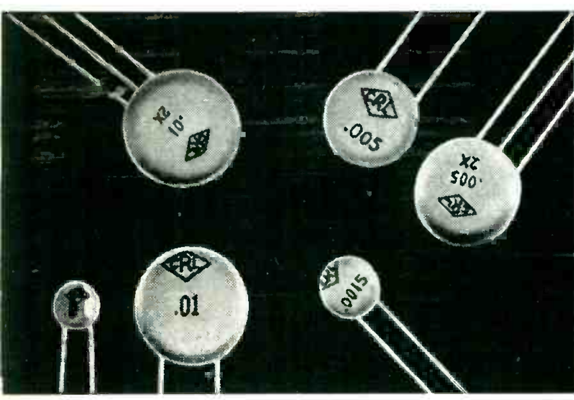


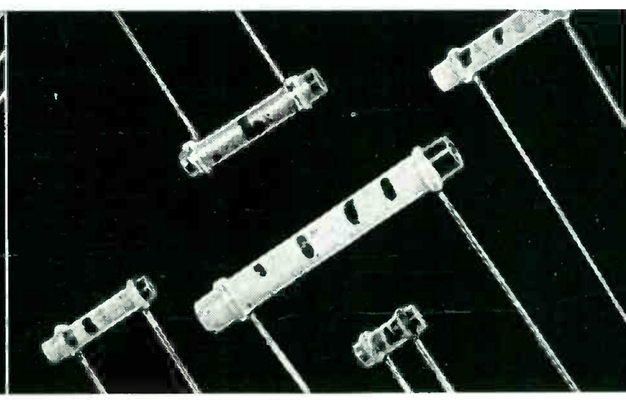
High voltage ceramic capacitors. Capacitance: 5 to 500 mmf., 5 KV to 40 KV D.C. working. Ideal for portable or mobile equipment. Primarily designed for high voltage, high frequency gear. For complete information, check Bulletin No. 42-102 in coupon below.



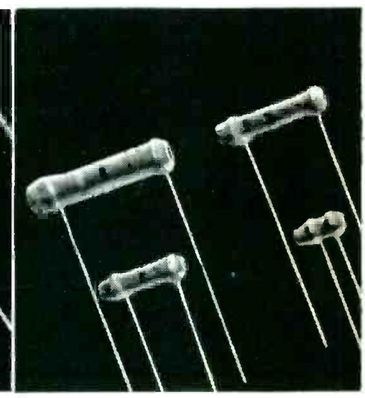
Centralab's famous TV Hi-Vo-Kaps are the standard for the TV industry. Capacitance: 500 mmf., 10 KV, 20 KV and 30 KV D. C. working. Best suited for high voltage, low power applications. For complete information, check Bulletin No. 42-10R in coupon below.



Ceramic Disc Hi-Kap Capacitors hold thickness to a minimum. Make possible very high capacity in extremely small size. Use in HF bypass and coupling. Bulletin No. 42-4R.



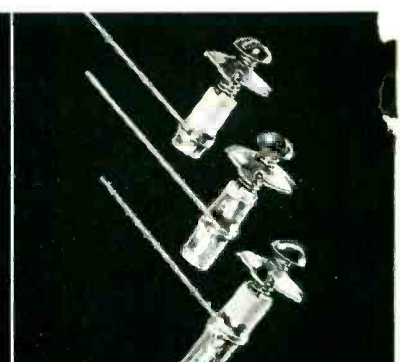
TC (Temperature Compensating) Tubulars—Type TCZ show no capacitance change over wide range of temperature. Type TCN have special ceramic body to vary capacitance according to temperature. Bulletin No. 42-18.



BC (Bypass Coupling) Tubulars — Recommended for by-pass coupling. Well suited to general circuit use. Bulletin No. 42-3.

FT (Feed Through) Hi-Kaps — Designed for single hole mounting with ground to chassis or shield. Bulletin No. 975.

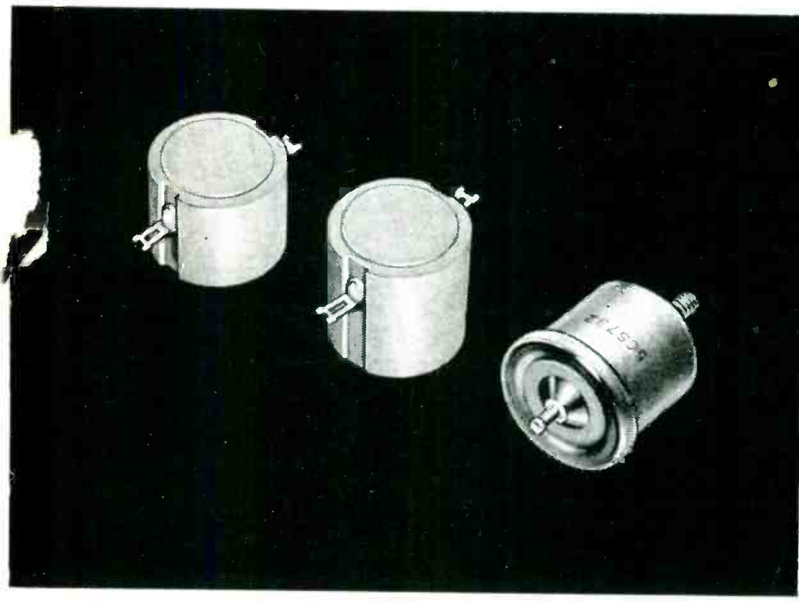
Something new in miniature ceramic capacitors! These "button types" are available in 5 different styles. Used for bypassing in low-power, high frequency applications where small size, low inductance and light weight are essential. Check Bulletin No. 42-122 in coupon for more information.



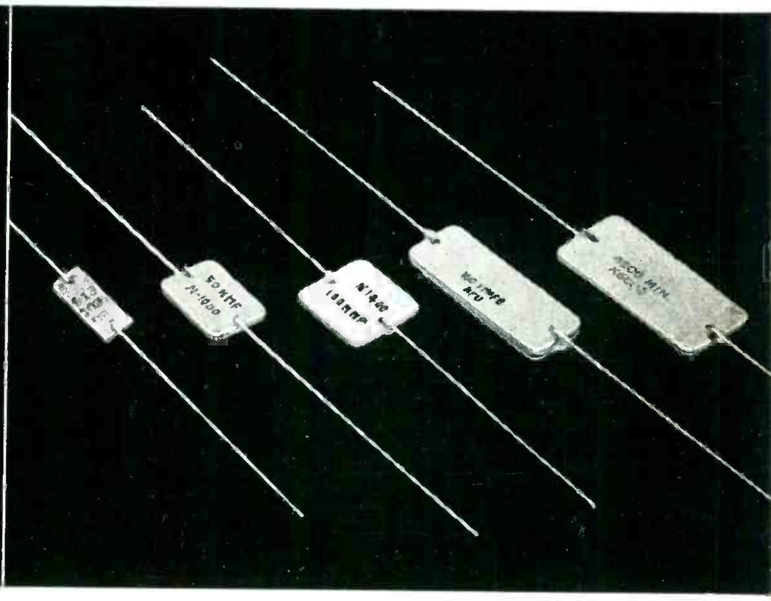
TV Trimmer Capacitors — ceramic tubulars—threaded. Complete with lock-nut and screw. Use in TV, FM. Bulletin No. 42-59.

Complete Line of Ceramic Capacitors

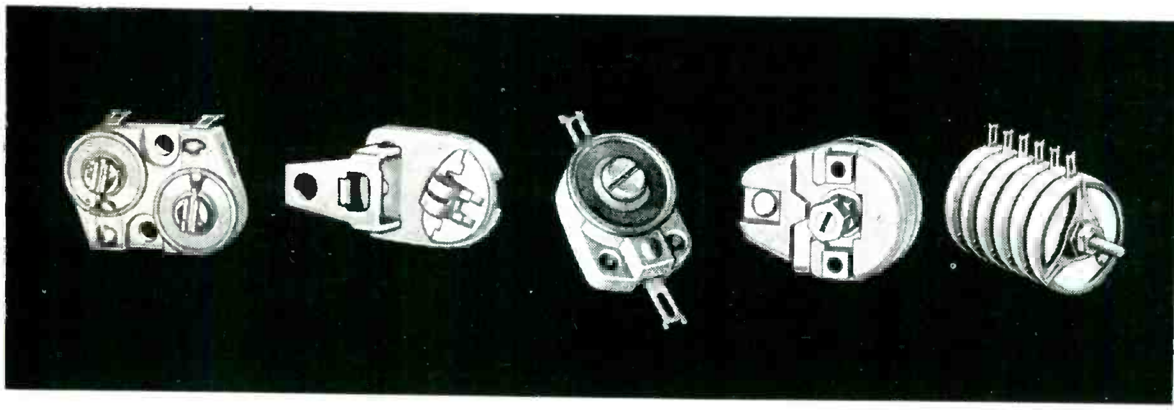
(JAN) MILITARY APPLICATION



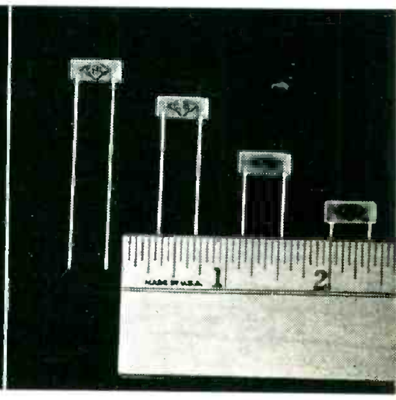
High Accuracy capacitors. Precision units to meet exacting requirements involving extremely rigid frequency control. Extensively used for holding oscillator frequencies to close limits. For complete information, check Bulletin No. 42-123 in coupon below.



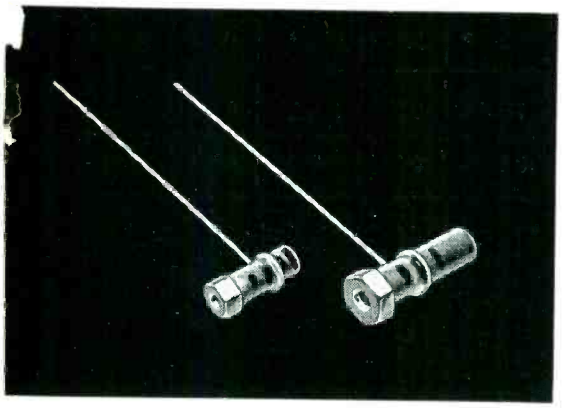
Flat Plate, end-lead capacitors. Temperature compensating. Capacitances: 5, 10, 20, 50 and 100 mmf., 500 volts D. C. working. Temperature Compensating Tolerance: 15% or 30 PPM whichever is larger. For complete information Check Bulletin No. 42-124 in coupon below.



Centralab Ceramic and Steatite Trimmers provide high quality stable capacitors, with small size, light weight, easy mounting. Readily adjustable with screw driver and give full capacity range with 180° rotation. Equal stability mantained in any position — minimum to maximum. Have excellent stability under vibration. Rotor and stator contact under spring pressure on optically ground flat surface. Check Bulletin No. 42-101 for more data.



Min-Kaps are very tiny capacitors used where space is at extreme premium. Ask for Bulletin No. 42-24.



Stand-off ceramic capacitors — both Bypass Coupling and Temperature Compensating types. One end threaded. For complete information check No. 42-121 in coupon below.

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☐ 42-123	☐ 42-18	☐ 42-24	☐ 42-59	

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FUNCTIONAL GROUP	SPECIFICATIONS				
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	Reg. accuracy	±0.25% at any voltage setting.			
	Ripple	1% RMS max.			
	Output	Model	SR-10	SR-30	SR-50
		VDC	3-135	3-30	3-13
		Amps	1-10	3-30	5-50

FUNCTIONAL GROUP	SPECIFICATIONS
400~ EQUIPMENT: LINE REGULATORS	Similar to 60~ regulators except: Accuracy ±0.5%; distortion 5% max.; frequency 400~ ±10%.
NOBATRONS*	Same general specifications as 60~ Nobatrons.
3ø REGULATORS 60~	Capacity 450VA to 45KVA. Wye to wye 115/230, 4-wire preferred. Delta to delta no neutral possible with phase transformation and reasonably balanced loads.
3ø REGULATORS 400~	Capacity 100, 250, and 750 VA. Delta to delta normal.
VARIABLE AUTO-TRANSFORMERS	Output 0-130 VAC, 350-2400~. Current range 5 and 15 amperes. Cased or open construction.
REACTORS	Built to customer specifications.
WOUND COMPONENTS: POWER TRANSFORMERS	Limit capacity to 5KVA and 5000 volts.
PLATE TRANSFORMERS	Limit capacity to 5KVA and 3000 volts C.T.
FILAMENT TRANSFORMERS	Usual specifications.
AUTOTRANSFORMERS	Up to 10KVA capacity
DC REACTORS, CHOKES	Up to 5000 insulation voltage limit. Limit to 20 henries @ 1 ampere.
AC REACTORS	Up to 5KVA limit
400-800~ TRANSFORMERS	Using hypersil or thin gauge lamination construction.
RECTIFIER TRANSFORMERS	Capacity and voltage limitations above. Wound components can be hermetically sealed to pass JAN-T-27, Grade 1 specifications. Conventional "potting" — fosterited — varnish impregnated to specifications.
FOSTERITE PROCESS	Up to 500 cubic inches. Under Westinghouse license.

Standard design AC regulators can be converted to meet appropriate AN-E-19, MIL, and JAN specifications.

Coast to Coast

Authorized Sorensen representatives and their field engineers are listed below. Find the one located nearest you — don't hesitate to call on him for consultation and advice.

CALIFORNIA — HOLLYWOOD
Neely Enterprises
7422 Melrose Ave.; Phone Whitney 1147

CALIFORNIA — SACRAMENTO
Neely Enterprises
2334 42nd St.; Phone Hillcrest 6-5521

CALIFORNIA — SAN FRANCISCO
Neely Enterprises
2830 Geary Blvd.; Phone Walnut 1-3960

D.C. — WASHINGTON
Burlingame Associates — F. L. Horman
2017 S St., N.W.; Phone Decatur 8000

FLORIDA — FORT MYERS
Arthur H. Lynch & Associates
P. O. Box 466; Phone 5-6762

GEORGIA — ATLANTA
Floyd Fawsett & Son
1347 Beecher St., S.W.; Phone Raymond 3104

ILLINOIS — CHICAGO
Loren F. Green & Associates
4949 W. Diversey Ave.; Ph. National 2-2370

KANSAS — WICHITA
Standard Products, Inc.
650 E. Gilbert Ave.; Phone Wichita 2-1431

MASSACHUSETTS — BOSTON
Burlingame Associates — P. G. Yewell
270 Commonwealth Av.; Ph. Kenmore 6-8100

MICHIGAN — DETROIT
S. Sterling Company
13331 Linwood Av.; Phone Townsend 8-3130

MINNESOTA — MINNEAPOLIS
Graybar Electric Co. — W. G. Pree
824 S. Fourth St.; Phone Geneva 1621

NEW MEXICO — ALBUQUERQUE
Neely Enterprises
107 S. Washington St.; Phone 5-8731

NEW YORK — FAYETTEVILLE
Burlingame Associates — J. D. Ryerson
113 Edgemere St.; Phone 485-R

NEW YORK — NEW YORK
Burlingame Associates
103 Lafayette St.; Phone Digby 9-1240

NORTH CAROLINA — CHARLOTTE
James L. Highsmith
P. O. Box 1011; Phone 5-6436

OHIO — DAYTON
Charles D. Boehme
Talbott Bldg.; Phone Fulton 8188

OHIO — CLEVELAND
H. A. Watson, Jr.
817 Citizens Bldg.

OREGON — PORTLAND
Electronic Specialty Representatives
331 S.E. 62nd Ave.; Phone East 4331

PENNSYLVANIA — PHILADELPHIA
Burlingame Associates — Ivan Robinson
422 W. Coulter St.; Phone Tennessee 9-2006

PENNSYLVANIA — PITTSBURGH
H. E. Ransford & Co.
Grant Bldg.; Phone Grant 1-1880

TENNESSEE — KNOXVILLE
A. R. Hough
P. O. Box 1452; Phone 8-4312

TEXAS — HOUSTON
Earl W. Lipscomb & Associates
2420-B Rice Blvd.; Phone Linden 9303

TEXAS — DALLAS
Earl W. Lipscomb & Associates
3561 Marquette St.; Phone Emerson 6-7989

CANADA — TORONTO, ONT.
Charles W. Pointon
1926 Gerrard St., East.; Phone Oxford 7435

Specify SORENSEN

ANOTHER *RMC* FIRST!

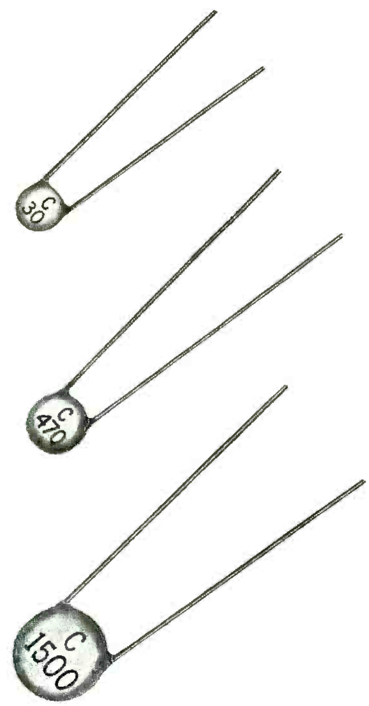
A MONEY-SAVING DISCAP TO REPLACE MICA AND TUBULAR CERAMIC CONDENSERS

With the expanding defense program requiring a larger share of available mica and tubular ceramic condensers, several of the larger TV manufacturers are replacing many of these items with RMC DISCAPS.

Now, at a substantial saving in cost, RMC offers TV producers a DISCAP rated at 600 V.D.C. which is readily available in quantity and in a capacity range between 5 MMF and 2000 MMF. And, in addition, DISCAPS provide greater mechanical strength with small size for speedy production line assembly.

This is the time to check on the advantages of using RMC DISCAPS. If you will advise us of the capacities required we will quote prices and supply samples for your consideration.

SEND FOR SAMPLES AND TECHNICAL DATA



ACTUAL SIZE

You can rely on RMC because we produce the complete condenser including the dielectric element. RMC control of *all* production phases is your guarantee of quality and trouble-free operation. Every DISCAP is 100% tested for capacity, leakage resistance and breakdown.

DISCAP CERAMIC CONDENSERS

RMC

RADIO MATERIALS CORPORATION

GENERAL OFFICE: 1708 Belmont Ave., Chicago 13, Ill.

FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.

Two RMC Plants Devoted Exclusively to Ceramic Condensers

G.E.'s 24-inch metal tube—24AP4—is coming off the line as you read this, Mr. TV-set Designer! No blue sky about this pace-setter—the promise stage was over long ago, performance of the tube has been amply demonstrated, production is here . . . now!

335 square inches of full-width picture area . . . you have real set appeal, sales appeal in the 24AP4's newspaper-size GIANT picture! And quality of image is tops, with a neutral-density faceplate giving maximum contrast—accenting lights, enriching shadows.

Compact TV cabinet? The 24-inch length of the 70-degree-deflection-angle 24AP4 helps you keep down receiver bulk. . . . Tube weight? Only 27½ pounds, substantially less than with a glass type of equal size.

Act fast—*today!* Telegraph or write for technical bulletin ETD-101, giving ratings and performance information on the 24AP4. Or, at your request, a G-E tube engineer will be glad to call on you. *Electronics Department, General Electric Company, Schenectady 5, New York.*

24AP4

Recommended operating conditions

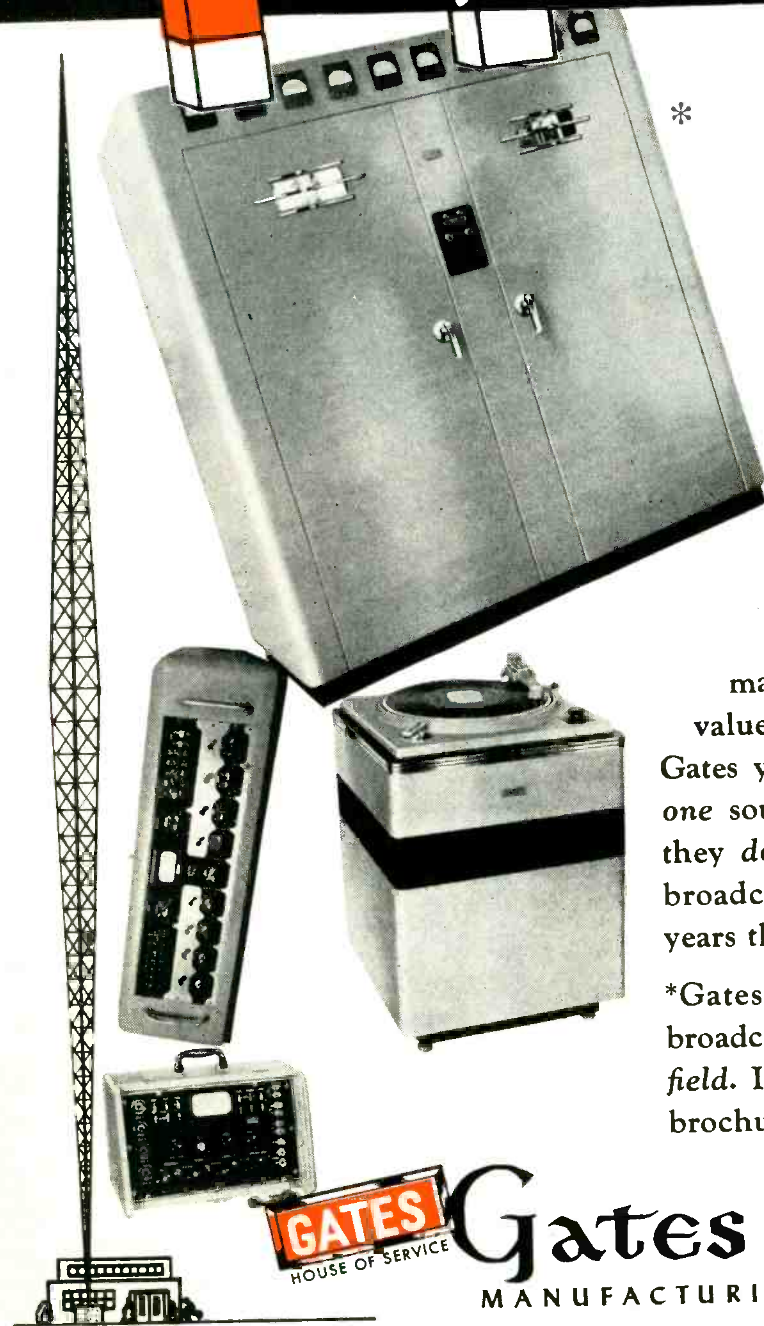
Anode voltage	15,000 v
Grid-No.-2 voltage	300 v
Grid-No.-1 voltage	−33 to −77 v
Focusing-coil current (RMA Coil No. 109 at 3½ inches)	114 ma
Ion-trap field intensity	36 gausses

GENERAL ELECTRIC

181-K2

Gates
PACKAGED BROADCASTING EQUIPMENT

-for Proved Performance



There is no split responsibility when installing Gates—all items of consequence are manufactured in the spacious Gates factory. These include such vital accessories as frequency and modulation monitors, turntables, antenna coupling equipment, phasors and many other similar equipments often purchased and not manufactured.

Performance and appearance-wise — quality and construction-wise—there is great value in the Gates matched package system. The greatest value of all is in "no buck to pass" — with Gates your one source supply, Gates is the *one* source that must produce results, and they *do!* This is evidenced by more Gates broadcasting installations in the past five years than any other make.

*Gates BC1F air-conditioned 1000 watt broadcast transmitter. *Leader in the quality field.* In use all over the world. Descriptive brochure on request.

GATES HOUSE OF SERVICE

Gates RADIO COMPANY

MANUFACTURING ENGINEERS SINCE 1922

QUINCY, ILLINOIS, U. S. A.

2700 POLK AVE., HOUSTON, TEXAS—WARNER BLDG., WASHINGTON, D. C.
INTERNATIONAL DIV., 13 E. 40th ST., NEW YORK CITY — CANADIAN MARCONI COMPANY, MONTREAL, QUEBEC

OHMITE JAN-TYPE WIRE-WOUND RESISTORS

MEET REQUIREMENTS OF JOINT ARMY-NAVY SPECIFICATION JAN-R-26A

STYLES AND SIZES

TAB-TERMINAL TYPE
†Characteristics G and J

Style	Overall length	Diameter	*Watts
RW-29	1-3/4"	1/2"	8
RW-30	1"	19/32"	8
RW-31	1-1/2"	19/32"	10
RW-32	2"	19/32"	12
RW-33	3"	19/32"	18
RW-34	3"	29/32"	30
RW-35	4"	29/32"	38
RW-36	4"	1-5/16"	60
RW-37	6"	1-5/16"	78
RW-38	8"	1-5/16"	110
RW-39	12"	1-5/16"	166

TAB-TERMINAL TYPE with terminal hole to clear No. 8 screw
†Characteristics G and J

Style	Overall length	Diameter	*Watts
RW-40	3"	29/32"	24
RW-41	4"	29/32"	32
RW-42	4"	1-5/16"	49
RW-43	6"	1-5/16"	74
RW-44	8"	1-5/16"	100
RW-45	12"	1-5/16"	160
RW-46	10-1/2"	1-5/16"	135
RW-47	10-1/2"	1-9/16"	145

FERRULE-TERMINAL TYPE
†Characteristics G and J

Style	Overall length	Diameter	*Watts
RW-10	11-7/16"	1-5/16"	140
RW-11	9-5/8"	1-5/16"	116
RW-12	7-7/16"	1-5/16"	86
RW-13	5-1/8"	1-1/16"	50
RW-14	4-7/16"	1-1/16"	40
RW-15	2-15/16"	3/4"	20
RW-16	2-3/8"	3/4"	14

FLAT (Stack Mounting) TAB-TERMINAL TYPE
Characteristics G and J

Style	Overall length	Width of Core	Thickness of Core	*Watts
RW-20	2-1/2"	1-3/16"	1/4"	15
RW-21	3-1/4"	1-3/16"	1/4"	22
RW-22	4-3/4"	1-3/16"	1/4"	37
RW-23	6"	1-3/16"	1/4"	47
RW-24	7-1/4"	1-3/16"	1/4"	63

AXIAL-TERMINAL TYPE
Characteristics G and J

Style	Length of Core**	Diameter	*Watts
RW-55	1-3/8"	5/8"	5
RW-56	2"	5/8"	10

**2-1/2" wire leads

*Watts free air JAN Characteristic "G"

†Also available to meet requirements of Characteristics F, H, E, and D which were recently removed from Spec. JAN-R-26A. (Amend. 2)

Ohmite offers an unusually complete line of resistors that meet the most rigid requirements (Characteristics "G" and "J") of Joint Army-Navy Specification JAN-R-26A. To meet these requirements, resistors must pass severe moisture resistance and thermal shock tests. They are required to withstand strenuous vibration applied for five continuous hours. And, they must satisfy the requirements of many other tests, including momentary overload, mechanical strength, and terminal strength.

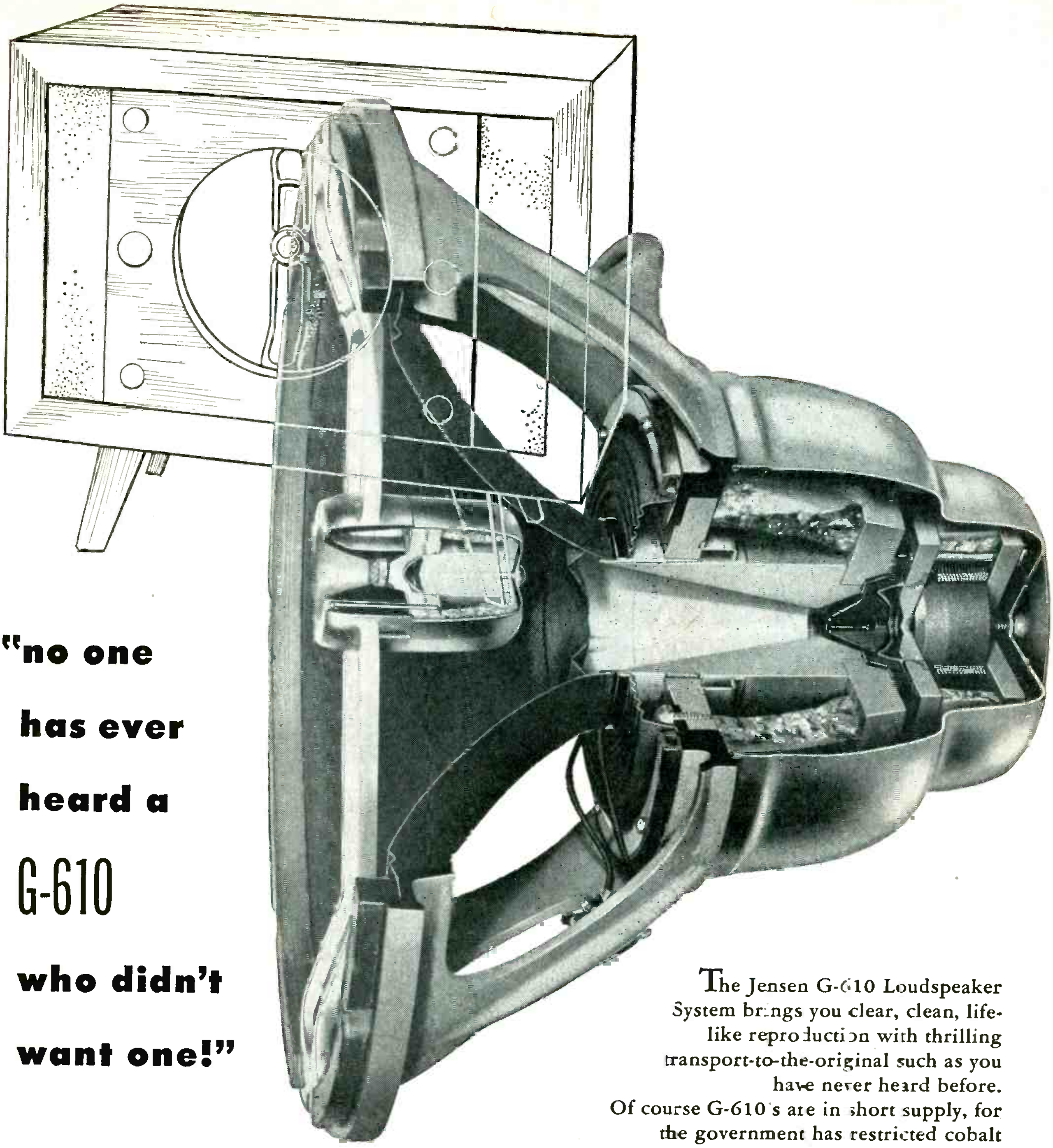
Of the 38 different resistor styles listed in JAN-R-26A, Ohmite offers 33 styles that meet these specifications. These styles represent the most popular resistors, and are available in a complete range of resistance values, in the types and sizes listed.

OHMITE MANUFACTURING COMPANY
4818 Flournoy St., Chicago 44, Ill.

Be Right with...

OHMITE®

RHEOSTATS • RESISTORS • TAP SWITCHES



"no one has ever heard a G-610 who didn't want one!"

We believe this statement is literally true . . .

The Jensen G-610 Loudspeaker System brings you clear, clean, life-like reproduction with thrilling transport-to-the-original such as you have never heard before. Of course G-610's are in short supply, for the government has restricted cobalt for Alnico V magnets—and the G-610 has more magnetic energy than any speaker ever built. But when restrictions are relaxed and G-610's are again plentiful, then be *sure you get* a G-610 . . . NO ONE has ever heard one who didn't want one!

Illustrated with Blonde model M-253 cabinet showing accessory legs.

Jensen MANUFACTURING COMPANY

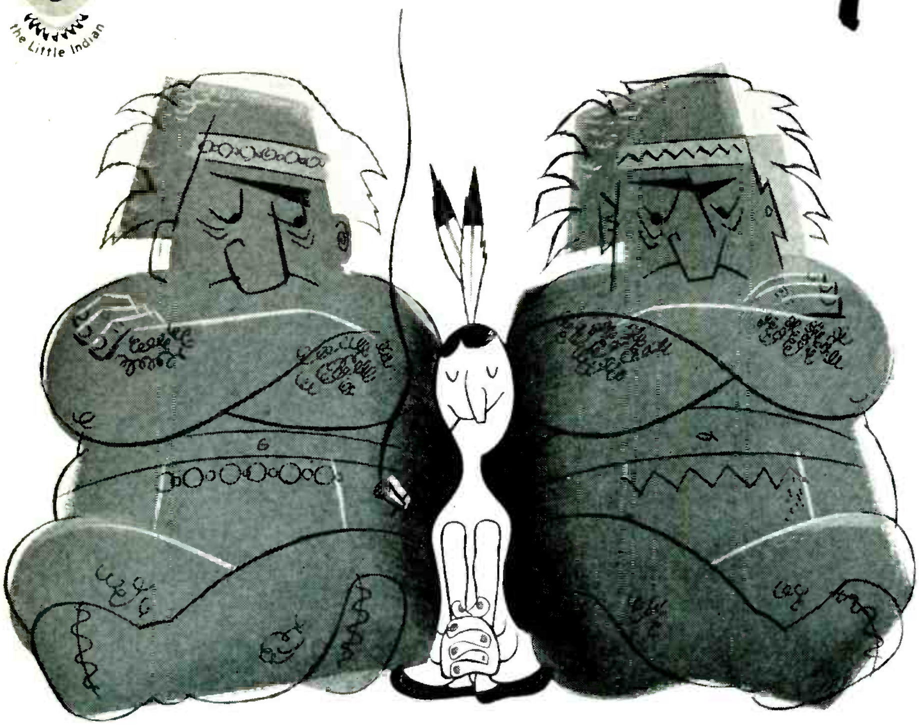
DIVISION OF THE MUTER COMPANY

6601 SOUTH LARAMIE AVENUE

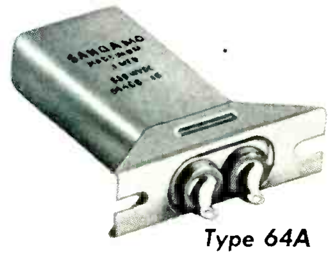
CHICAGO 38, ILLINOIS

BURTON BROWNE ADVERTISING

THE LITTLE INDIAN SAYS- "Fit in tight Spots!"



SANGAMO PAPER CAPACITORS



Type 64A

Sangamo Type 60 Capacitors

Type 62B

You're *right* when you specify Sangamo Type 62 and 64 Paper Capacitors for use where exceptionally small filter capacitors are required for aircraft, guided missile work, or similar applications.

These capacitors are mineral oil impregnated for E characteristic and assure excellent long life performance at temperatures from —55° C to +85° C. Types 62 and 64 capacitors are *smaller* than the size requirements of joint Army and Navy Specification JAN-C-25, CP 60 Series. They are hermetically sealed in seamless drawn steel cases. Non-magnetic copper or brass cases can be supplied if desired.

Full information on these, and many other types of Sangamo Paper Capacitors, is given in Catalog No. 832. Write for your copy.

Type 62A

Your Assurance of The SANGAMO Tribe — PAPER·MICA·SILVER·ELECTROLYTIC CAPACITORS *Dependable Performance*

SANGAMO ELECTRIC COMPANY

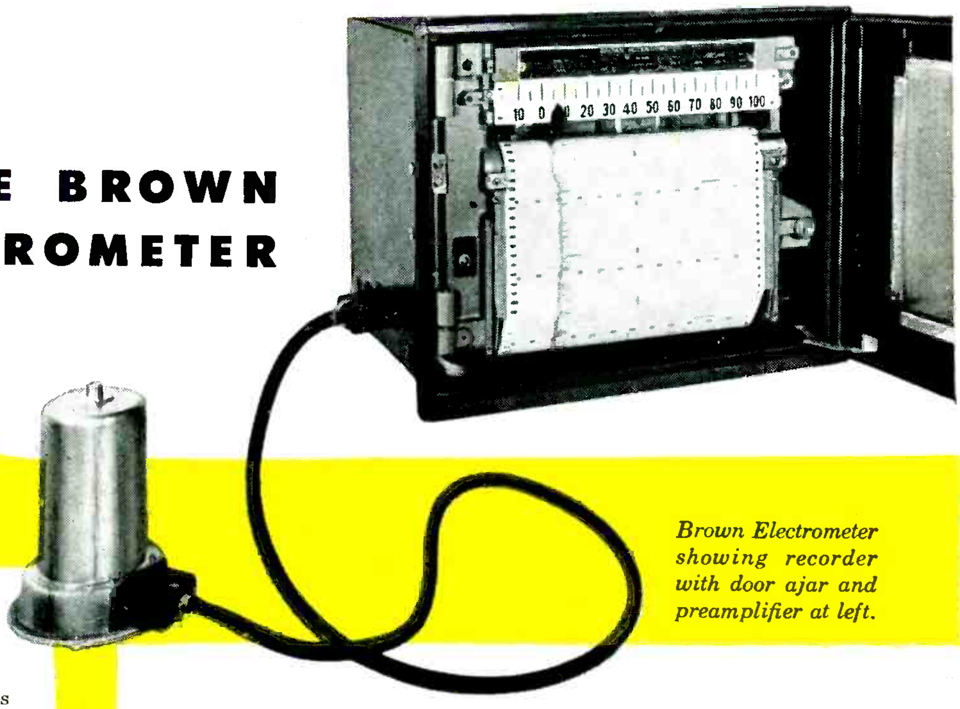
SPRINGFIELD, ILLINOIS

IN CANADA: SANGAMO COMPANY LIMITED, LEASIDE, ONTARIO

BROWN INSTRUMENTS ACCELERATE RESEARCH

for measuring and recording currents as low as 10^{-15} amperes

...THE BROWN ELECTROMETER



Brown Electrometer showing recorder with door ajar and preamplifier at left.

ELECTRICAL CHARACTERISTICS

- FULL SCALE CURRENT RANGES AVAILABLE: 10^{-13} amperes with 10^{11} ohm resistor, and selector switch adjustment for full scale of 10^{-12} or 10^{-11} amperes. Using other resistors, full scale current ranges up to 10^{-7} amperes can be supplied with selector switch adjustment up to 10^{-5} amperes.
- INPUT RESISTOR: 10^{11} ohms for most sensitive current measurement. (Also supplied in values down to 10^{5} ohms.)
- SYSTEM ACCURACY: Approximately 1 per cent of scale.
- ZERO DRIFT: Should not exceed 0.3 millivolt per day.
- SYSTEM NOISE: Approximately 5 microvolts.
- INSTRUMENT SPEED OF RESPONSE: Available for either 24, 12 seconds or 4½ seconds full scale.
- MAXIMUM SPEED OF RESPONSE USING 4½ SECOND INSTRUMENT SPEED: 5 seconds for 90 per cent of change, with preamplifier located at source.
- POWER SUPPLY: 115 volts, 60 cycles. Also dry cell supplied in instrument.
- POWER REQUIREMENTS: 65 watts.

ACCURATE measurement of extremely small currents is accomplished in this instrument through the use of a null balance servo system and a-c amplifiers that prevent drift and consequent instability. It is the only such system that incorporates a recorder as an integral part of the circuit. Designed to measure and record minute currents in ionization chambers, the Brown Electrometer may be used in any application where currents as low as a billionth of a microampere are encountered.

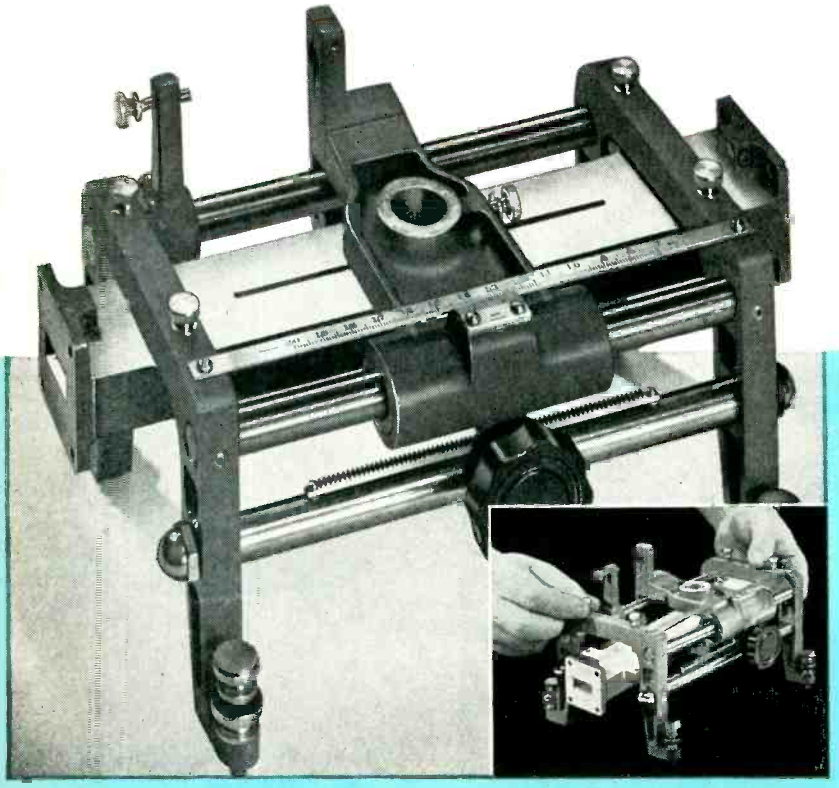
Features of the instrument include a special power supply to prevent false measurements from stray signals which might originate in an a-c power source . . . vibration frequency carefully selected to prevent phase shift . . . and automatic standardization of voltage across the slide-wire. For detailed information, write for a copy of Data Sheet 10.0-4.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4428 Wayne Ave., Philadelphia 44, Pa. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

MINNEAPOLIS Honeywell

BROWN INSTRUMENTS

IMPEDANCE



COMPLETE COVERAGE!

CONTINUOUS microwave coverage, 10 mc to 12,400 mc. High mechanical stability. Simple operation. Broad applicability. Precision accuracy. Compact size!

New *-hp-* microwave equipment gives you *complete coverage* for VHF, UHF and SHF impedance measurements. Instrumentation includes VHF Bridges as well as the slotted coaxial and waveguide sections which are fundamental tools in impedance measurements. These instruments can be used to measure load or antenna impedance, system flatness, connector reflection, percentage of reflected power, standing wave magnitude or phase, characteristics of coaxial transmission lines or rf waveguide systems, characteristics of rf chokes, resistors, condensers.

For complete details see your *-hp-* sales representative or write direct.

HEWLETT-PACKARD COMPANY

2160A Page Mill Road • Palo Alto, California

Sales representatives in principal areas.
Export: Frazar & Hansen, Ltd.
San Francisco, New York, Los Angeles

-hp- 809B UNIVERSAL PROBE CARRIAGE with -hp- 810A WAVEGUIDE SLOTTED SECTIONS

Now—a single probe carriage operates with up to 5 different slotted sections — waveguide or coaxial! This means important savings in time; lower investment in instrumentation. The new *-hp-* 809B Universal Probe Carriage mounts slotted sections covering frequencies from 3,000 to 12,400 mc (see table on opposite page)—and you can *interchange sections in 30 seconds* or less!

-hp- 809B Carriage is accurately calibrated in mm. for readings as low as 0.1 mm. Dial gauge may be readily mounted if more accurate readings are needed. Carriage travels on a new 3-point ball-bearing suspension system, and operates in conjunction with *-hp-* 442A Broad-Band Probe and *-hp-* 440A Coaxial Detector combination; or with *-hp-* 444A Untuned Probe. The extremely broad usefulness of this new Universal Carriage means far greater flexibility and lower cost for complete microwave instrumentation.

-hp- 417A VHF DETECTOR

For use with *-hp-* 803A VHF Bridge. A super-regenerative (AM) receiver covering all frequencies 10 to 500 mc in 5 bands. Offers approx. 5 μv sensitivity over entire band; quick, easy operation, direct-reading frequency control. Thoroughly shielded, suitable for general laboratory use including approximate frequency checks, measurements of noise, interference, etc. $200.00 f.o.b. factory.

-hp- 415A STANDING WAVE INDICATOR

Designed for use with all waveguide or coaxial slotted sections, to give direct reading of standing wave ratio in VSWR or db. Consists of high gain amplifier with low noise level, operating at fixed frequencies between 300 and 2,000 cps. (Normal frequency 1,000 cps., plug-ins for other frequencies available). Input circuits for use with crystal detector or bolometer. $200.00 f.o.b. factory.

HEWLETT-PACKARD hp INSTRUMENTS

READINGS

10 to 12,400 mc.

–hp– 805A/B COAXIAL SLOTTED SECTIONS

Continuous coverage 500 to 4,000 mc. High accuracy and mechanical stability; negligible slope, minimum leakage. Incorporates radically different structural design employing rigid parallel planes and a non-bowing central conductor. Probe setting readable in mm. to 0.1 mm. Maximum VSWR of basic section and connectors less than 1.04. *-hp-* 805A, 50 ohms impedance, for Type N connector and flexible cables. Model 805B, 46.3 ohms impedance, for ⅞″ rigid transmission lines.

–hp– 806B COAXIAL SLOTTED SECTION

Continuous coverage 3,000 to 12,000 mc. Employs same time-tested parallel plane principle as *-hp-* 805A/B. Designed for use with *-hp-* 809B Universal Probe Carriage. Maximum VSWR of slotted section and connecters is 1.06 to 10,000 mc. Negligible slope, 50 ohm impedance. Uses Type N connectors for flexible coaxial cable. Sets new standard for mechanical stability in coaxial slotted sections.

–hp– 440A COAXIAL DETECTOR

Tunable crystal and bolometer mount. May be used as an rf detector for coaxial systems between 2,400 and 12,400 mc. Fits Type N connectors; operates with bolometer or silicon crystal. $85.00 f.o.b. factory.

–hp– 442A BROAD-BAND PROBE

May be used in combination with *-hp-* 440A to provide highly sensitive, easily tuned detector for slotted sections. Micrometer depth adjustment provides quick control of rf coupling. $75.00 f.o.b. factory.

–hp– 444A UNTUNED PROBE

Frequency range 2,400 to 12,400 mc. Includes 1N26 silicon crystal. Highly sensitive, compact, easy to use. Requires no tuning. $50.00 f.o.b. factory.

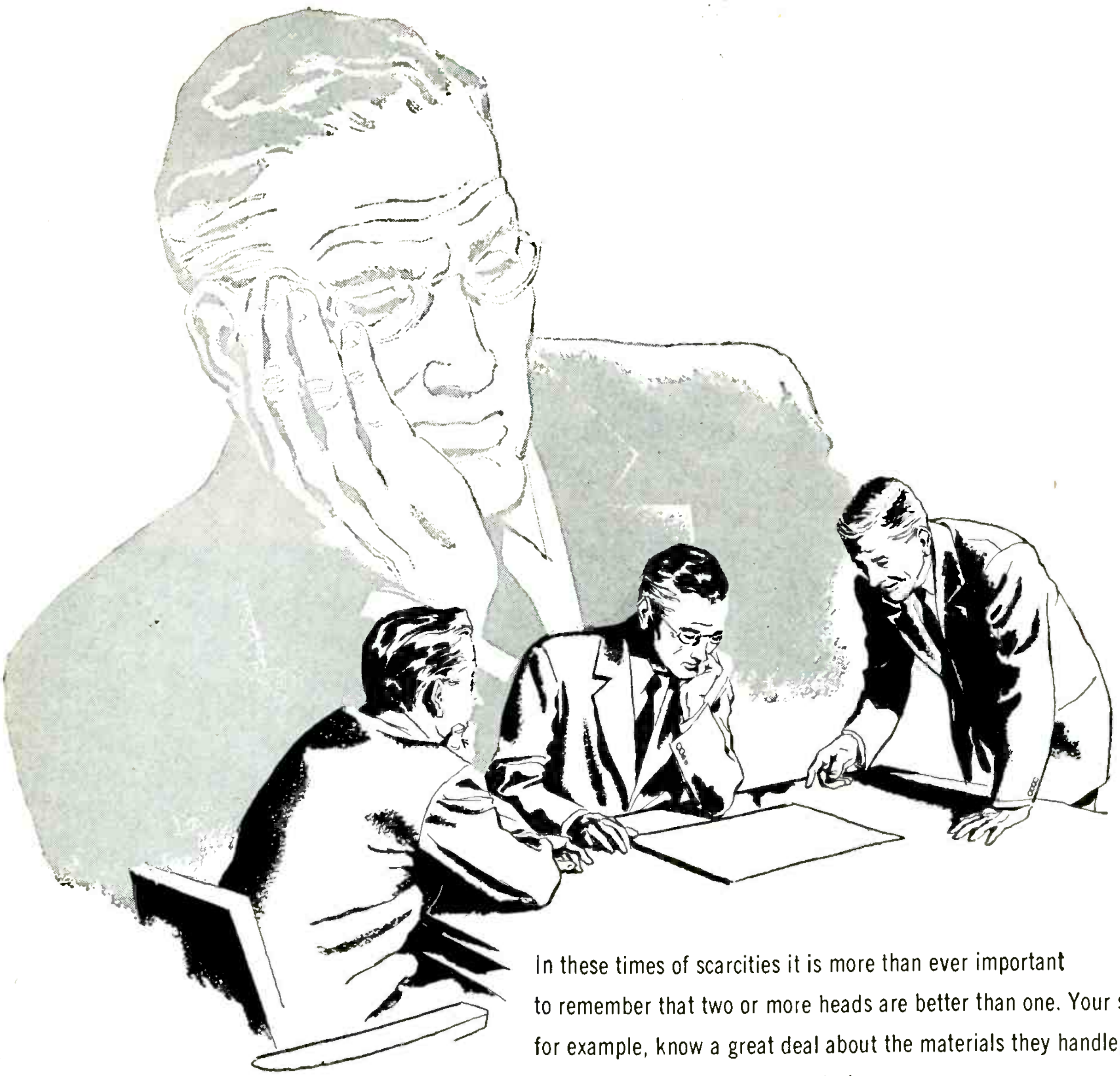
–hp– 803A VHF BRIDGE

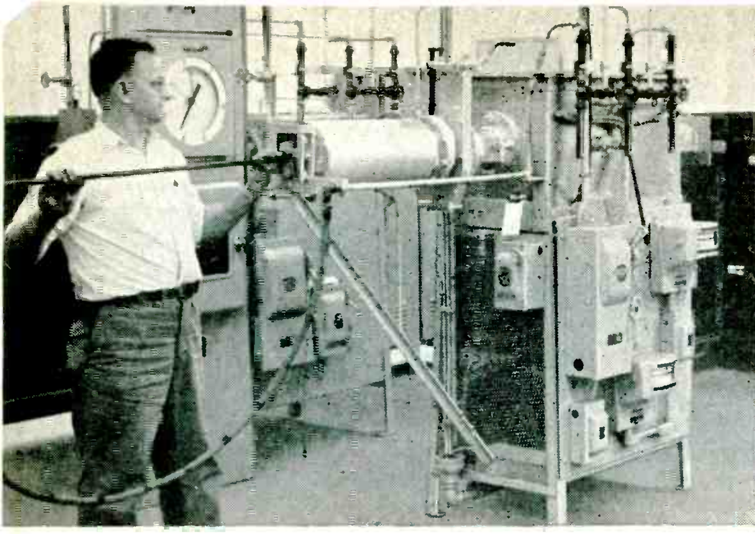
Gives direct readings in impedance magnitude and phase, 10 to 500 mc. Rapid operation for new speed, convenience in reading impedance, or resistance and reactance. Operates on new principle of sampling magnetic and electric field of transmission line. Useful for comparative measurements, 5 to 1,000 mc. Impedance range 2 to 2,000 ohms. Phase angle —90° to +90°, at 52 mc and above. Offers utmost convenience in determining characteristics of antennas, transmission lines, rf chokes, resistors and condensers; in measuring connector impedances, standing wave ratios, percentage of reflected power, VHF system flatness.

–hp– IMPEDANCE MEASURING EQUIPMENT

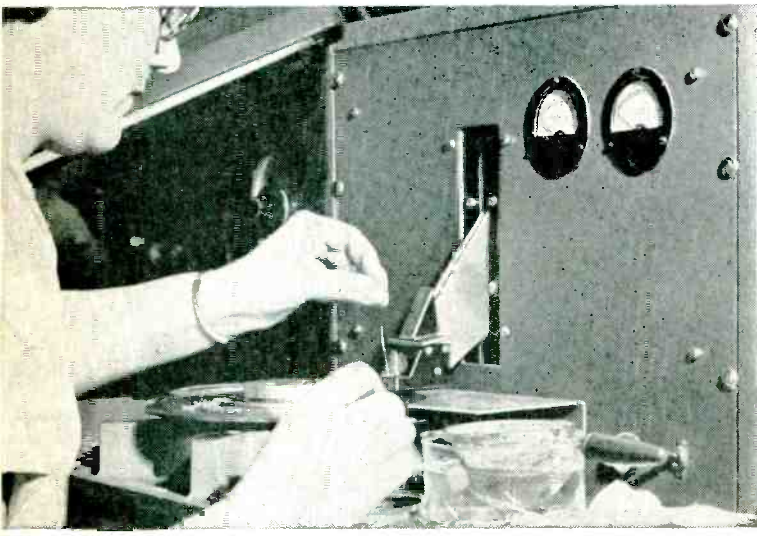
INSTRUMENT		FREQUENCIES—COAXIAL	FREQUENCIES—WAVEGUIDE	PRICE (F.O.B. FACTORY)
803A	VHF BRIDGE	10 to 500 mc		$495.00
805A/B	SLOTTED SECTION	500 to 4,000 mc		$475.00
806B	SLOTTED SECTION	3,000 to 12,000 mc		$200.00
S810A	SLOTTED SECTION		2,600 to 3,950 mc	$450.00
G810B	SLOTTED SECTION		3,950 to 5,850 mc	$ 90.00
J810B	SLOTTED SECTION		5,850 to 8,200 mc	$ 90.00
H810B	SLOTTED SECTION		7,050 to 10,000 mc	$ 90.00
X810B	SLOTTED SECTION		8,200 to 12,400 mc	$ 90.00
809B	UNIVERSAL PROBE CARRIAGE	For slotted sections, 3,000 to 12,400 mc		$160.00

Data Subject to Change Without Notice

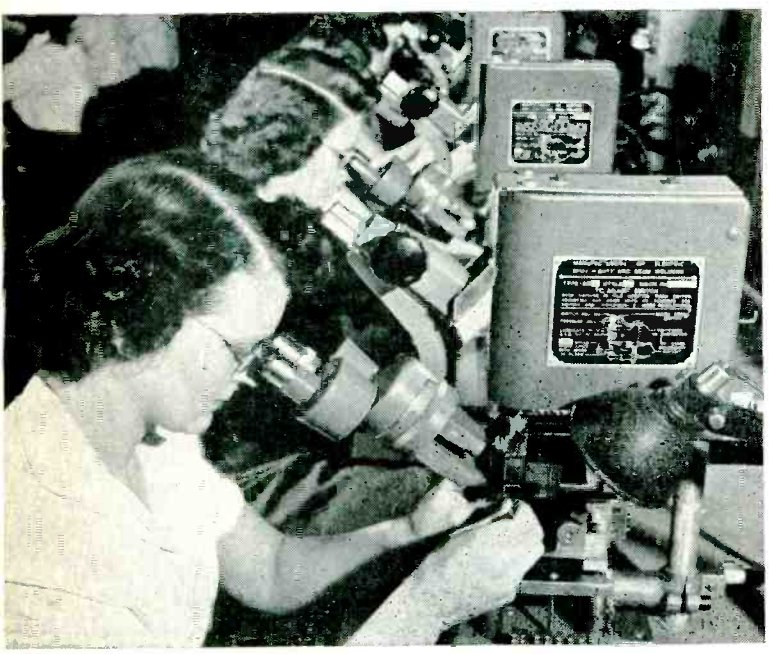




1. **MAXIMUM METAL PURITY** is essential in the manufacture of diodes. In photograph above dioxide powder is being reduced to pure germanium metal.



2. **GERMANIUM PELLETS** are mounted to pin assemblies prior to assembly in cases. Precision centering as well as speed are essential to produce these quality units at low cost.



3. **FORMING, SHEARING, AND WELDING WHISKERS** on diode pin assembly calls for careful manipulation under microscope for accurately formed .003 inch diam. whisker.

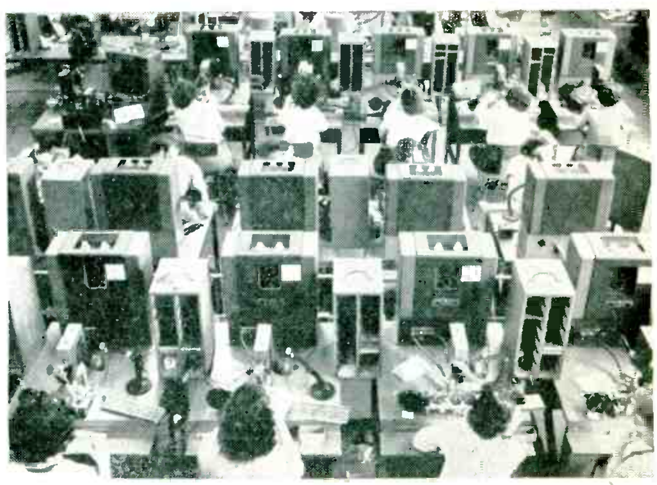
NEW GENERAL ELECTRIC PLANT CAN PRODUCE TODAY'S TOTAL INDUSTRY NEEDS OF

WELDED GERMANIUM DIODES

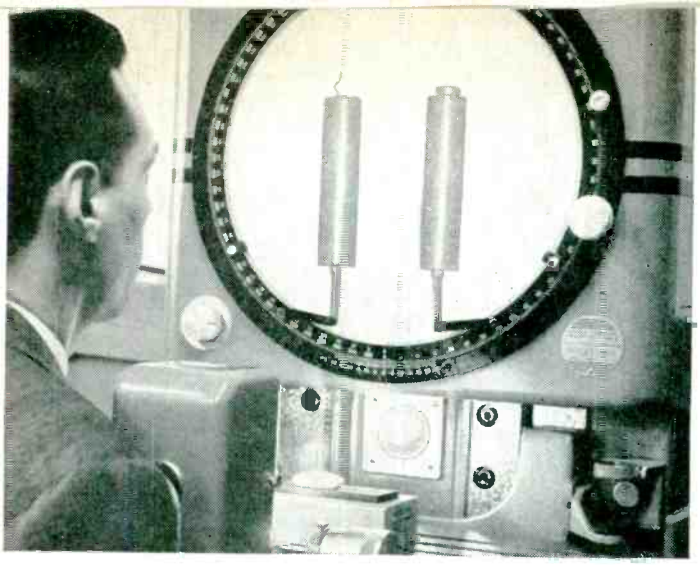
Capacity unlimited in the production of germanium diodes is the aim of General Electric's new plant* at Clyde, New York. An offspring of the mother plant at Electronics Park, this factory is equipped to assemble and test as many as 12 million diodes a year. New technological advances in research and manufacture—already proved feasible—can raise this ceiling tremendously. As diodes for commercial and military applications are produced in ever increasing quantities, costs are driven down. To fill your diode requirements—*with speed, accuracy, and at low cost*—compare G. E. with all other manufacturers.

Would you like more information on this? Ask us to call. *General Electric Company, Electronics Park, Syracuse, New York.*

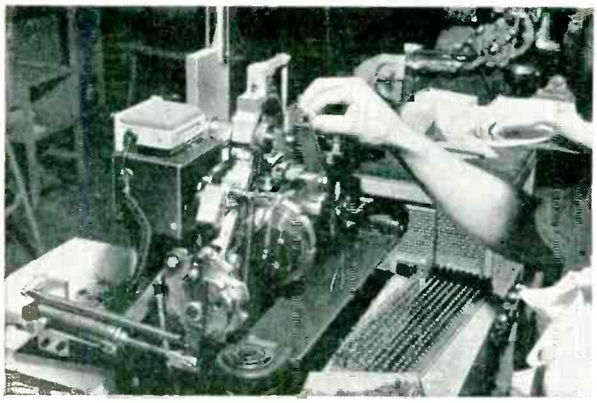
*Which you are invited to inspect when in the Syracuse area. Meanwhile, let us send you additional information and specifications on G-E diode products. Write for bulletin #X57-01A.



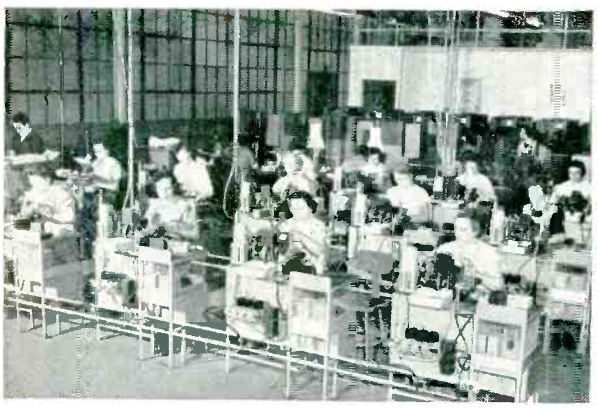
4. **ORDERLY BANK OF WHISKER MACHINES** is typical of modern production facilities in the new G-E plant. Quantities up to 12 million units a year can be produced here.



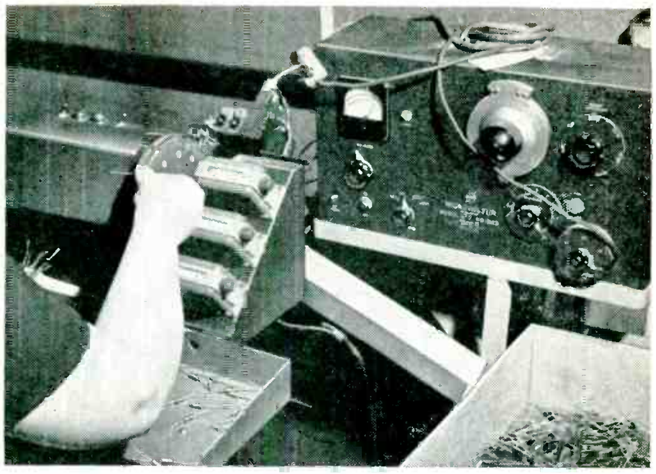
5. CONTOUR PROJECTION of diode parts for microscopic inspection. Pellet and whisker (on screen) must follow rigid specifications. This is typical of quality control processes.



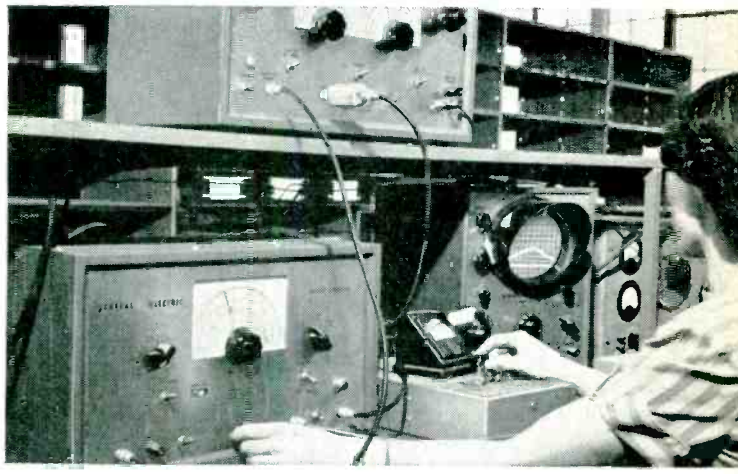
6. FINAL ASSEMBLY of whisker and pellet pins in plastic cases requires special machines designed by G-E engineers for speed and accuracy.



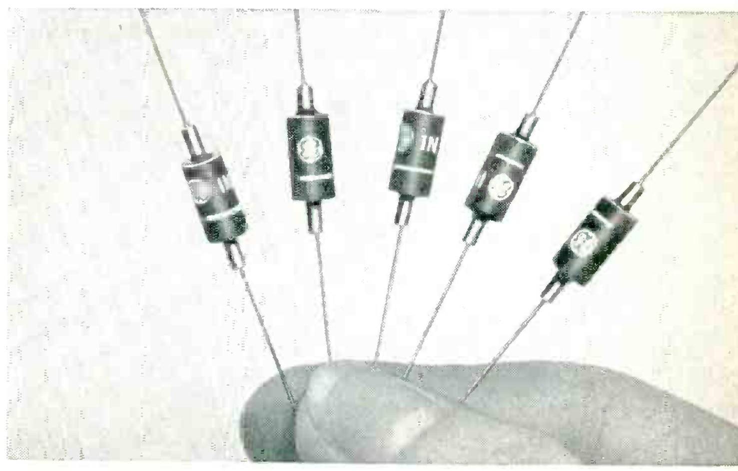
7. ASSEMBLY MACHINES turn out diodes of 12 different varieties. This process represents unusual advancement over former "hand-made" methods.



8. AUTOMATIC TEST SEPARATION of diodes by types eliminates costly hand sorting of thousands of units per hour. Every G-E diode is tested many times.



9. HIGH-FREQUENCY TESTING of diodes for television applications has proved successful in supplying over 2 million G-E units to television manufacturers for high efficiency needs.



10. FINISHED G-E DIODES of various types are small, rugged, efficient, and low in cost. These components can replace some categories of vacuum tubes.

You can put your confidence in—

GENERAL ELECTRIC

HIGHER EFFICIENCY

WITH BENDIX SCINFLEX ELECTRICAL CONNECTORS

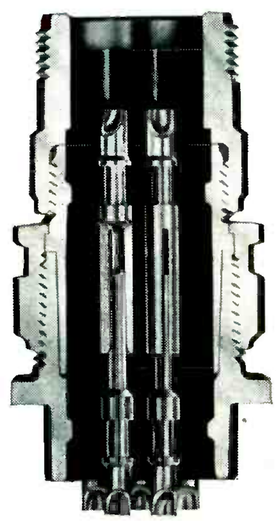
MINIMUM VOLTAGE DROP

PLUS

- Moisture proof
- Pressure Tight
- Radio Quiet
- Single-piece Inserts
- Vibration proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

The ability to carry maximum currents with only a minimum voltage drop is an outstanding characteristic of Bendix Scinflex Electrical Connectors. This important feature is only a part of the story of Bendix success in the electrical connector field. The use of Scinflex dielectric material, an exclusive Bendix development of outstanding stability, increases resistance to flash over and creepage. In temperature extremes, from −67°F. to +275°F. performance is remarkable. Dielectric strength is never less than 300 volts per mil. All in all, no other electrical connector combines as many important exclusive features as you will find in Bendix Scinflex connectors. For higher efficiency in your electrical connectors be sure to specify Bendix Scinflex. Our sales department will gladly furnish additional information on request.

PLUS



SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.

CONTACTS
High current capacity . . . Low voltage drop.

SCINFLEX ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.

Bendix

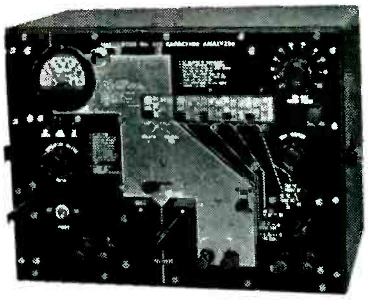
SCINTILLA MAGNETO DIVISION of
SIDNEY, NEW YORK

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

Bendix AVIATION CORPORATION

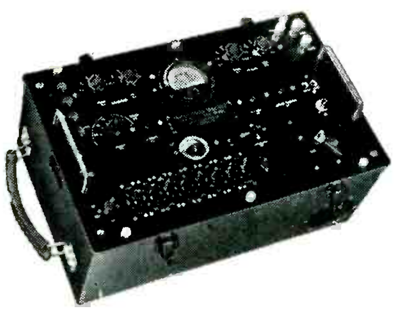
FACTORY BRANCH OFFICES:
117 E. Providencia Ave., Burbank, California • 23235 Woodward Ave., Ferndale, Michigan • 7829 W. Greenfield Ave., West Allis 14, Wisconsin • 582 Market Street, San Francisco 4, California

Something New



WIDE-RANGE, DIRECT-READING CAPACITOR ANALYZER

A laboratory-type Capacitor Analyzer meeting the need for a highly accurate, wide-range, direct-reading measuring instrument capable of determining the essential characteristics of capacitors has been announced by the Shallcross Manufacturing Co. This versatile instrument will determine capacitance values between 5mmf. and 12,000 mfd.; insulation resistance from 1.1 to 12,000 megohms; also leakage current, dielectric strength, and percentage power factor. A divided panel carrying an outline of the operating instructions makes it readily possible to use the instrument without reference to an instruction book. The Shallcross analyzer operates on 110 volt, 60-cycle alternating current. Literature giving full details will gladly be sent on request to the Shallcross Manufacturing Company, Collingdale, Pa.



MULTI-PURPOSE TRANSMISSION TEST SET

In addition to measuring the electrical characteristics of telephone lines and equipment the new Shallcross multi-purpose transmission test set may be used for efficiency tests on local and common battery telephone lines and sets, carbon microphones, receivers, and magnetic microphones. It also provides a fast, efficient means of testing capacitors, generators, ringers, insulation resistance, dials, and continuity. Key switches and dials are used to select and control the test circuits. The 693 Transmission Test Set is powered by external batteries. It features compact, substantial construction and is fully portable, thus making it ideal for either field or laboratory use. Details may be obtained from the Shallcross Manufacturing Company, Collingdale, Pennsylvania.

ADV.

SHALLCROSS

DECADE *Resistance* BOXES

36 STANDARD TYPES FROM WHICH TO CHOOSE!

TYPE	DIALS	OHM STEPS	TOTAL RESISTANCE—OHMS
542	1	0.01	0.1
543	1	0.1	1
544	1	1	10
545	1	10	100
546	1	100	1,000
547	1	1,000	10,000
548	1	10,000	100,000
549	1	100,000	1,000,000
550	1	1,000,000	10,000,000
840	2	0.1	11
841	2	1	110
842	2	10	1,100
843	2	100	11,000
844	2	1,000	110,000
817	3	0.01	11.1
818	3	0.1	111
820	3	1	1,110
821	3	10	11,100
822	3	100	111,000
823	3	1,000	1,110,000
824	3	10,000	11,100,000
817-A	4	0.01	111.1
819	4	0.1	1,111
825	4	1	11,110
826	4	10	111,100
827	4	100	1,111,000
828	4	1,000	11,110,000
817-B	5	0.01	1,111.1
8285	5	0.1	11,111
829	5	1	111,110
830	5	10	1,111,100
831	5	100	11,111,000
817-C	6	0.01	11,111.1
8315	6	0.1	111,111
832	6	1	1,111,110
833	6	10	11,111,100

Accuracy

Adjustment of individual resistors is as follows:

0.01 ohm 5%
0.1 ohm 1%
1.0 ohm 0.25%
All others 0.1%

Closer tolerances available on request

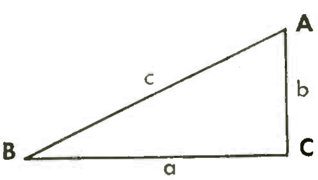
Write for Shallcross Engineering Data Bulletin L-17

SHALLCROSS MANUFACTURING COMPANY
Collingdale, Pa.

Precision Resistors • D-C Bridges • Low Resistance Test Sets • High-voltage measuring equipment • Galvanometers • Rotary Selector Switches • Attenuators Capacitor Analyzers • Transmission Test Sets . . . and custom-built electronic specialties

LITTLE THINGS ARE IMPORTANT!

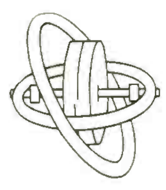
Arma Electrical Resolver



Making important things little is a militarily vital objective of the accelerated engineering activity which characterizes Arma. Making them little and interchangeable and more accurate . . . all at the same time.

An example of advancing miniaturizing accomplishment is the new lighter, more accurate and interchangeable Arma electrical resolver. This is one of the computing components that replaced a formidable aggregation of gears, bearings and slides previously used in fire-control equipment to solve the trigonometric functions. It is the "thinking" mechanism in modern military instrumentation which solves such gun-laying equations as $a = c \sin A = c \cos B$ instantaneously.

The mechanical resolvers of World War II have since given way to the electrical. Application of the new miniature Arma electrical resolvers to the needs of all the Services is widening as rapidly as accelerated engineering can push it. This is another way Arma engineers work to help make America safe against those who wish to destroy it.



QUALITY ARMA INSTRUMENT PRECISION

ARMA CORPORATION

254 36th STREET, BROOKLYN 32, N. Y.

SUBSIDIARY OF AMERICAN BOSCH CORPORATION

PRINCIPAL PRODUCTS

Gyroscopic Compasses • Gunfire Control Systems • Stabilizing Devices • Automatic Control Switchboards • Electrical & Electronic Equip. Electrical Computers • Airborne Instrumentation • Navigational & Plotting Instruments • Mechanical Computers • Servo Mechanisms

TONE ARMS—STYLI

...still available ...still tops

PRODUCT shortages? Sure. But there's *never* a letdown in the *quality* of G-E phono-accessories . . . and the items shown above are still available to manufacturers, jobbers, dealers and servicemen.

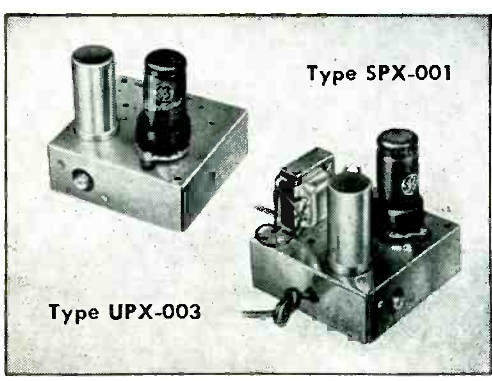
The G-E tone arm is built to accommodate the famous G-E Triple Play Cartridge (also in stock). It's equipped with ball bearings for smooth lateral movement . . . special light weight alloy keeps the arm mass to a minimum . . . stylus pressure is *constant at 6-8 grams for all three speeds* to reduce record wear. Plainly marked selector knob projects through the top of the arm—a single twist places either stylus in playing position.

General Electric's high compliance Baton Stylus with diamond or sapphire tip is unsurpassed in its field. Stock it in quantity—give your customers listening quality that lasts.

MANUFACTURERS: Your production requirements of General Electric phono-accessories can still be filled. General Electric application engineers have suggestions that will help you design a better product. Call or wire us today for details. *General Electric Company, Parts Section, Electronics Park, Syracuse, New York.*

HERE'S PLUS BUSINESS!

Use G-E phono Preamplifiers to sell *modernization* to your customers. Self-contained for easy installation, these units are ready to operate when connected to a power source. They provide sufficient amplification to enable the Variable Reluctance Cartridge to be used with any standard phonograph.



General Electric Company, Section 451
Electronics Park—Syracuse, N. Y.

Please forward information on the G-E phono accessories checked:

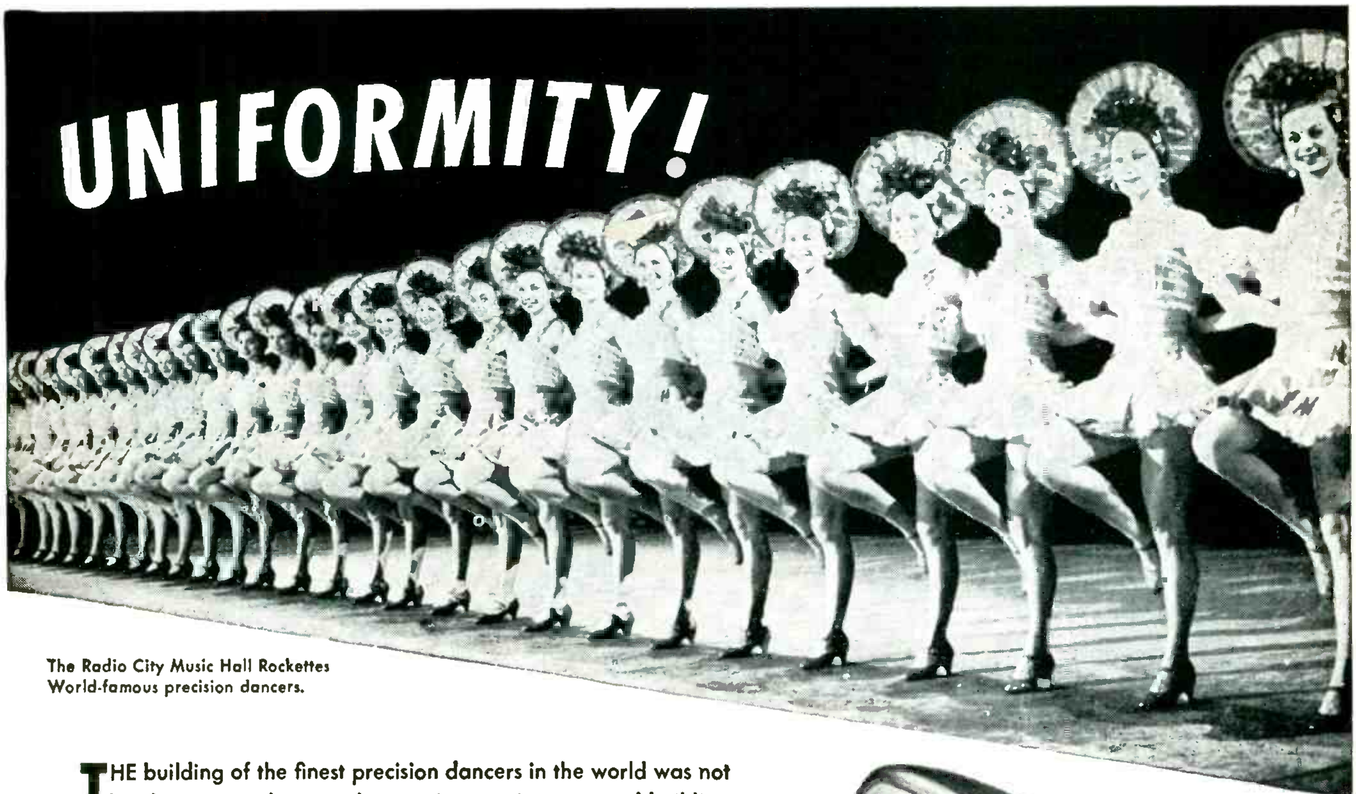
☐ Variable Reluctance Cartridges ☐ Replacement Styli ☐ Phono Preamplifiers ☐ Tone Arms

NAME________________

ADDRESS________________

CITY________________STATE________

GENERAL ELECTRIC



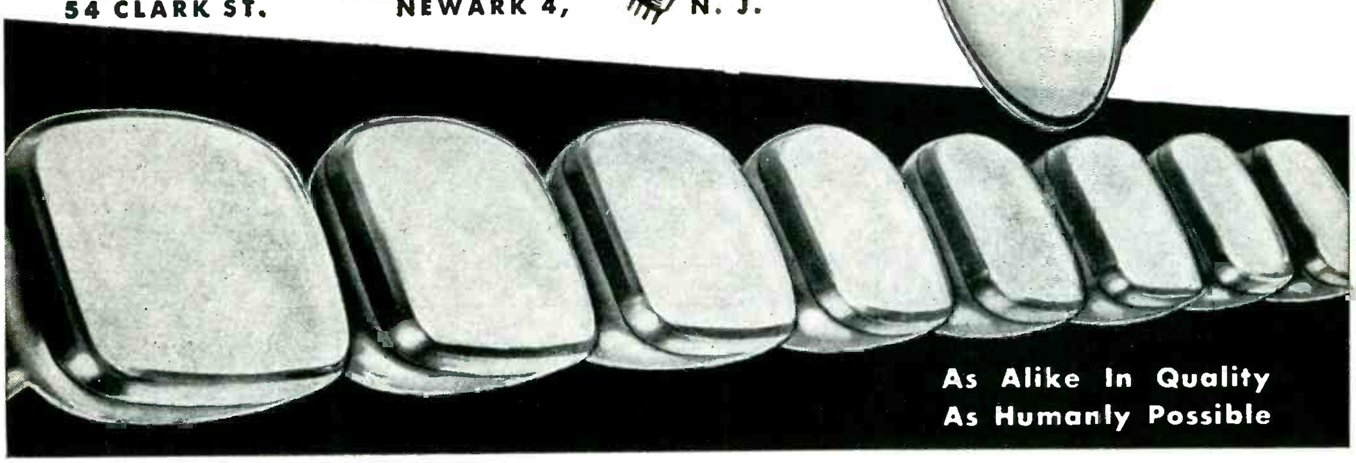
The Radio City Music Hall Rockettes
World-famous precision dancers.

THE building of the finest precision dancers in the world was not by chance. Neither was the creating, engineering and building of the ARCTURUS television tube, an act of chance. UNIFORM PERFORMANCE AND DEPENDABILITY in each Arcturus tube was the goal we set in the early days of television . . . that plus the finest tube man could build. The most informed engineering, the most precise mechanization and the best materials PLUS the unrivaled ARCTURUS QUALITY CONTROL have placed ARCTURUS TUBES at the top of the list of the world's most dependable tubes, and kept it there year after year. You can depend on every Arcturus tube to be as fine as they come in sharpness of picture . . . brilliance . . . long life . . . and stability.

COMPLETE LINE
IN SIZES
10" to 24"

THE OLDEST NAME IN ELECTRONICS

ARCTURUS
ELECTRONICS, INC.
54 CLARK ST. NEWARK 4, N. J.



TUNG-SOL

6AX4 GT

damper diode

for transformerless receivers

for "direct drive" deflection circuits

see other side for additional information

TUNG-SOL
DAMPER DIODE

6AX4 GT

Unique ceramic sleeve of aluminum oxide, fired to extreme hardness, completely isolates the cathode from the heater wire. Maximum heat transfer is obtained with fullest insulation protection.

- ★ ***doubles heater-to-cathode insulation rating***
- ★ ***eliminates external damper tube transformer***
- ★ ***no top cap—simplified wiring***
- ★ ***conserves critical materials***
- ★ ***lowers manufacturing costs***

Here is a new TUNG-SOL tube designed for use in television horizontal frequency damper service, which is one of the most important and timely engineering developments ever to come out of any electronic laboratory.

It is a single, indirectly heated diode with the high voltage insulation requirement removed from an external transformer and built into the tube itself.

A specially-designed ceramic sleeve completely isolates the heater from the cathode and other circuits. The receiver designer can handle the damper tube heater just as he does any other heater in the receiver. Normal "warm-up" time is achieved since most of the ceramic insulator body is cut away and yet no sacrifice is made in the insulating properties.

Heater-to-cathode insulation rating has been sharply boosted from 2000 to 4000 volts (pulse rating) and 450 to 900 volts (D.C. rating), thus giving circuit designers new and greater latitude.

Use of the TUNG-SOL 6AX4GT affords manufacturers the opportunity to conserve scarce materials and to effect production economies with the promise of improved set efficiency.

Mechanical Data

Coated unipotential cathode

Outline drawing	RMA #9-11	Bulb	T-9
Base	RMA #B6-48	Short intermediate shell octal 6-pin	
Maximum diameter			1-9/32"
Maximum overall length			3-5/16"
Maximum seated height			2-¾"
Pin connections		RMA basing	#4CG
Pin 1—no connection		Pin 5—plate	
Pin 2—no connection		Pin 7—heater	
Pin 3—cathode		Pin 8—heater	
Mounting position			Any

Electrical Data

(Interpreted according to RMA Standard M8-210)*

Ratings

Heater voltage (ac or dc)	6.3 VOLTS
Heater current	1.2 AMPS.
Maximum heater-cathode voltage (heater negative)	900 VOLTS
Maximum peak heater-cathode voltage (heater negative)	4000 VOLTS * *
Maximum heater-cathode voltage (heater positive)	100 VOLTS
Maximum peak inverse plate voltage	4000 VOLTS * *
Maximum steady state peak plate current	600 MA.
Maximum transient peak plate current	3.0 AMPS. * * *
Tube voltage drop (measured with tube conducting 250 ma.)	32 VOLTS
Maximum dc plate current	125 MA.

Interelectrode Capacitance

Heater to cathode	7.5 $\mu\mu$f.

* These are design center ratings. Because of the nature of the service for which this tube is intended, it is important that these values not be exceeded by more than 10% under the most unfavorable operating conditions.

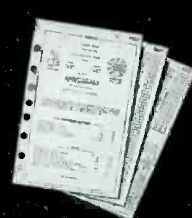
* * This rating is applicable where the duty cycle of the voltage pulse does not exceed 15% of one scanning cycle, and its duration is limited to 10 micro-seconds.

* * * This rating applies to hot switching where transient duration does not exceed 0.2 seconds.

This type is also available with 12.6 Volts, 600 MA. heater and is designated 12AX4GT.

TUNG-SOL
ELECTRON TUBES

The TUNG-SOL engineering which has produced the 6AX4GT and the 12AX4GT is constantly at work on a multitude of special electron tube developments for industry. Many exceptionally efficient general and special purpose tubes have resulted. Information about these and other types is available on request to TUNG-SOL Commercial Engineering Department.

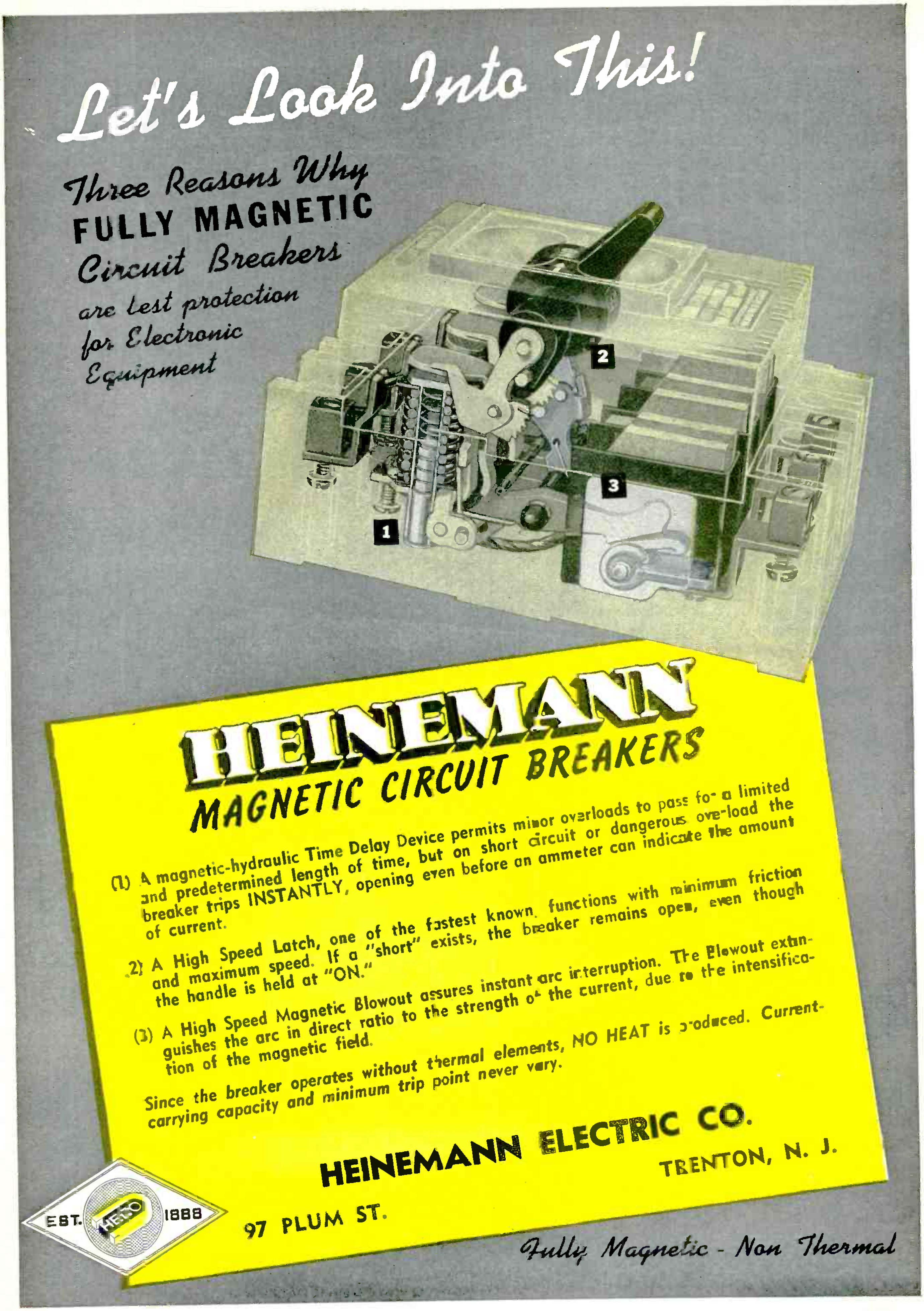


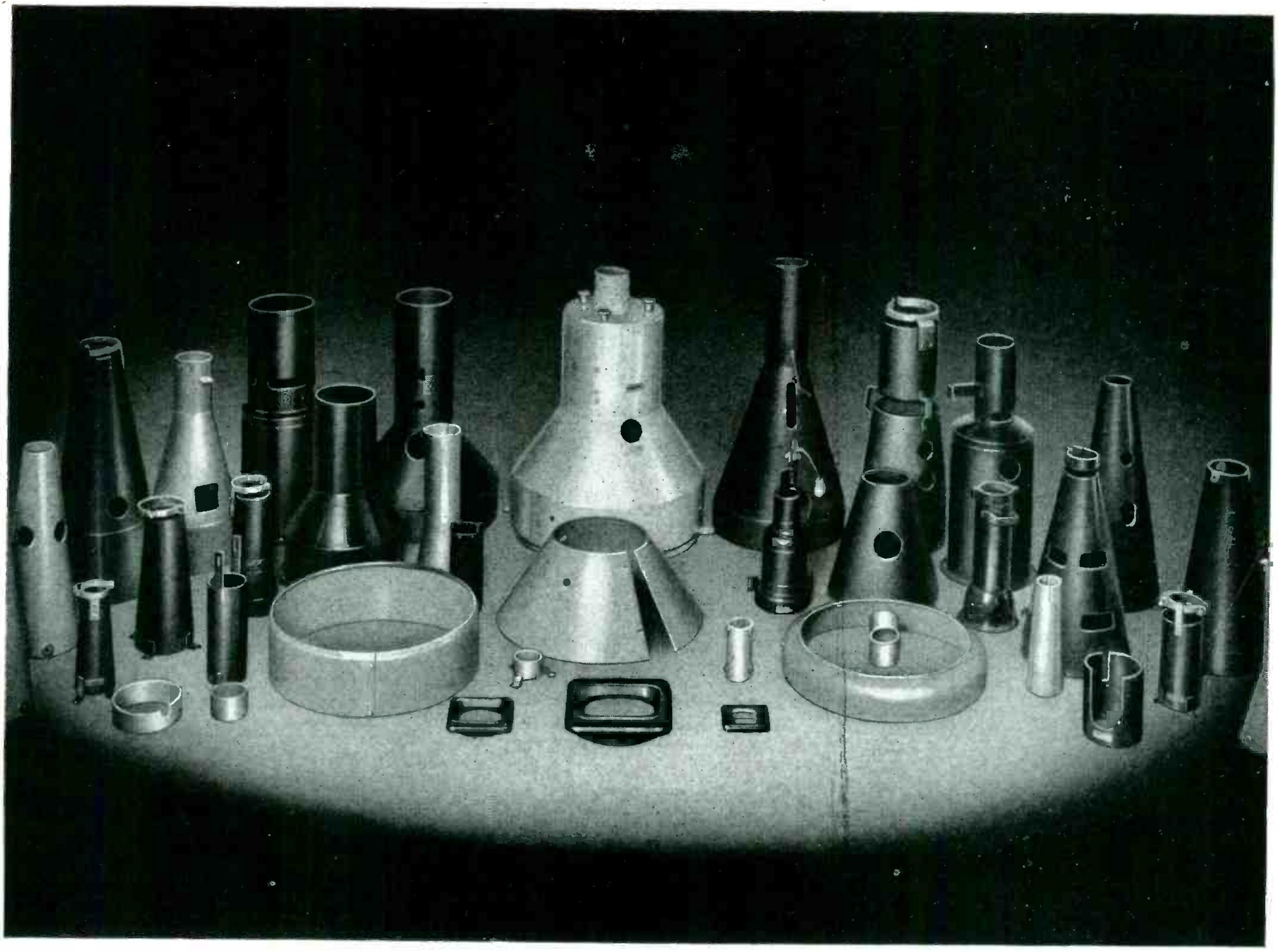
TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

SALES OFFICES: ATLANTA · CHICAGO · DALLAS · DENVER · DETROIT · LOS ANGELES · NEWARK

TELEVISION TUBES · RADIO TUBES · DIAL LAMPS · ALSO ALL-GLASS SEALED BEAM LAMPS AND SIGNAL FLASHERS

MAY, 1951


Let's Look Into This!
Three Reasons Why
FULLY MAGNETIC
Circuit Breakers
are best protection
for Electronic
Equipment
1
2
3
HEINEMANN
MAGNETIC CIRCUIT BREAKERS
(1) A magnetic-hydraulic Time Delay Device permits minor overloads to pass for a limited and predetermined length of time, but on short circuit or dangerous over-load the breaker trips INSTANTLY, opening even before an ammeter can indicate the amount of current.
(2) A High Speed Latch, one of the fastest known, functions with minimum friction and maximum speed. If a "short" exists, the breaker remains open, even though the handle is held at "ON."
(3) A High Speed Magnetic Blowout assures instant arc interruption. The Blowout extinguishes the arc in direct ratio to the strength of the current, due to the intensification of the magnetic field.
Since the breaker operates without thermal elements, NO HEAT is produced. Current-carrying capacity and minimum trip point never vary.
HEINEMANN ELECTRIC CO.
97 PLUM ST.
TRENTON, N. J.
EST. 1888
Fully Magnetic - Non Thermal



Designed for Application

Mu Metal Shields

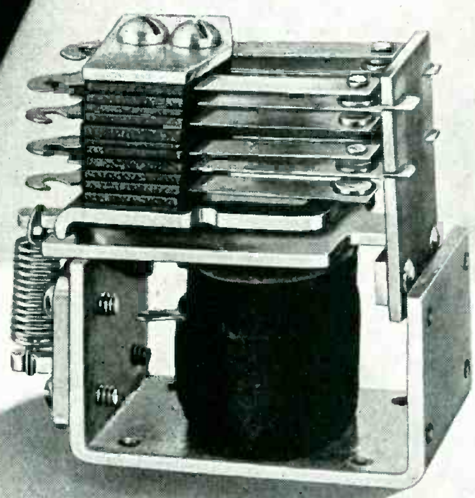
The James Millen Mfg. Co. Inc. has for many years specialized in the production of magnetic metal cathode ray tube shields for the entire electronics industry, supplying magnetic metal shields to manufacturing companies, laboratories and research organizations. Stock shields are immediately available for all of the more popular sizes and types of cathode ray tubes as well as bezels for 2″, 3″ and 5″ size tubes.

Many production problems, however, make desirable special shields designed in conjunction with the specialized requirement of the basic apparatus. Herewith, are illustrated a number of such custom built shields. Our custom design and fabrication department is at the service of our customers for the development and manufacture of magnetic metal shields of either nicoloi or mumetal for such specialized applications.

JAMES MILLEN MFG. CO., INC.
MAIN OFFICE AND FACTORY
MALDEN, MASSACHUSETTS, U.S.A.

PEAK

IN POWER VERSATILITY QUALITY PERFORMANCE



TYPE PK RELAY

HERE ARE THE FACTS AND FIGURES:

CONTACTS: 10 amp. standard. 24 volts D.C., 115 volts A.C.
15 amp. contacts available.

SENSITIVITY: D.C.: 4 pole 1.5 watts
2 pole .7 watts
A.C.: 4 pole 5 volt amperes
2 pole 2.5 volt amperes
Can also be furnished in 6 pole AC and DC up to 4000 Ohms.

COIL: To 115 volts D.C., 230 volts A.C.

NOMINAL HEAT RISE: D.C. 30°C above room ambient
A.C. 45°C above room ambient

MAX. INPUT FOR 85° RISE: D.C. 5 watts
A.C. 11 volt amperes

MOUNTING: Base or end mounting

WEIGHT: 4.5 oz. 4 P.D.T.

WEIGHT HERMETICALLY SEALED: 7.7 oz.

DIMENSIONS: Open Relay—2 1/16", 1 1/8", 2 1/16"
Sealed Relay—3 1/8", 1 1/2", 2 5/16"
Overall Mounting Flange—3 1/8"
Center to Center Mounting Holes—2 11/16"

A Quality Relay

The new Allied PK Relay is designed to offer versatility in a power relay where quality and low cost are factors. Besides stability in operation its reliability allows a range in applications from high quality instruments to vending machines. The PKU relay will comply with Underwriters' Laboratories requirements and can also be supplied hermetically sealed.

Bulletin PK gives complete details. Send for your copy today.

Be sure to send for your copy of Allied's Relay Guide. It gives the engineering data for 27 Allied relays in a concise tabular form for easy reference.

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

Complete Coverage!

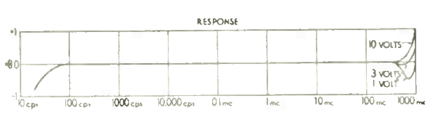
2 to 700,000,000 cps

-hp- precision voltmeters for every ac voltage measuring need!

From 2 cps to 700 mc, there's an accurate, easy-to-use *-hp-* voltmeter for any voltage measuring job. You can choose from 5 precision instruments (including a battery-operated portable unit) the dependable *-hp-* voltmeter that exactly fills your need. Each gives you familiar *-hp-* operating characteristics of high sensitivity, wide range, broad applicability, time-saving ease of operation. *-hp-* also provides a complete line of voltmeter accessories—voltage dividers, connectors, shunts and multipliers—to extend the useful range of your equipment. For complete details, see your *-hp-* sales representative or write direct.

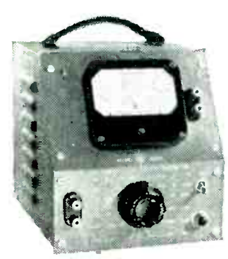
New -hp- 410B Vacuum Tube Voltmeter

Gives same wide range and flat response performance as -hp- 410A voltmeter, but sets new standard of mechanical convenience, ease of operation, minimum bench space. Readily detachable probe leads fit in handy compartment in new, compact, streamlined case. Special diode probe design places capacity of approximately 1.3 $\mu\mu$fd across circuits under test. Shunt impedance is extremely high—10 megohms at low frequencies—thus circuits under test are not disturbed and true voltage readings are assured. New -hp- 410B provides 1 db accuracy from 20 cps to 700 mc; and may be used as a voltage indicator up to 3,000 mc. Also serves as audio or dc voltmeter or ohmmeter.



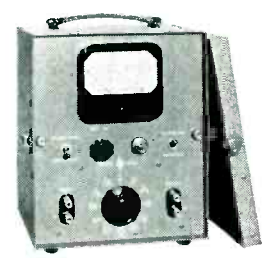
Response, -hp- 410B Voltmeter

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	VOLTAGE RANGE	INPUT IMPEDANCE	PRICE
-hp- 400A	General purpose ac measurement	10 cps to 1 mc	.005 to 300v 9 ranges	1 megohm 24 $\mu\mu$fd shunt	$185.00
-hp- 400B	Low frequency ac measurements	2 cps to 100 kc	.005 to 300v 9 ranges	10 megohms 24 $\mu\mu$fd shunt	$195.00
-hp- 400C	Wide range ac measurements High sensitivity	20 cps to 2 mc	.0001 to 300v 12 ranges	10 megohms 15 $\mu\mu$fd shunt	$200.00
-hp- 404A	Portable, battery operated	2 cps to 50 kc	.0005 to 300v 11 ranges	10 megohms 20 $\mu\mu$fd shunt	$185.00
-hp- 410B	Audio, rf, VHF measurements; dc voltages; resistances	20 cps to 700 mc	0.1 to 300v 7 ranges	10 megohms 1.3 $\mu\mu$fd shunt	$245.00



-hp- 400C Vacuum Tube Voltmeter

General purpose precision voltmeter offering wide range, high sensitivity, high stability. Quick-reading linear meter scale shows RMS volts or dbm direct from −72 dbm to +52 dbm. Broad usefulness includes direct noise or hum measurements, transmitter and receiver voltages, audio, carrier or supersonic voltages, or power gain. Also may be used as 54 db amplifier to increase signal level to oscillascopes, recorders, power amplifiers, etc.



-hp- 404A Battery-Operated Voltmeter

Precision vacuum tube instrument for general voltage measurement where ac power is not available. Compact, portable, splash-proof—ruggedly constructed for field operations. Wide voltage range permits all types of measurements including remote broadcast line and carrier checks, strain gauge system tests, telemetering and geophysical circuit measurements, etc. In the laboratory, offers completely hum-free measurements of very low noise level.

HEWLETT-PACKARD CO.

2251A Page Mill Road • Palo Alto, Calif., U.S.A.

Sales representatives in principal areas

Export: Frazar & Hansen, Ltd.
San Francisco • New York • Los Angeles

HEWLETT-PACKARD -hp- INSTRUMENTS

99.22%
RELIABILITY

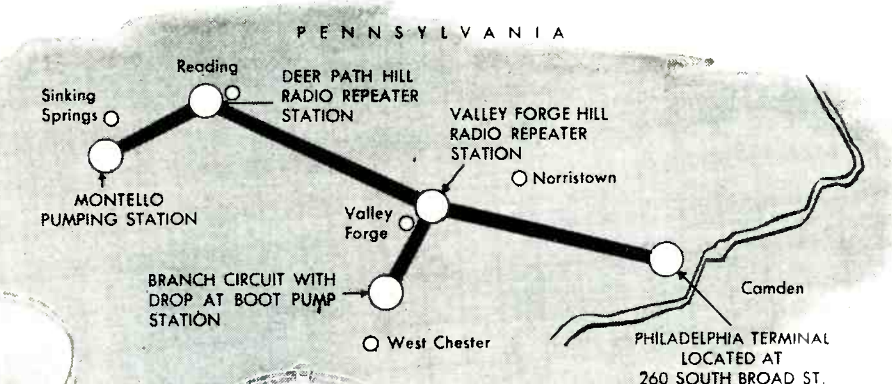
in first year's operation of world's first PTM MICROWAVE for a PIPE LINE

That's the outstanding record of reliability, continuity and quality service achieved by Keystone Pipe Line Company with Federal's Pulse-Time-Modulation Multiplex Microwave System... on the job 99.22% of the time... despite ice, snow, windstorms and other communication problems.

Keystone's pioneer microwave system, comprising 2 repeaters and 3 terminals, extends from Philadelphia to Montello, Pa., a distance of 60 miles. Operated *without* the necessity of standby RF equipment and requiring only routine maintenance, the first year's total outage time was a mere 0.78%—of which approximately *one-half* represents time consumed by the maintenance man in traveling to outages.

Here is conclusive evidence of the ruggedness, dependability, efficiency and economy of Federal PTM Microwave!

RAILROADS, UTILITIES, TELEPHONE COMPANIES, RADIO-TV BROADCAST, AVIATION and other fields, as well as pipe lines, can use Federal PTM Microwave to gain outstanding savings and communication facilities.



For further information on the application of Federal PTM Microwave to your requirements, address: Wire and Radio Transmission Systems Division.

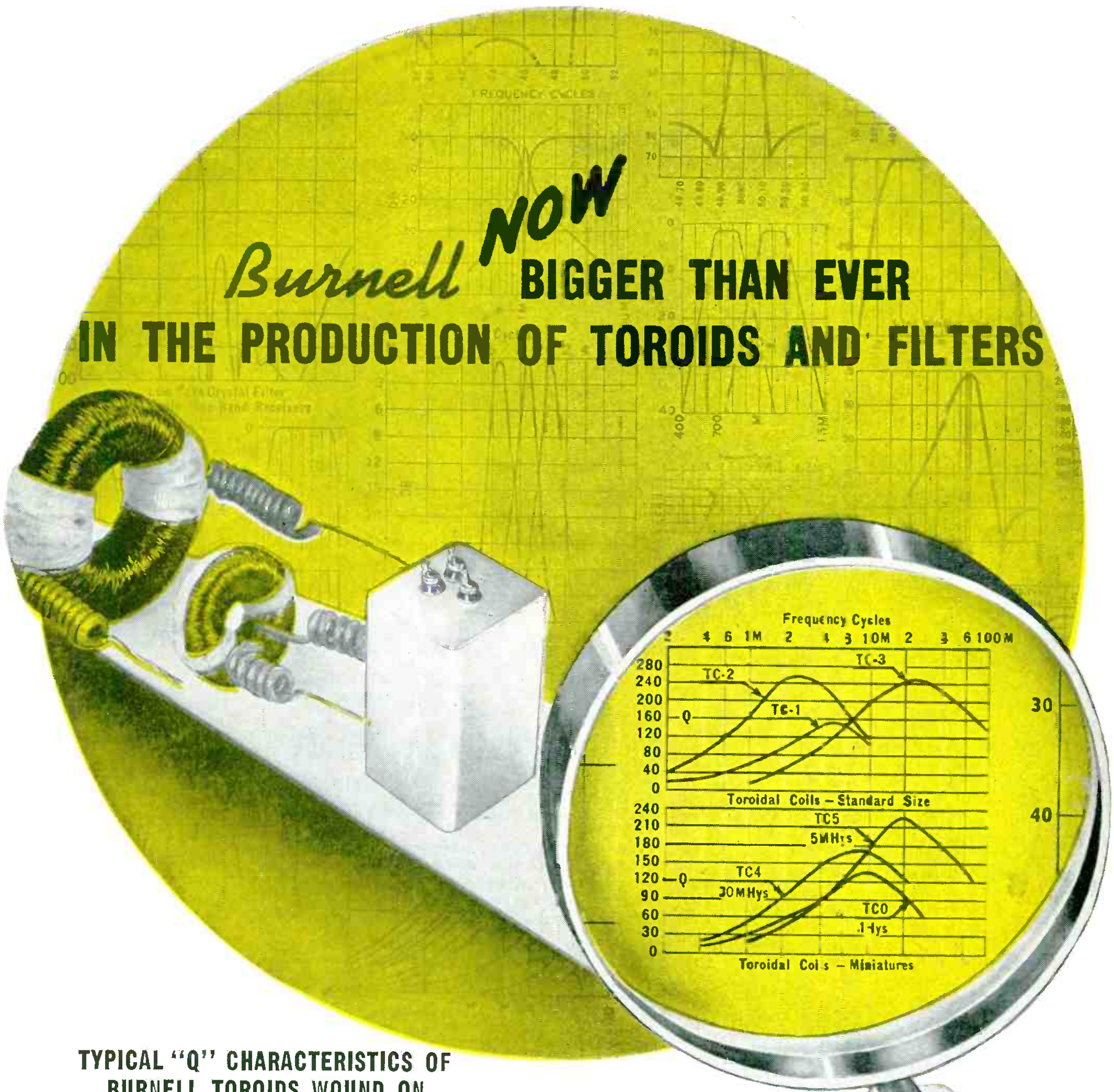
FEDERAL TELEPHONE & RADIO FTR — AN IT&T ASSOCIATE

Federal Telephone and Radio Corporation

100 KINGSLAND RD., CLIFTON, N. J.

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

Burnell NOW BIGGER THAN EVER IN THE PRODUCTION OF TOROIDS AND FILTERS



TYPICAL "Q" CHARACTERISTICS OF BURNELL TOROIDS WOUND ON MOLYBDENUM PERMALLOY CORES

Several years ago we began to specialize in the design and manufacture of toroidal coils and audio filter networks. At that time too few electronic engineers were aware of the full value of toroids (particularly those wound on molybdenum permalloy dust cores) as very little publicity had ever been devoted to a product that was fast becoming one of the most vital in the development of modern communications and control equipment.

We believe that since then through our technical service and advertising methods we have helped thousands of engineers to understand and appreciate the toroid as an essential in network applications.

The resulting popularity and industry acceptance of our toroidal coils and filters have necessitated an expansion of our production facilities to ten times what they were five years ago and we are proud to point to this growth as an expression from our customers of their satisfaction in the quality of our product and our service.

STANDARD SIZES
TC-1 = 1 5/8" O.D. x 5/8"
TC-2 = 2 1/4" O.D. x 7/8"
TC-3 = 1 1/2" O.D. x 9/16"

MINIATURE SIZES
TC-0 = 7/8" O.D. x 1/4"
TC-4 = 1-3/16" O.D. x 9/16"
TC-5 = 1-3/16" O.D. x 9/16"

MAXIMUM INDUCTANCE
TC-1 — Ind.-Up to 10 Hys.
TC-2 — Ind.-Up to 100 Hys.
TC-3 — Ind. MHY-Up to 750
TC-0 — Ind.-Up to 2 Hys.
TC-4 — Ind.-Up to 10 Hys.
TC-5 — Ind. MHY-Up to 750

EXCLUSIVE MANUFACTURERS OF COMMUNICATIONS NETWORK COMPONENTS

Burnell & Company
YONKERS 2, NEW YORK
CABLE ADDRESS "BURNELL"

HAVE YOU CHECKED YOUR

PLANT PULSE LATELY?

ELECTRO MECHANICAL TYPE EM4115 SHOWN

AUTOMATIC VOLTAGE REGULATION WILL HELP CURE OPERATING DEFICIENCIES

STABILINE EM *Automatic* VOLTAGE REGULATORS

feature LOW COST and EFFICIENT OPERATION IMPROVE PERFORMANCE and REDUCE COSTS

Increased demands on today's electrical manufacturing equipment call for maximum performance, extended parts life and reduced maintenance. When incoming line voltages fluctuate, manufacturing inefficiencies and rising costs are bound to occur. To maintain constant voltage to equipment regardless of variations in line voltage or load current, install a STABILINE Automatic Voltage Regulator type EM (ELECTRO MECHANICAL).

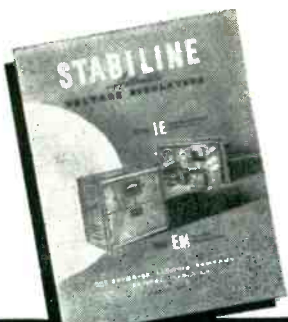
Simple and easy to install, a STABILINE type EM features high efficiency — zero waveform distortion — complete insensitivity to magnitude and power factor of load — adjustable output voltage and no critical adjustments.

	Nom. Output Voltage	Input Voltage Range	Output Voltage Range	Output Current (Amperes)	Output KVA	Type
Single Phase	115	95-135	110-120	17.5	2.0	EM4102
				52.0	6.0	EM4106
				130.0	15.0	EM4115
	230	195-255	220-240	32.5	7.5	EM4207
				120.0	27.5	EM4228
	460	400-520	420-460	15.0	6.6	EM4407
				40.0	17.6	EM4418
Three Phase	230	195-255	220-240	25.0	10.0	EM6210Y
				38.0	15.0	EM6215Y
				50.0	20.0	EM6220Y
				113.0	45.0	EM6245Y
				175.0	70.0	EM6270D
	460	400-520	420-460	16.0	12.5	EM6412Y
				22.0	17.5	EM6417Y
				33.0	25.0	EM6425Y
				66.0	50.0	EM6450Y
				100.0	75.0	EM6475Y
		420-500	420-460	131.0	100.0	EM64100Y

There's a STABILINE type EM to meet your need. Standard types are listed in the rating chart. For special requirements consult The Superior Electric Company, 405 Church St., Bristol, Conn.

STABILINE type IE (INSTANTANEOUS ELECTRONIC), a completely electronic unit with no moving parts, is available in ratings from 0.25 to 5.0 KVA.

Learn more about STABILINES type IE and EM. Write today for Bulletin S351 complete with application data, ratings, dimensions and circuit diagrams.



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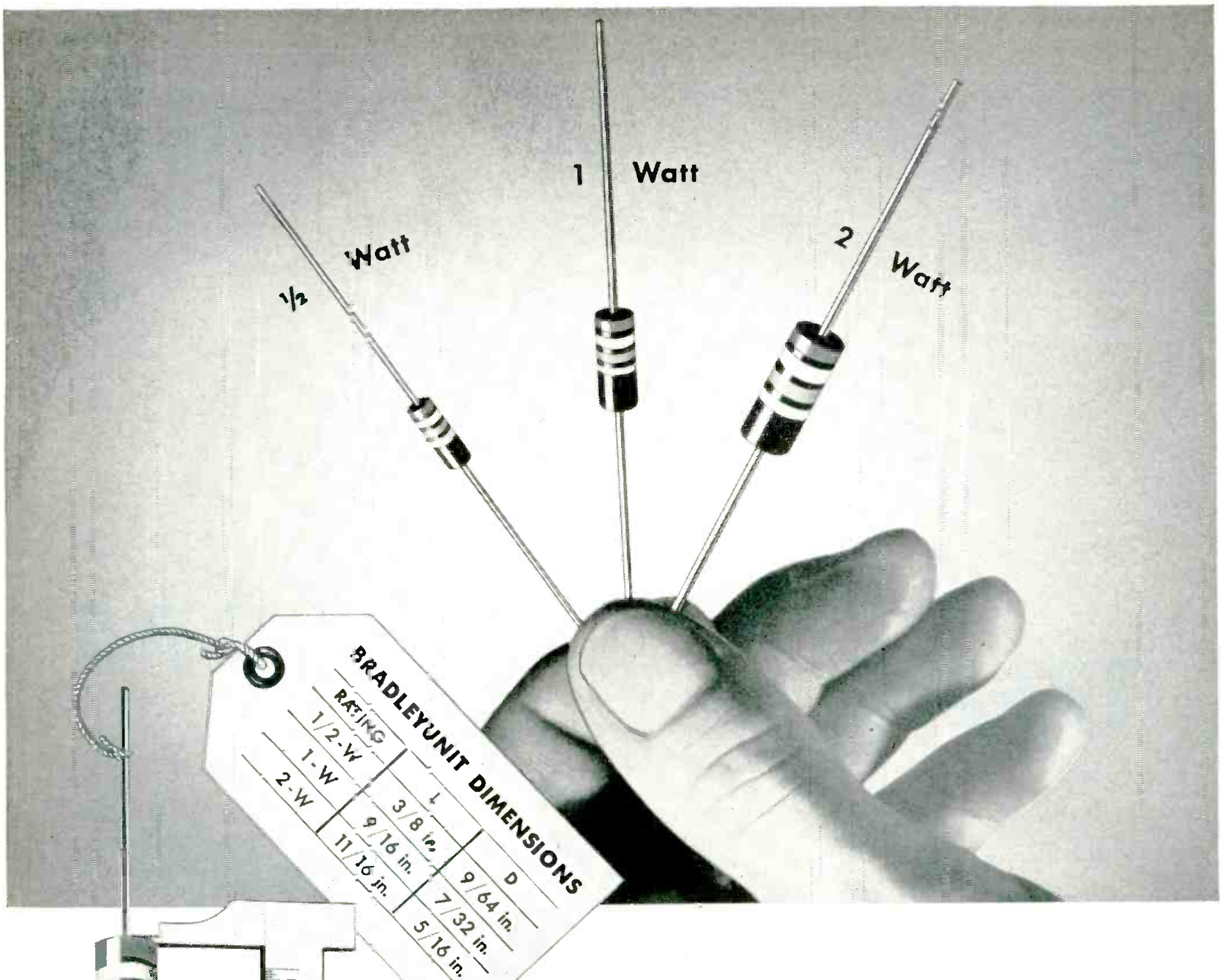
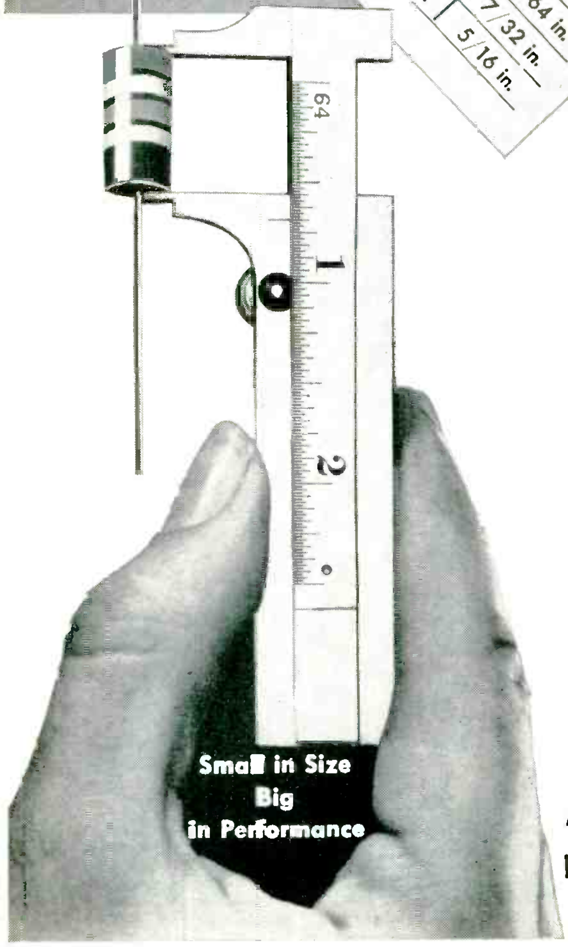
*Trade-mark.





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Bradleyunit resistors are solid molded. This construction assures stability and long life. Moreover, they are rated to operate continuously at 70C ambient temperature . . . not 40C. And, they need no wax impregnation to pass salt water immersion tests. Hence, they can withstand extremes of temperature and humidity without deterioration.

Made in standard R.T.M.A. values in 1/2 and 2 watt ratings from 10 ohms and 22 megohms; 1 watt from 2.7 ohms to 22 megohms. Let us send you a complete A-B resistor chart.

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A-B Quality

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for VARIABLE RESISTORS to MILITARY SPECIFICATIONS . . .

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EXCEPTIONALLY GOOD DELIVERY CYCLE ON MILITARY ORDERS due to tremendous precision mass production facilities.

Electronic engineers all over the world depend upon CTS for:
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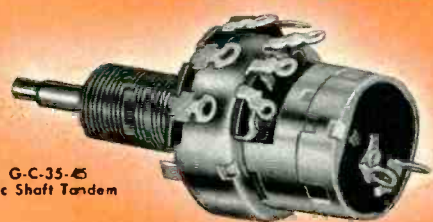
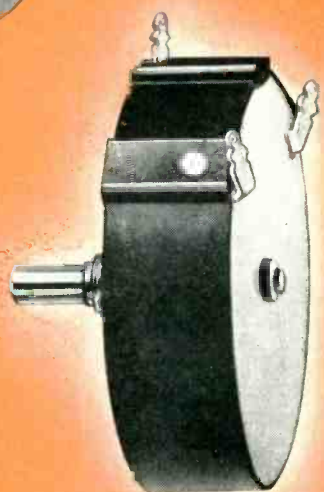
- Uniform high quality on a mass production basis.
- Each variable resistor thoroughly tested electrically and mechanically to assure top performance.
- Delivery when promised.

If you need variable resistors to exacting military specifications, let CTS specialists solve your problem.



Type G-C-35-45
Concentric Shaft Tandem

VARIABLE RESISTORS (COMPOSITION AND WIRE WOUND)



Type 85 NEW High Voltage, Electro-Static Focusing.

Type JJ-033 Microphone Jack

Type JJ-034 Phone Jack.

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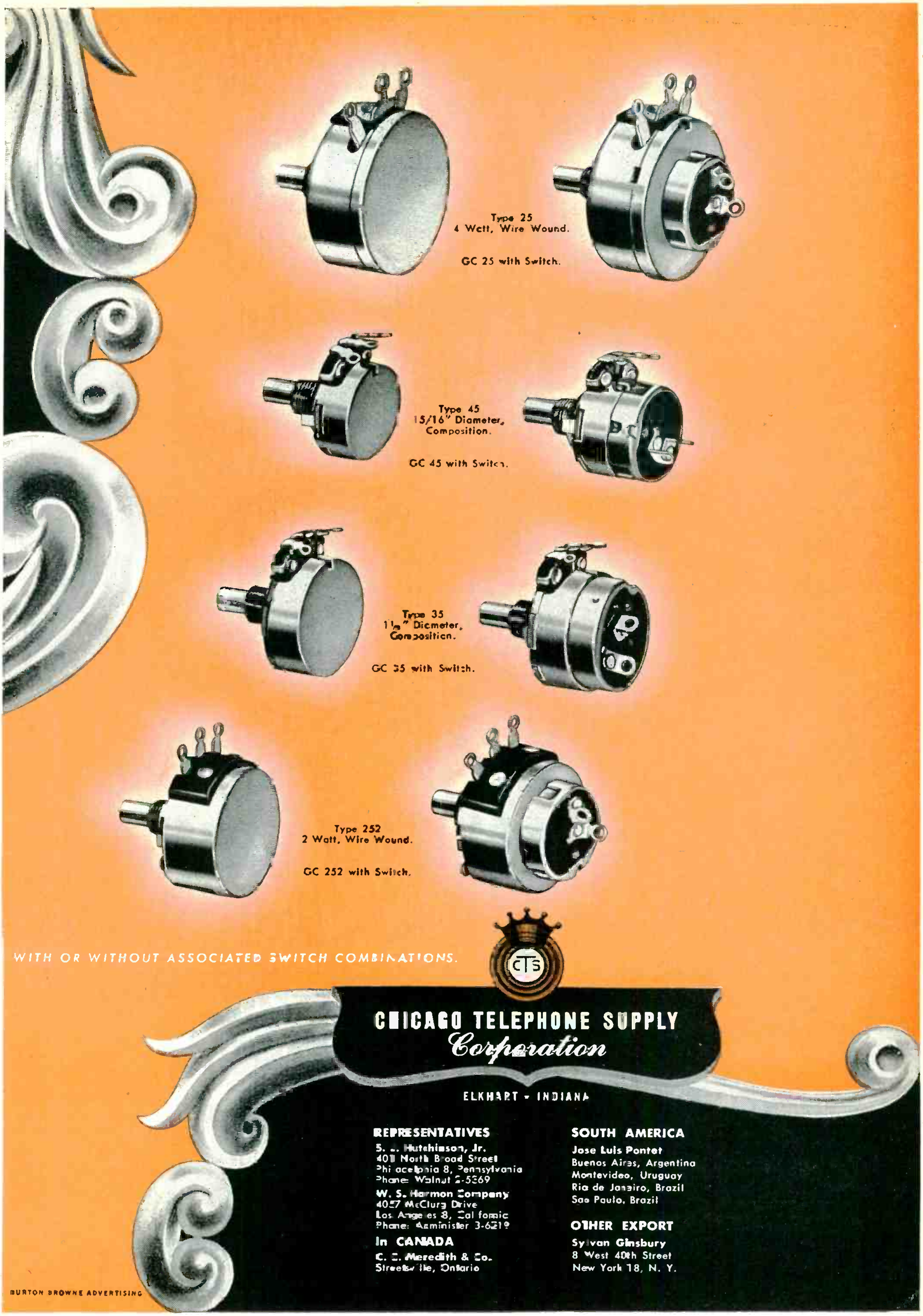

Type 25
4 Watt, Wire Wound.
GC 25 with Switch.
Type 45
15/16" Diameter,
Composition.
GC 45 with Switch.
Type 35
$1\frac{1}{8}$" Diameter,
Composition.
GC 35 with Switch.
Type 252
2 Watt, Wire Wound.
GC 252 with Switch.
WITH OR WITHOUT ASSOCIATED SWITCH COMBINATIONS.
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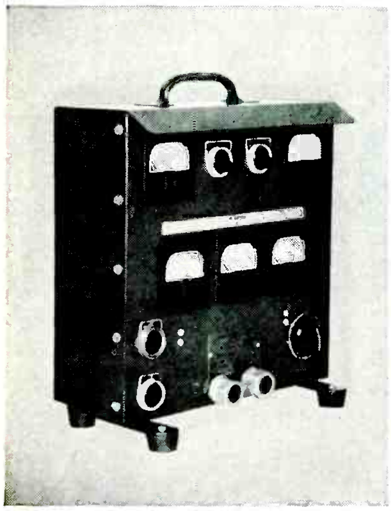
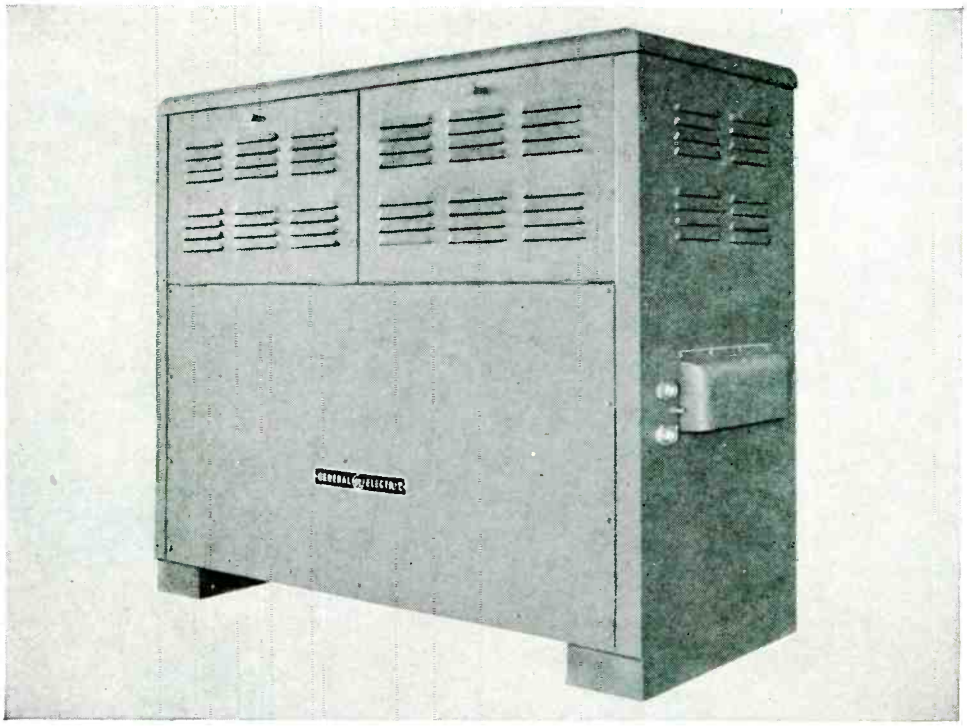


Operator's Control Unit



Motor-Generator-Type Frequency Changer

PACKAGED FREQUENCY CHANGERS

400-Cycle Ground Power Supply for Aircraft Radar Units

Here's a low-cost, high-performance, 400-cycle ground power supply with a regulated output voltage adjustable from 187 to 229 volts. It's rugged enough for permanent installation, yet compact enough to be moved on a fork truck. A 30-kva output rating is more than sufficient for virtually all radar, radio, or general load applications.

Voltage regulation: ±2 per cent variation under all conditions of balanced load, power factor, and heating, within normal operating range.

Voltage recovery: To within 5 per cent of steady-state value in 0.1 second.

Voltage adjustment: 187-229 volts in increments of 0.5 volts or less.

Wave shape: Low harmonic content.

Radio interference: Adequate suppression for most rigid applications.

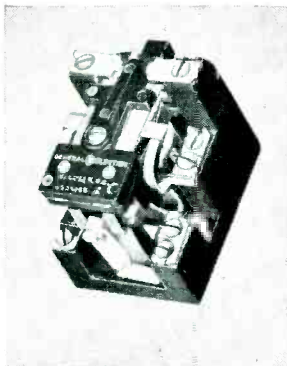
Enclosure: Dripproof cabinet houses motor, generator, and controls. A separate operator's panel contains "start-stop" push buttons, adjusting potentiometer, selector switches and meters.

For further data on these G-E frequency changers see Bulletin GEA-5589.

GENERAL ELECTRIC

TIMELY HIGHLIGHTS ON G-E COMPONENTS

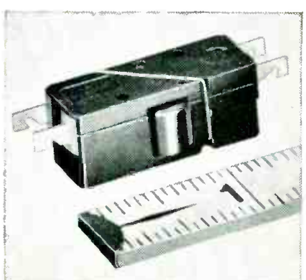
Husky Relays Mount 3 Ways Make or Break up to 45 Amps



For those heavy control-circuit applications, here's a versatile relay that can be front-connected, back-connected, or plug-in-connected, and is supplied in open or enclosed models. Circuits: spst, dpst, or dpdt.

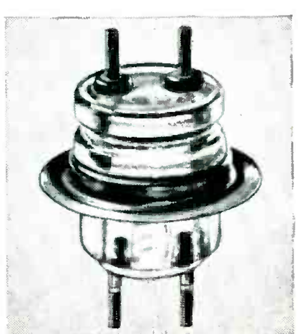
Heavy, long-lasting silver contacts carry 10 amps continuous. Normally open forms make or break 45 amps; normally closed forms make or break 20 amps. Coils are supplied for 12-, 24-, 115-, or 230-volt, 60-cycle a-c; for 6, 12, 24, 32, 125 or 250 volts d-c. Dimensions for enclosed model: 6 x 6 x 5 inches. Complete details are available in Bulletin GEC-257.

G-E Switchette Handles High Current in Crowded Quarters

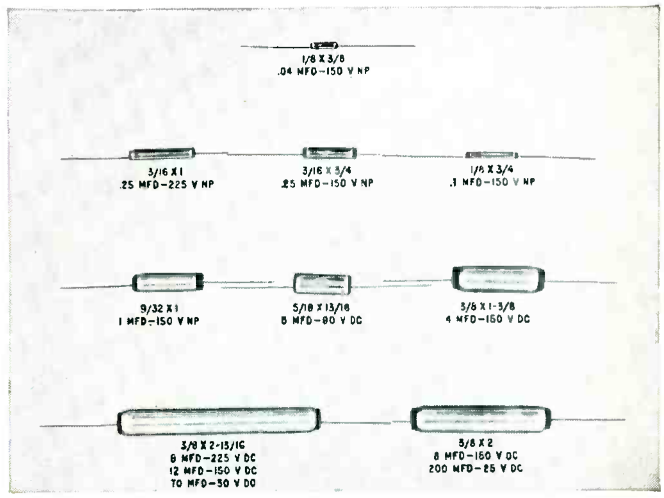


Though small and lightweight, the G-E switchette does the same work as many bulkier switches. Available in a wide variety of forms and circuits, this snap-action unit is approximately 1¼ x ½ x ½ inches, weighs only 9 grams, and operates dependably from sea level to 50,000 feet altitude. Contact arrangements available are single-circuit, normally open; single-circuit, normally closed; and two-circuit, one normally open and one normally closed. Rated ½ hp at 115 and 230 volts a-c, the switch is designed for ambient temperatures from −70F to +200F and meets the 50-hr salt-spray test for Specification AN-QQ-S-91. For full details, ask for Bulletin GEA-4888.

Cast-Glass Bushings Permit Hermetically Sealed Apparatus



Embedded nickel-steel hardware eliminates the need for gaskets and makes possible the soldering, brazing, or welding of G-E cast-glass bushings directly to apparatus. This assures gas-tight, oil-tight, or vacuum-tight construction. Extraordinary resistance to vibration and weather means the small, compact bushings are especially suited to aircraft applications or where high humidity occurs. They will not puncture or shatter under excess potentials. For full details ask for Bulletin GEA-5093A.



Tantalum + New Electrolyte = More Performance, Less Space

New G-E Tantalytic D-C Capacitors Feature

- Size and weight about the same as conventional electrolytics
- Over-all life as good as paper dielectrics
- Low-temperature properties and shock resistance better than either

By combining tantalum in foil form and a newly developed non-corrosive electrolyte, General Electric has designed a capacitor that packs superior performance into amazingly small space. Good stability, unusually low leakage currents, and hermetic sealing are additional advantages. Operating range is from −55C to +85C. Ratings presently available range from 0.02 muf to 12 muf at 150 volts d-c. Capacitors shown in illustration are representative. For additional information, furnish requirements such as temperature range, leakage resistance values, and operating voltage in writing to *Capacitor Sales Division, 42-304, General Electric Company, Pittsfield, Mass.*

General Electric Company, Section A667-15
Schenectady 5, N. Y.

Please send me the following bulletins:

(✓) Indicate for reference only

(X) For planning an immediate project

☐	GEC-257A	General-Purpose Relay
☐	GEA-4888	Size 1 Switchette
☐	GEA-5093	Cast-Glass Bushings
☐	GEA-5589	Packaged Frequency Changer

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We Must Pay As We Go

We must do our utmost to pay as we go for our present defense program.

On that proposition those who speak with authority are remarkably well agreed. This editorial – the second in a series on our mobilization for freedom – sets forth in simple terms why there is this agreement.

Next year – the fiscal year beginning next July 1 – the federal government's budget calls for the expenditure of $10 billion more than is scheduled to be collected in taxes. The deficit is due to the increase in defense expenditures.

A part of this deficit can be eliminated by cutting non-essential expenditures and increasing efficiency in the defense program. There is wide agreement on this. It is the duty of the President and Congress to see that it is saved.

How the remaining deficit anticipated in the federal budget–$5 billion to $10 billion–is handled is crucial. The government can meet it by raising taxes–by paying as we go. Or it can borrow, issuing more government bonds.

Borrow Again?

We relied heavily on borrowing in both World War I and World War II. In World War I only about one-third of the expenditures of the federal government were met by taxation. In World War II about 45 percent were met in this way. The rest we borrowed. Some people ask, why can't we rely heavily on borrowing again? Why is it crucially important to avoid adding $5 billion to $10 billion to a federal debt that is already $257 billion?

Part of the answer is found in the contrast between this defense program and our all-out effort of World War II. Another part–and one that is all-important in combatting inflation–results from the rapid decline in the purchasing power of the American dollar in recent years.

We went "all out" in World War II. We put almost half of everything we produced into our military effort. Taxes high enough to pay the financial costs as incurred would have meant huge tax increases. It was feared that such increases would kill financial incentives to get "all out" production. Since we expected the war to be short, borrowing seemed a safe expedient. Price control and rationing, with wartime patriotism to give them effective support, were relied upon to keep in check the inflationary pressure created by borrowing rather than taxing.

Our present defense program is scheduled to take a much smaller share of our production, but to take it over a much longer period. At its peak, the program as now planned will take only about 20 percent of our total national production. But, to use General Bradley's phrase, "the conditions under which we labor may persist for ten, fifteen and twenty years."

What About Controls?

For a period of any such duration it would be foolhardy to expect that the sort of controls we had for the few years of World War II could hold in check the inflationary pressure created by not paying as we go. It would be as foolhardy as it would be for a family to plan on borrowing to pay the expenses of a member discovered to be afflicted by a chronic ailment which might last a long lifetime.

Obviously, the only safe thing to do in such a case would be to adjust the family budget so that the expenses of the illness would be paid currently.

Our heavy reliance on borrowing in World War II had consequences which block a successful repeat performance.

If the borrowing had been done by persuading individuals to transfer their savings into government bonds, relatively little inflationary pressure would have been created. What the government would have spent with the proceeds of such bond sales would have been subtracted from the money individual consumers could spend.

But most of the borrowing was done from banks. That course expanded the amount of money available to the government without any offsetting subtraction of money from the hands of individuals. Thus, when direct price controls were removed after the war, this bottled-up purchasing power contributed to a price inflation which has cut purchasing power of the American dollar about in half — and decidedly changed the attitudes of the American people toward that dollar.

During World War II, Americans in general believed that:

The war would not last long.

The dollar would hold its value, and even gain value after the war.

Many wonderful new products would be available in the postwar period.

Today the American people have:

Seen the value of their dollars melt away fast.

Been assured that, at best, we may have a 10-15-20-year pull ahead.

Been warned not to expect a postwar paradise anytime soon.

One result of these changed attitudes is a notable lack of enthusiasm for government bonds on the part of individual investors. This is indicated by the fact that since Korea redemptions of E bonds have exceeded sales by about $600 million. Another result is a continuing rush to convert dollars into physical goods and equipment or claims on them. This trend weighs against financing the prospective federal deficit by borrowing from individuals.

Borrowing from banks to meet the deficit would again add fuel to inflation.

The prospective deficit is due to federal expenditures for military goods. Even if they are not blown up or shipped abroad, these goods will not be available to civilians. But the money paid to those who produce military goods will still be available to bid up the prices of civilian goods. Thus, at a time when people show relatively little disposition to save dollars, a menacing inflationary pressure — an inflationary gap, the economists call it — will be created.

If our fight against inflation is to be successful this gap must be closed by taxes. We need to do other things, too, for inflation has many different causes. Credit expansion must be effectively controlled. Production of civilian goods must be increased as much as possible by eliminating waste and inefficiency. But a pay-as-we-go tax program is basic to a successful attack on inflation. And inflation — unless it is checked — could wreck our defense effort.

We cannot pay as we go merely by soaking harder the corporations and those in the upper income brackets.

As the President's Council of Economic Advisers has reported, "by far the largest part of the additional revenue must come from the middle and lower tax brackets. These are the brackets in which the great bulk of the income is located."

Taxes Can Attack Inflation

By spreading tax increases broadly, taking small amounts from many people, inflationary pressure would be effectively reduced. It is the expenditures of the great mass of people, rather than the small numbers in the upper income tax brackets, that create most of the pressure. Moreover, it is possible to increase taxes broadly without killing the economic incentives to produce. Maintaining these incentives is essential to the success of the defense effort.

Our elected representatives cannot be expected to be enthusiastic about a pay-as-we-go tax program. It involves increasing the taxes of the great body of their constituents, an operation completely lacking in political glamour. However, such a program also involves the integrity of the American dollar. And that is absolutely essential to the success of the defense program. We shall be very foolish if we do not let our leaders know that we want them to do everything possible to pay as we go.

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It's a fact that

✔ Some of the very low expansion AlSiMag Ceramics have excellent heat shock qualities and can be heated red hot and suddenly cooled without damage.

✔ AlSiMag Ceramics are ideal elastic bodies. They do not show any plastic deformation and retain their original shape after release from strain.

✔ AlSiMag Ceramic plates can be ground to a flatness of 1 or 2 light bands, and retain this flatness even if subjected to severe temperature changes. What could be better as a reference subject?

✔ AlSiMag Ceramics can be made with varying thermal expansions to match those of many other materials. You can match the expansion of AlSiMag Ceramics with many glasses and metals and obtain a fit which will be retained indefinitely.

ALSIMAG

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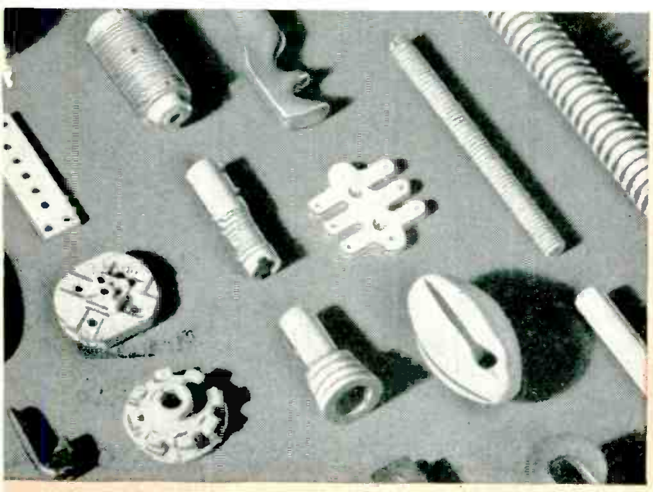

• Submit your difficult material requirements to American Lava Corporation and you will obtain free consultation for the best material for your application and helpful recommendations for solving your designing problems.

• It is this service which has given American Lava Corporation the reputation as THE consulting firm among ceramic manufacturers.

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and in producing new navigation and safety devices

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Capacitors • Trimmers • Choke Coils • Wire Wound Resistors

HI-Q TEMPERATURE COMPENSATING CAPACITORS

These high voltage tubular capacitors are available in capacities from 25 mmf. to 250 mmf. Units with working voltage of 3000 V. D. C., are 1.840″ long with .375″ diameter. Those between 500 V. D. C. and 3000 V. D. C. are slightly smaller. All are Durez coated and made of temperature compensating materials.

In the air, where space and weight are at a premium, the value of the minute compactness of **HI-Q** Components is vividly dramatized. Of equal importance is their never failing dependability under any and all conditions. For let a single small unit fail, and life itself may hang in the balance.

The same high engineering standards and unvarying quality which have made **HI-Q** a leader with producers of aircraft equipment, have found equal favor with other electronic manufacturers. Individual tests of every single component at each stage of production, and as a part of final inspection, insure the precise adherence to specifications, ratings and tolerances. That is one reason why **HI-Q** is now serving virtually every leading producer of television, communications and other electronic equipment. Another is the ready availability of **HI-Q** engineers to cooperate in the development of new components to meet specialized needs.

BETTER 4 WAYS

- PRECISION
- UNIFORMITY
- DEPENDABILITY
- MINIATURIZATION

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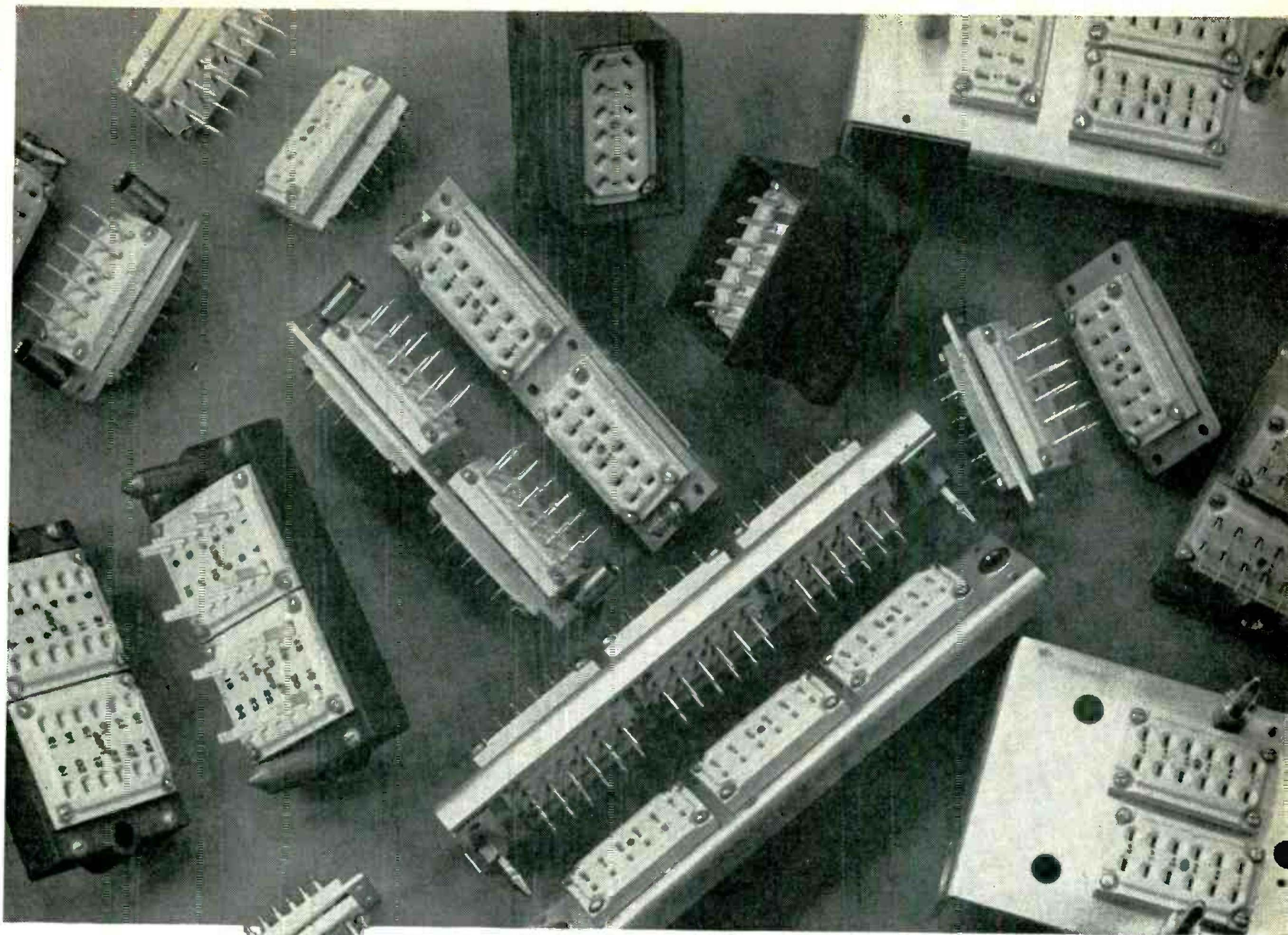
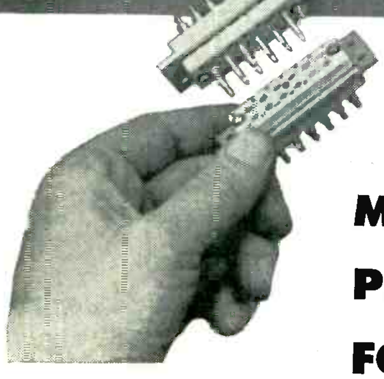
OLEAN, N. Y.

SALES OFFICES: New York, Philadelphia, Detroit, Chicago, Los Angeles

PLANTS: Olean, N. Y., Franklinville, N. Y. Jessup, Pa., Myrtle Beach, S. C.

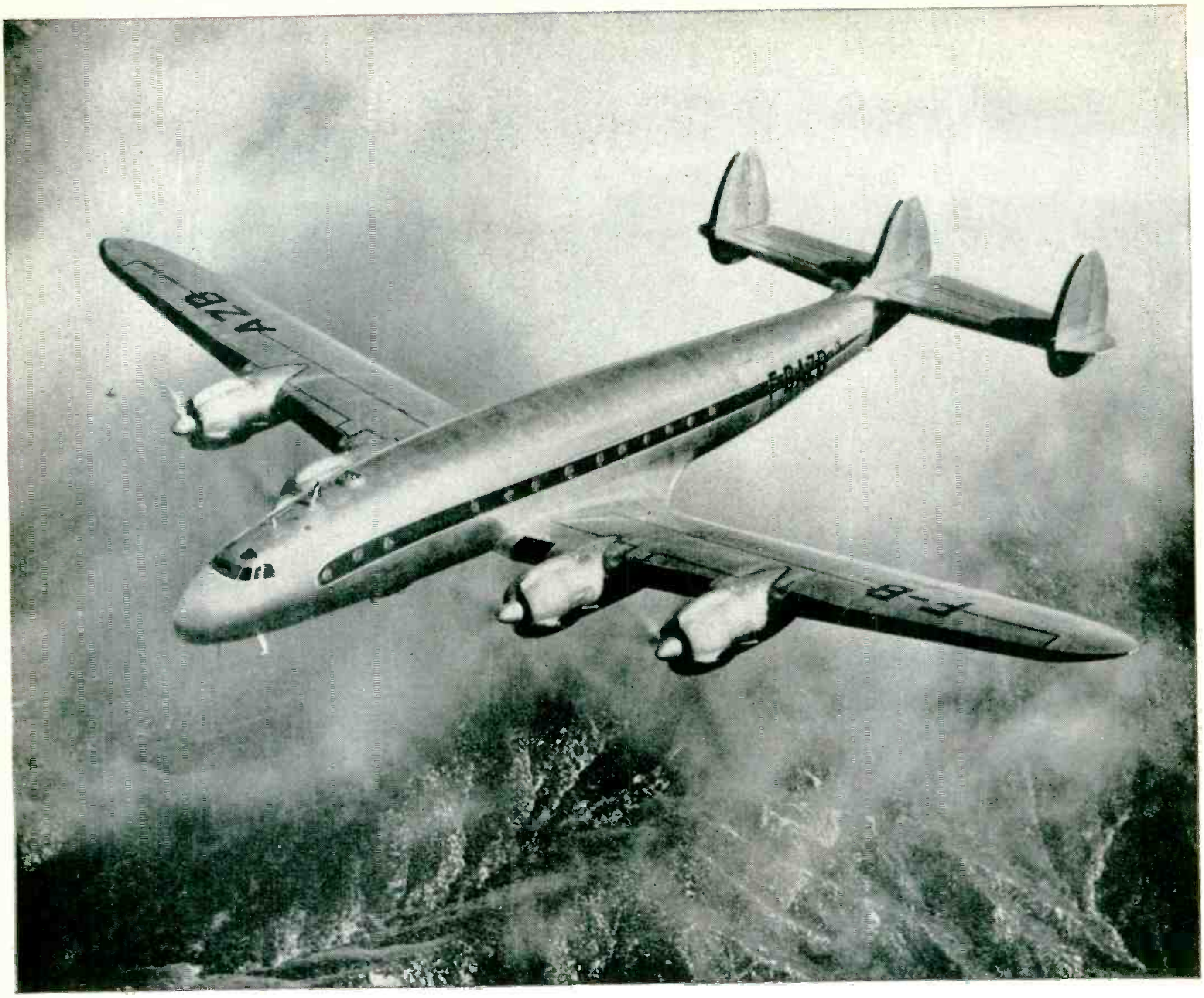




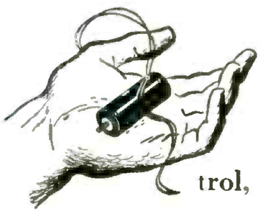
MULTIPLE-CONTACT PLUG-RECEPTACLE UNITS FOR SECTIONALIZING CIRCUITS

FOR panel-rack or other sectionalized circuits, Lapp offers a variety of plug-and-receptacle units, some of which are shown above. Any number of contacts can be provided (in multiples of twelve). Male and female contacts are full-floating for easy alignment and positive contact. Contacts are silver-plated, terminals tinned for soldering. Polarizing guide pins are provided where desired. Insulation is Steatite, the low-loss ceramic which is non-carbonizing even under leakage flashover resulting from contamination, moisture or humidity. Write for complete electrical and mechanical specifications of available units or engineering recommendations for an efficient component for your product. Radio Specialties Division, Lapp Insulator Co., Inc., LeRoy, N.Y.

Lapp



Hummingbirds that boss Eagles . . .



In the realm of the airman, where tiny high-precision motors regulate intricate systems of instrumentation and control, Kollsman miniature motors have no peer.

In fact, these accurate and dependable units have been a Kollsman specialty for years.

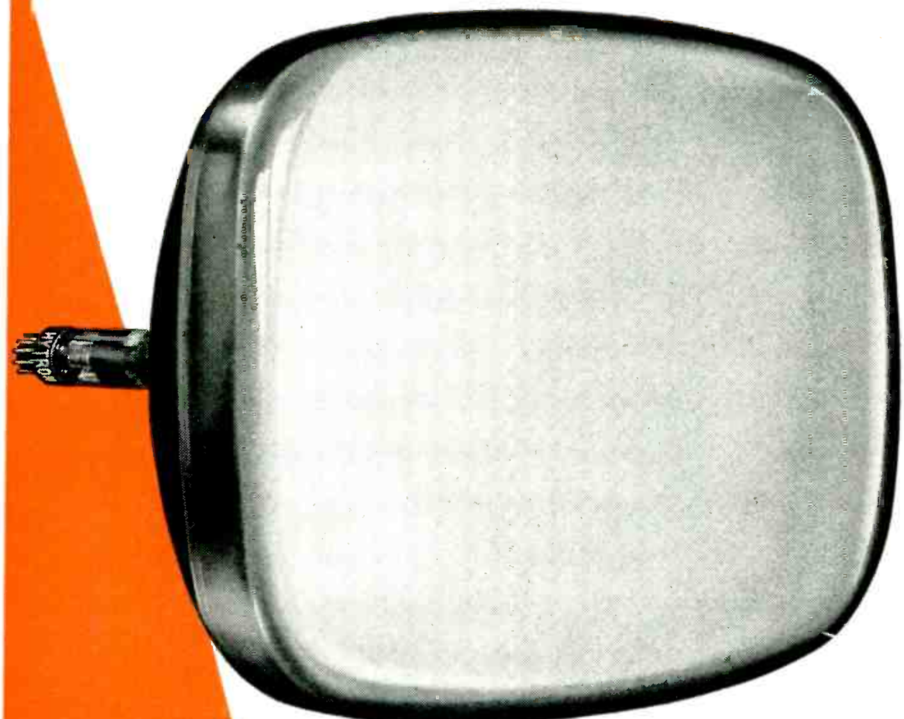
Yes, throughout aviation history—where hummingbirds have had to boss eagles—Kollsman has won renown for doing the job inimitably well.

***for precision and dependability look to* KOLLSMAN**

INSTRUMENT CORPORATION

Elmhurst, New York • Glendale, California

NEW ELECTROSTATIC RECTANGULAR 20FP4



ANOTHER

HYTRON FIRST

FOR YOU

To its logically designed original *studio-matched* rectangular, Hytron now adds new advantages: the cobalt-and-copper savings of electrostatic focus.

The original Hytron electrostatic type 20FP4 eliminates the magnetic focus unit. Uses a single-field ion-trap magnet. Yet the 20FP4 gives you unsurpassed, clear, sharp pictures . . . despite economies in associated components enforced by defense needs.

Seeing is believing. Watch for this newest Hytron first from the world's most modern picture-tube plant. You'll be seeing it, buying it soon. You'll marvel at its sharp pictures, even at lower line voltages.

Again you'll say it pays to stay out front in picture tubes. It pays to insist on Hytron's original *studio-matched* rectangulars . . . choice of 9 out of 10 leading TV set makers.

MANUFACTURERS OF RECEIVING TUBES SINCE 1921

HYTRON

RADIO AND ELECTRONICS CORP.

HYTRON RADIO TUBES

MAIN OFFICE: SALEM, MASSACHUSETTS

HAVE YOU GOT YOUR COPY?

The new 5th edition of the Hytron Reference Guide for Miniature Electron Tubes is out. See your Hytron jobber. Get your free copy of this old friend brought up to date today.

improve your product with —

MYCALEX

THE OUTSTANDING **LOW LOSS** HIGH FREQUENCY **INSULATION** FOR OVER A QUARTER OF A CENTURY

MYCALEX is a highly developed glass-bonded mica insulation backed by a quarter-century of continued research and successful performance. Both pioneer and leader in low-loss, high frequency insulation, MYCALEX offers designers and manufacturers an economical means of attaining new efficiencies, improved performance. The unique combination of characteristics that have made MYCALEX the choice of leading electronic manufacturers are typified in the table for MYCALEX grade 410 shown below. Complete data on all grades will be sent promptly on request.

MYCALEX is efficient, adaptable, mechanically and electrically superior to more costly insulating materials

- **PRECISION MOLDS TO EXTREMELY CLOSE TOLERANCE**
- **READILY MACHINEABLE TO CLOSE TOLERANCE**
- **CAN BE TAPPED THREADED, GROUND, SLOTTED**
- **ELECTRODES, METAL INSERTS CAN BE MOLDED-IN**
- **ADAPTABLE TO PRACTICALLY ANY SIZE OR SHAPE**

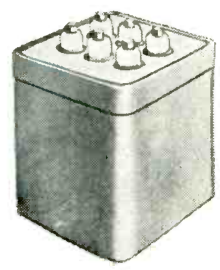
MYCALEX is available in many grades to exactly meet specific requirements

CHARACTERISTICS OF MYCALEX GRADE 410

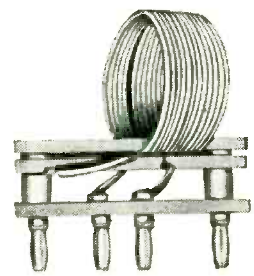
Meets all the requirements for Grade L-4A, and is fully approved as Grade L-4B under Joint Army-Navy Specification JAN-1-10

Power factor, 1 megacycle	0.0015
Dielectric constant, 1 megacycle	9.2
Loss factor, 1 megacycle	0.014
Dielectric strength, volts/mil	400
Volume resistivity, ohm-cm	1×10^{15}
Arc resistance, seconds	250
Impact strength, Izod, ft.-lb/in. of notch	0.7
Maximum safe operating temperature, °C	350
Maximum safe operating temperature, °F	650
Water absorption % in 24 hours	nil
Coefficient of linear expansion, °C	11×10^{-6}
Tensile strength, psi	6000

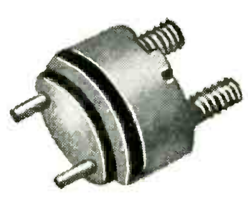
MYCALEX is specified by the leading manufacturers in almost every electronic category



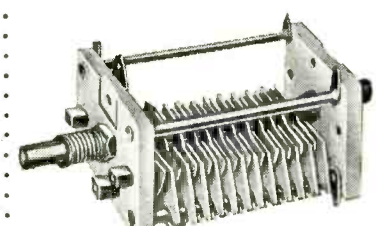
TRANSFORMER WITH MYCALEX-METAL ASSEMBLIES TO GIVE TIGHT SEAL



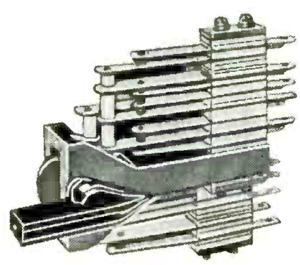
MYCALEX COIL HOLDER AND BASE



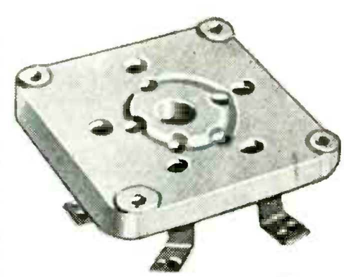
TERMINAL BASE ASSEMBLY FOR FIRE DETECTION EQUIPMENT



CONDENSER WITH MYCALEX LOW-LOSS END PLATES



MULTI-POSITION LEVER SWITCH WITH MYCALEX SPACERS



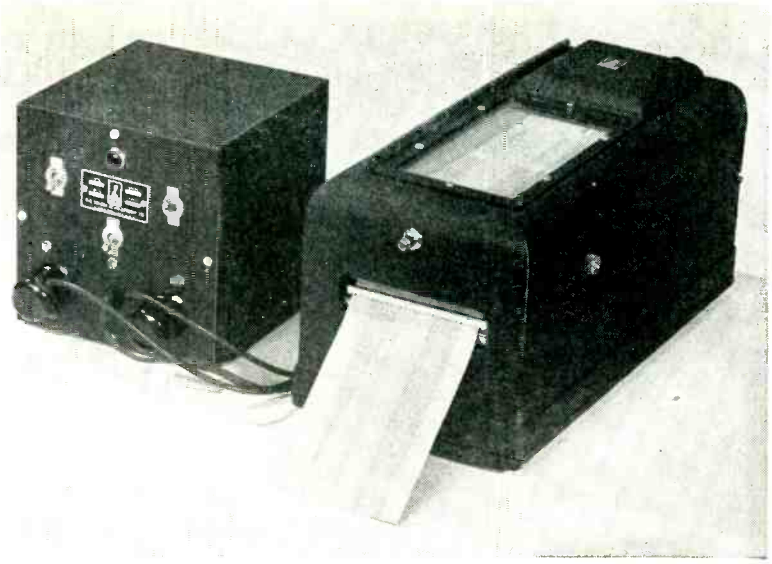
TUBE SOCKET OF MOLDED MYCALEX FOR HIGH FREQ. USE

SINCE 1919 MYCALEX THE INSULATOR TRADE MARK REG US PAT OFF

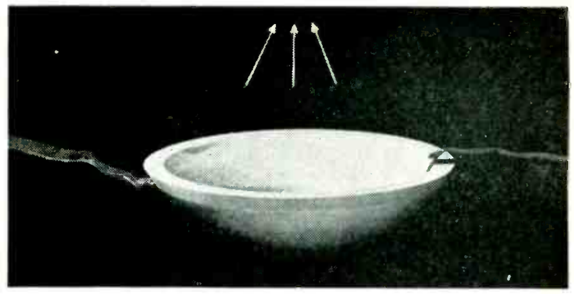
CORPORATION OF AMERICA

Owners of 'MYCALEX' Patents and Trade-Marks

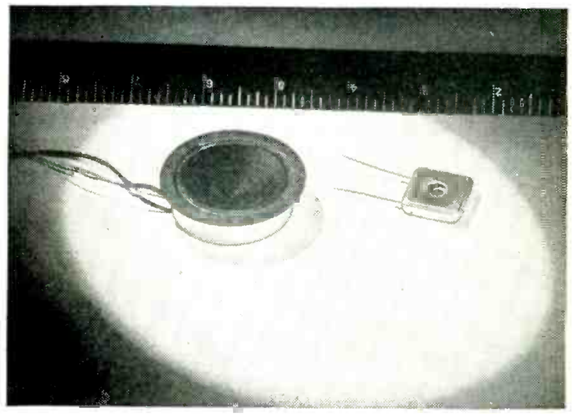
Executive Offices: 30 Rockefeller Plaza, New York 20 • Plant and General Offices: Clifton, New Jersey



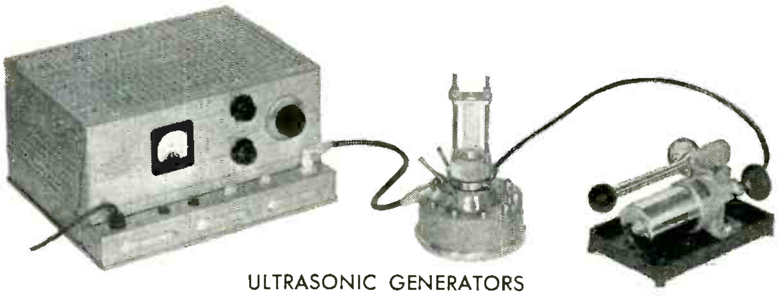
INSTRUMENTS



ULTRASONIC TOOLS



ACOUSTIC PRODUCTS



ULTRASONIC GENERATORS
(Laboratory Size)

"THIS IS Brush" OUR BUSINESS IS THE FUTURE

● The new and useful in the fields of Ultrasonics, Piezoelectric Crystals, Recording Devices, Acoustic Products, and Instruments are specialties for which we are equipped with comprehensive engineering and physical facility. Our research has been continuous, fruitful and helpful to many other companies besides our own.

We make finished products valued in industry for their precision and modernity . . . we make component parts for many of the nation's most respected companies and for the Armed Forces. We also do product development work. For our comprehensive booklet, "This is Brush", telling about Brush products and methods, write our Commercial Engineering Department.

Manufacturers of

ACOUSTICAL EQUIPMENT
- Microphones—General Purpose and Specialized
- Hearing Aid Microphones
- Earphones—Of Many Types

MAGNETIC RECORDING DEVICES
- Tape
- Plated Wire, Disc and Drum
- Multichannel Recorders
- Recording and Erase Heads
- Memory Storage Units
- Computer Components

RESEARCH AND INDUSTRIAL INSTRUMENTS
- Universal Strain Analyzers
- Surface Analyzers
- Multichannel Direct Writing Oscillographs
- AC, DC and Carrier-type Amplifiers
- Uniformity Analyzers
- Transient Recorders

PIEZOELECTRIC CRYSTALS

ULTRASONIC EQUIPMENT
- Generators and Analyzers
- Laboratory Equipment

THE BRUSH DEVELOPMENT COMPANY
3405 Perkins Avenue • Cleveland 14, Ohio

Excerpts from
ENGINEERING REPORTS
R. R. to H. W. C. to 8/30/50

Company "A"
pointed out considerable savings possible by shifting to Nylclad. Purchasing Department estimated this totals almost $50,000 for the year.

Company "B"
large motor manufacturer has made extensive tests with Nylclad. Savings resulting from use estimated $20,000. Engineer stated that none of competitive wires checked were nearly as good as Nylclad from heat and pressure resistance standpoint.

Company "C"
This manufacturer of special equipment has approved Nylclad on the basis of chief engineer's recommendation. Most enthusiastic about its resistance to the solvent action of hot varnish.

Company "D"
Winding foreman, previously highly critical, said, "Nylclad is great stuff — it got me out of a hole." He liked the high abrasion resistance against winding abuse.

Company "E"
Chief Engineer says Nylclad is the answer to many of his company's winding problems. Results of tests exceptionally good, particularly the resistance to softening under heat.

Company "F"
Engineer, after testing Nylclad, told buyer he was convinced it was excellent wire and recommended its use. He noted its uniform solderability.

NYLCLAD MAGNET WIRE combines the desirable properties of Formvar and Nylon types. Its tough, durable coating eliminates the need for paper- or textile-covered wires (in many applications) and reduces winding space requirements. It solders uniformly at 1050°F. Nylclad* provides increased toughness to resist winding abuses, increased solvent resistance, and resistance to softening under heat and hot varnish; it is not subject to solvent crazing. Nylclad's "slipperiness" means improved windability — more compact coils — many over-all plus values at *no* increase in price.

Belden Manufacturing Co.
4625 W. Van Buren St., Chicago 44, Illinois

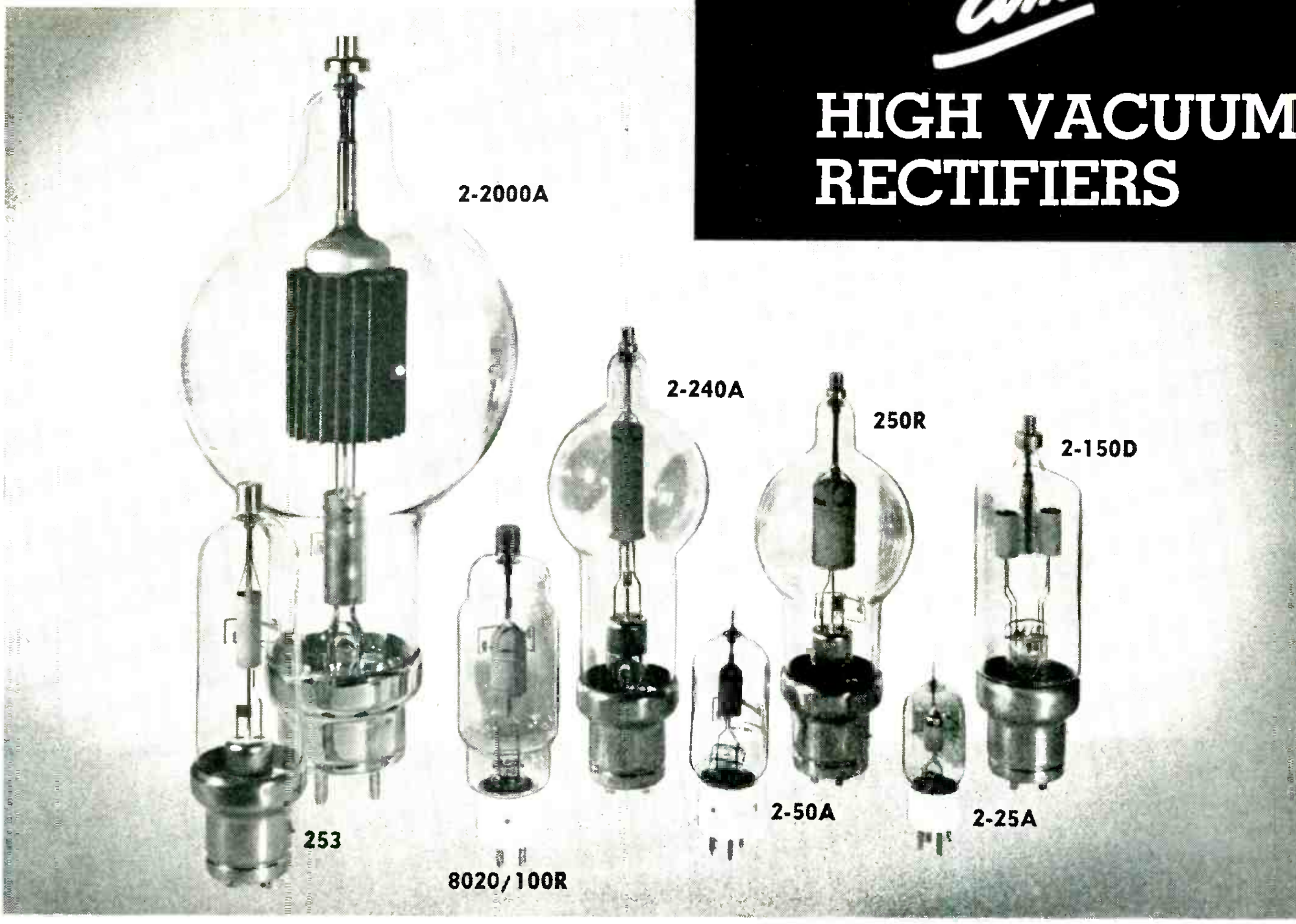
Nylclad* by Belden

*TRADE MARK

THE MAGNET WIRE WITH THE PERFECTED INSULATION

Eimac

HIGH VACUUM RECTIFIERS



Eimac's comprehensive series of vacuum rectifiers permits a choice of "per-tube" ratings of d-c plate current from 50 ma. to 750 ma. and a choice of inverse voltage ratings from 15,000 to 75,000 volts.

These are ruggedly constructed tubes built to withstand more than normal abuse in rectifying and voltage multiplying circuits or as diode clippers. Their design incorporates many of the features long associated with the famous Eimac transmitting tubes . . . Pyrovac plates . . . thoriated tungsten filaments . . . no troublesome internal insulating materials . . . and, of course, a "hard" vacuum.

Put Eimac high vacuum rectifiers to work for you. Write today for detailed data sheets giving complete operating information and application notes.

EITEL-McCULLOUGH, INC.
San Bruno, California

Export Agents: Frazar & Hansen, 301 Clay St., San Francisco, California

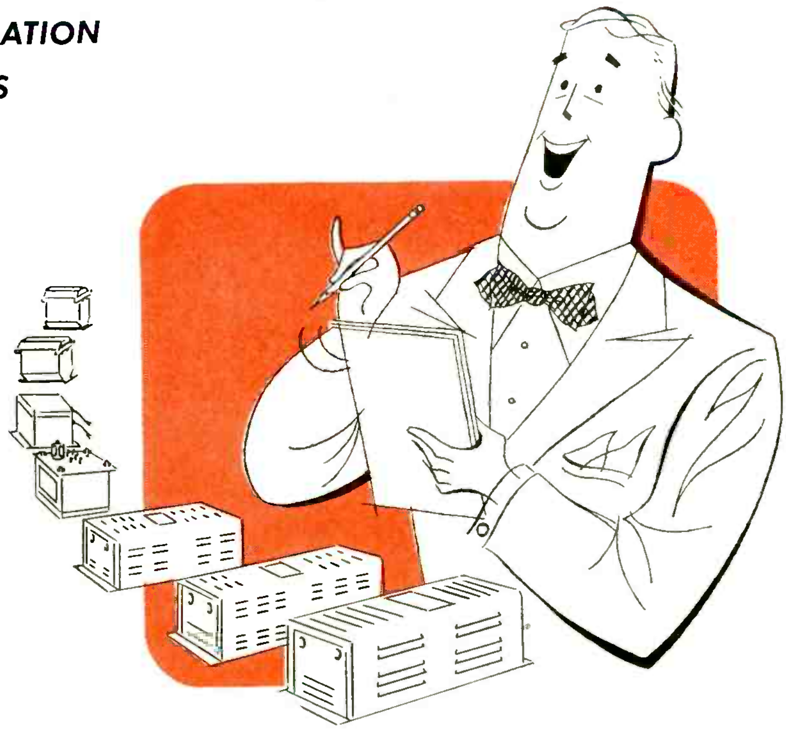
284

TYPE	DESCRIPTION	MAXIMUM DIMENSIONS Length Inches	Diameter Inches	AVERAGE PLATE CUR. Ma.	PLATE DISSIPATION Watts	PEAK INVERSE VOLTAGE Volts	FILAMENT Volts	Amps.
2-25A	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	4.5	1.5	50	15	25,000	6.3	3.0
2-50A	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	5.75	2	75	30	30,000	5.0	4.0
2-150D	High vacuum rectifier. High voltage medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8.88	2.75	150	90	30,000	5.0	13.0
2-240A	High vacuum rectifier. High voltage, high current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	11.25	4	500	150	40,000	7.5	12.0
2-2000A	High vacuum rectifier. High voltage, high current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	18	8.25	750	1,200	75,000	10.0	25.0
250R	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	10.25	4	250	150	60,000	5.0	10.5
253	High vacuum rectifier. High current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	9	2.75	350	100	15,000	5.0	10.0
8020/100R	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8	2.38	100	60	40,000	5.0	6.5

CHECK THE COMPLETE LINE OF

G-E Automatic Voltage Stabilizers

- FOR IMPROVED REGULATION
- FOR DECREASED COSTS



Need Dependable Voltage Control for One of These Applications?

Radio transmitters and radar equipment
Laboratory and factory testing equipment
Motion picture projectors
Precision photographic equipment
Electron microscopes
Calibration of electric instruments
Color comparators
Wheel balancing equipment
Radio testing devices
Telephone apparatus
Motion picture sound equipment
Photometers
X-ray filament circuits
Electronic apparatus
Electrochemical analysis
Full wave rectifiers
Electric furnaces
Heater units
Frequency oscillators
Communication systems
Temperature controls
Television equipment
Signal and alarm systems
Sound recording equipment
Life testing of bulbs
Small motors of instrument recording apparatus
Photographic lighting systems
(especially color-photography lighting)
Automatic developing and printing machinery
Photo-engraving equipment
Photocell fire control apparatus
Dielectric heaters
UHF beam relays
Aircraft landing systems
Simulated flight trainers
Electronically operated weight machines
Electrostatic paint spraying outfits
Magnetic measuring gauges
Oscillographs
Electrophoresis equipment
Moisture detection equipment
Gas analyzers and detectors
Instruments used to measure a difference
(such as in bridge circuits)

To provide closely controlled voltage for critical equipment, experienced designers select General Electric automatic voltage stabilizers. They get assurance that their equipment will operate better, longer, and more efficiently with the input voltage held close to nominal. You can't make a better investment!

Investigate G-E automatic voltage stabilizers for the answer to your voltage problems. They decrease field calls, increase customer satisfaction, and save money.

For complete details on how this equipment can help you, contact your local G-E representative. For additional information write for bulletin GEA-3634. General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC

411-88

fountain of youth*

A Zetka picture tube stays young . . . stays brilliant always . . . is sharply focused . . . safe . . . long lived. There's no old, dull, tired look on the face of a Zetka tube. It will always reflect the brightness of your reputation, because only Zetka utilizes the power-tube method of producing pace-setter picture tubes.

In addition, each and every Zetka tube (no spot checking permitted) is set-tested in the factory before being shipped. Here indeed is proof positive that Zetka is by far your best buy in picture tubes. Rectangulars and rounds in 16", 17", 19" and 20".

zetka*

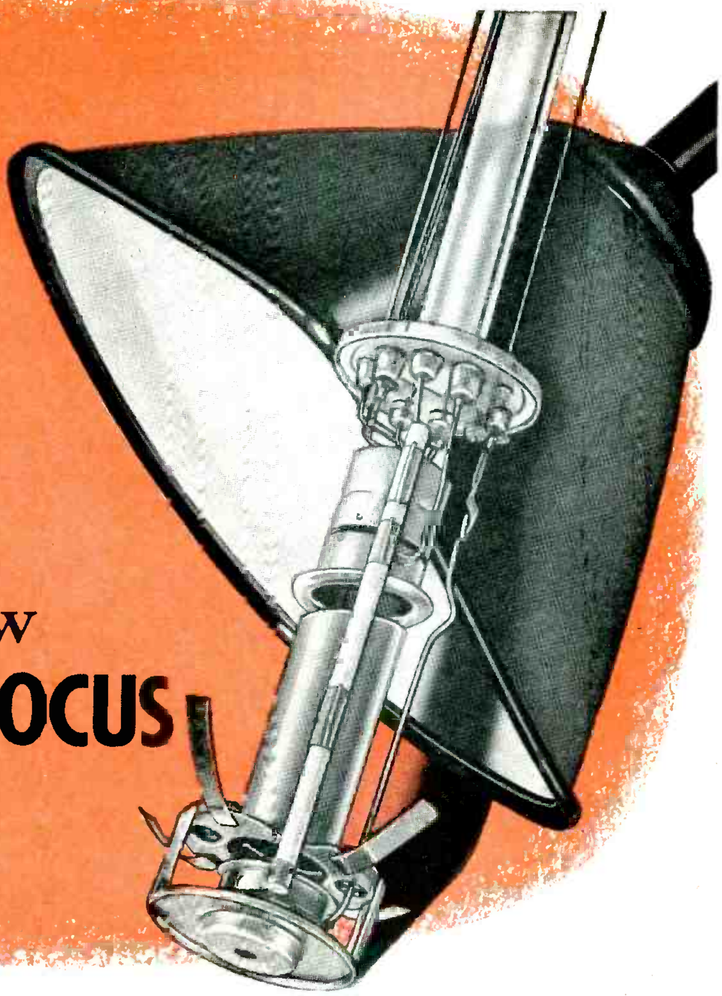
THE ARISTOCRAT OF TELEVISION TUBES

* *Most Trusted Name in Picture Tubes*

zetka TELEVISION TUBES, INC. 131-137 GETTY AVE. • CLIFTON, N. J.

For 37 years, Zetka has been a respected name in the radio and television industry.

Again a
D-H ALLOY
contributes as
RCA
introduces new
ELECTROSTATIC-FOCUS
TV TUBES



Once more, RCA leads the field! This time, with new rectangular picture tubes which require no focusing coil or focusing magnet . . . thus effecting important savings in critical materials.

The currently used magnetic focus in TV sets requires coils and magnets containing the metals cobalt and copper . . . both on the Government's restricted list.

To meet the shortages, RCA engineers have developed improved electrostatic focusing for wide-deflection-angle TV tubes—eliminating need for a focusing magnet or coil. Result: The new RCA kinescopes—which not only make possible savings in critical materials, but introduce advantages that destine them to become industry's most widely used picture tubes.

Such advantages, for example, as: (a) An improved electron gun which provides excellent uniformity of focus over the entire picture area, and is so designed that the focusing electrode takes negligible current—permitting voltage for the electrode to be supplied easily and economically; (b) Focus automatically maintained with variation in line voltage and adjustment of picture brightness; (c) Simplification of tube installation and adjustment for optimum performance.

When RCA produced its outstanding Image Orthicon, "eye" of the television camera, it called upon the superlative Driver-Harris radio alloy Nichrome* V to provide 95% of the metal components of the tube. Now, in the case of the kinescopes, a Driver-Harris produced alloy fills a need.

Here are typical examples of how Driver-Harris stands ready to serve all industry with alloys necessary for new or standard applications.

During the present emergency, of course, strategic materials and the alloys made from them are on strict allocation. However, we shall be glad to make recommendations based upon your specific needs, and serve you to the best of our ability.

Makers of world-famous Nichrome and over 80 other alloys for the electronic, electrical and heat-treating fields*

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

In Canada: The B. GREENING WIRE COMPANY, LTD., Hamilton, Ontario, Canada

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

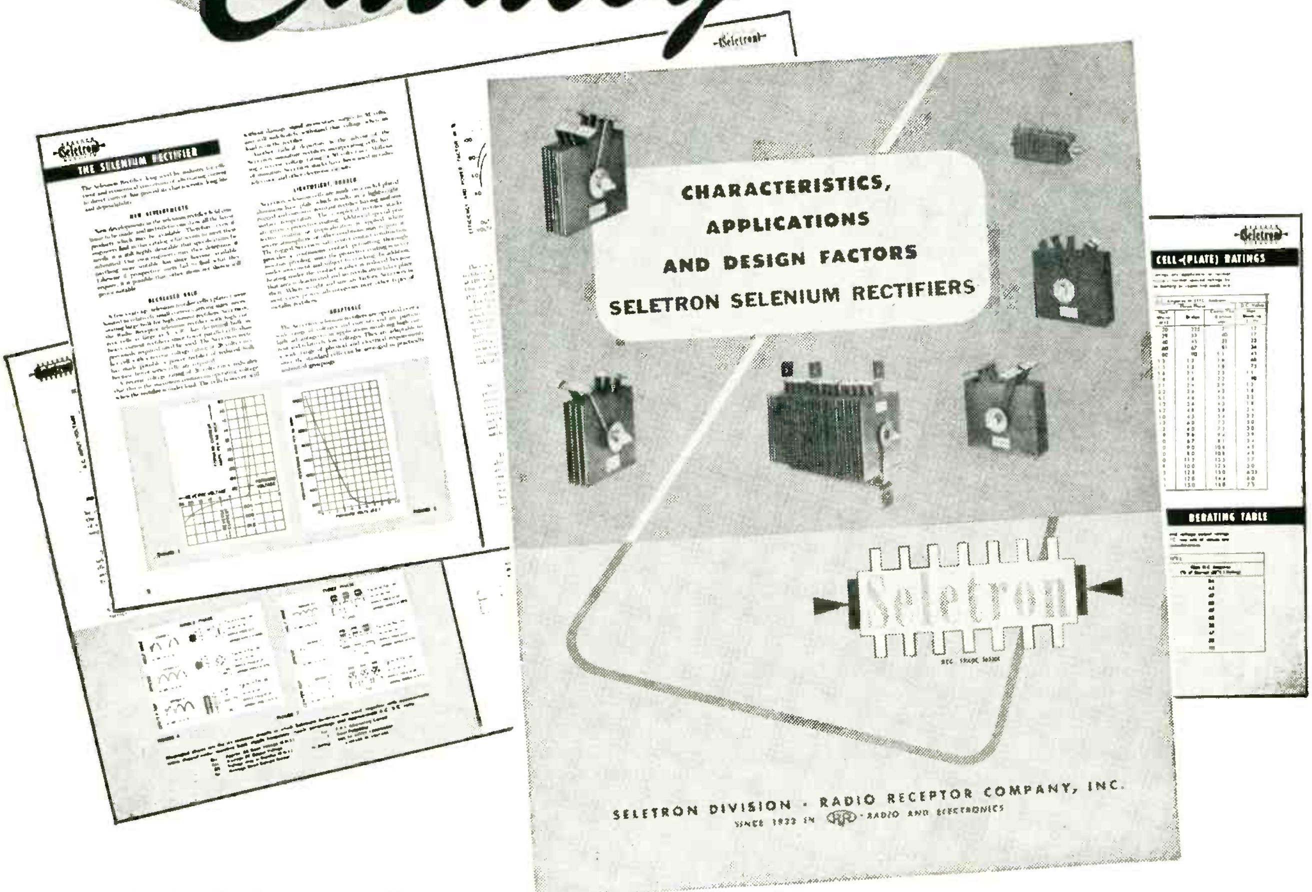
*T. M. Reg. U. S. Pat. Off.

16 PAGES OF VALUABLE RECTIFIER DATA...AND YOURS FOR THE ASKING!

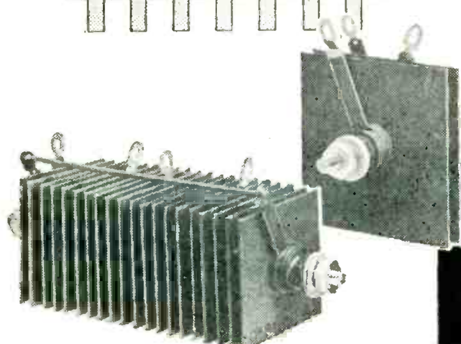
New

INFORMATION-PACKED SELETRON SELENIUM RECTIFIER

Catalog



Seletron



THIS NEW two-color, fully illustrated catalog just off the press belongs on your desk for handy reference. Includes comprehensive listings of dimensions and ratings for miniature SELETRON selenium rectifiers, as well as a large selected group of power stacks. Also contains complete background material on these versatile rectifiers and illustrates many of their uses.

Request *your* copy today—It's FREE, of course. When ordering, ask for new catalog No. ES-39.

SELETRON DIVISION

RADIO RECEPTOR COMPANY, INC.

Since 1922 in Radio and Electronics

Sales Department: 251 West 19th St., New York 11, N. Y.

Factory: 84 North 9th St., Brooklyn 11, N. Y.

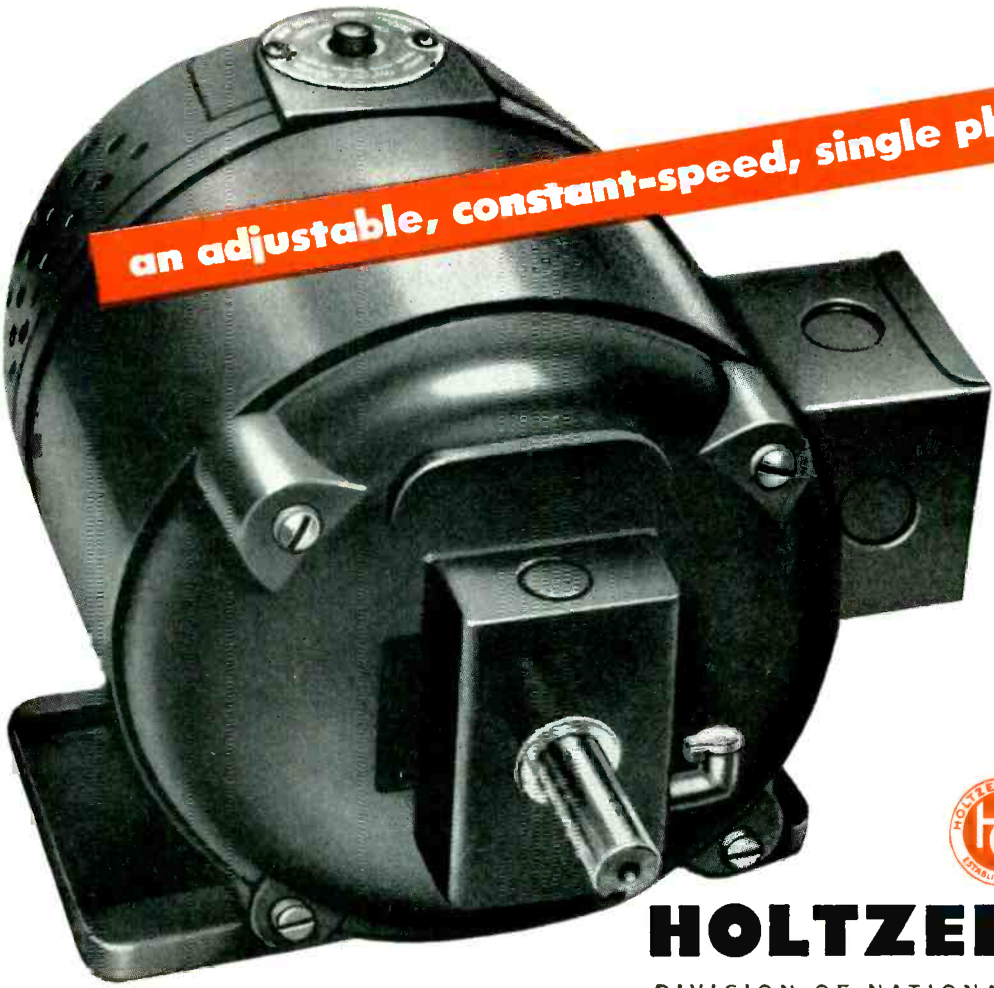
ANOTHER UNIQUE HOLTZER-CABOT PRODUCT

This adjustable motor satisfies a long-felt need. It converts AC electrical energy directly to mechanical energy, without use of tubes or other converting equipment. And its advanced design combines many other features. For example—

- standard controller provides 12 speeds with approximate 7 to 1 range, for instance, 3500 RPM to 500 RPM
- dial control gives smooth, instant change-over from one speed to another
- each speed setting remains constant regardless of variations in load
- instant starting at desired speed—no warm-up period, no lag
- maximum torque for starting under load and for rapid acceleration
- compact—no auxiliary equipment required—ideal for use as a built-in unit
- can be mounted for either local or remote control
- economical—the lowest-price motor unit of its kind, and easy to maintain

This new multi-speed motor is made for AC, single phase, 115 or 230 volts. It is suitable for any application where an adjustable-speed DC motor is used, and has an additional advantage—the starting and maximum torques increase rapidly at high speeds. This motor can be built to operate at speeds as high as 8000 RPM. (A *single-speed* model with the same characteristics is also available.) The fact that the RBA or RWA motor has a service life comparable to that of a DC motor opens up many new and important application possibilities.

an adjustable, constant-speed, single phase AC motor!



Holtzer-Cabot builds precision motors in a variety of types, ranging from the small instrument sizes up to heavy duty 1½ horsepower units. They meet demanding specifications for such varied applications as office and recording machinery, machine tools, fans, pumps, hoists, blower units, farm equipment, etc.

Into each Holtzer-Cabot motor goes the same engineering skill and manufacturing excellence that through the years have made Holtzer-Cabot the standard of high quality in motors. Write today for expert assistance in solving your motor problems.

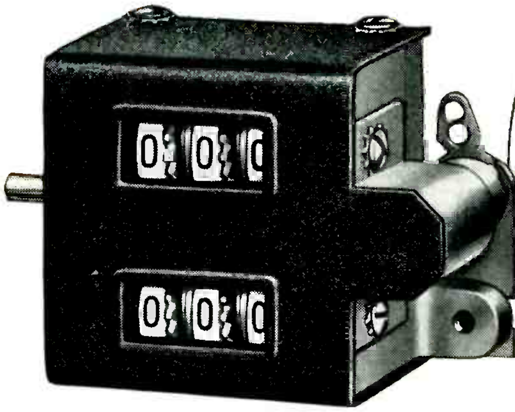
HOLTZER-CABOT ESTABLISHED 1875

HOLTZER-CABOT

DIVISION OF NATIONAL PNEUMATIC CO., INC.

BOSTON 19, MASSACHUSETTS

"Manufacturers of fine electrical apparatus since 1875"



"Round and 'round and 'round they go— and what they count only radarmen know!"

Everyone Can Count on VEEDER-ROOT

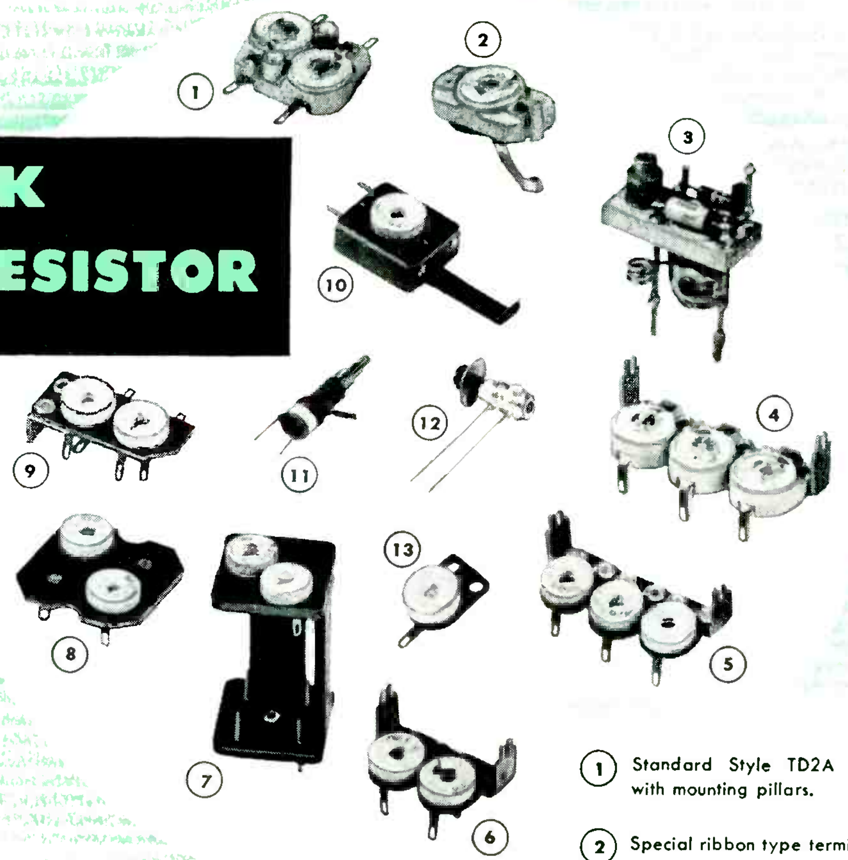
Yes, this time as before, every arm of the service counts on Veeder-Root in some way or other. The counters shown, for instance, supply figures that radarmen readily translate into vital information.

And there are scores of other Veeder-Root Counters, standard and special, electrical and mechanical, that "talk the language" of more military and civilian jobs than you can shake a slide-rule at!

VEEDER-ROOT INC.
HARTFORD 2, CONN. • GREENVILLE, S. C.
Montreal, Canada   Dundee, Scotland
Offices and agents in principal cities

VEEDER-ROOT COUNTERS *"Count Everything on Earth"*

ASK *Erie* RESISTOR



. . . about custom designed trimmers

Pictured above are several custom designed trimmers that incorporate the elements of standard Erie Disc and Tubular Ceramicon Trimmers. Each has been developed for a specific purpose, and each does its job efficiently and economically. Proper design and precision manufacturing, plus our years of experience, are the keynote to Erie quality.

Look at these units carefully. They should suggest the possibility of using Erie Resistor know-how and facilities to make your equipment more compact and more efficient.

Erie has the most complete trimmer line in the industry. We would like to work with you on combining trimmers, fixed capacitors, and other circuit elements into integrated sub-assemblies. Inquiries should specify complete mechanical and electrical requirements.

(1) Standard Style TD2A Dual Trimmer with mounting pillars.

(2) Special ribbon type terminals on standard Style TS2B Trimmer for direct connection to other components.

(3) Compact Trimmer—Capacitor—Resistor—Coil Design. A complete oscillator unit.

(4) (5) (6) Where special mounting is desired, standard Erie Style TS2A and Style 557 Trimmers can be supplied mounted on brackets.

(7) (8) Two trimmer elements become an integral part of this coil form and I. F. top section.

(9) Special bracket and terminal arrangements on dual trimmer unit.

(10) A compact pluggable assembly for mounting a trimmer in parallel with a plug-in crystal.

(11) Special tubular ceramic trimmer and variable inductance having one common terminal.

(12) Special steatite tubular dual trimmer.

(13) Standard Erie Style 557 Trimmer with special bent rotor terminal.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND . . . TORONTO, CANADA

Safe Arrival Anywhere Packaged in TEXLITE®

RUBBERIZED CURLED HAIR

Texlite is the lining material for cases, cartons and containers that cushions away ruinous "G's"—assures safe shipment of delicate and costly equipment to any corner of the globe. Yet Texlite simplifies and speeds packaging—makes every packer a skilled packer.

TEXLITE *rubberized curled hair*

- combines high deflection with low density—weight ranges from 3 to 5 lbs. cu. ft.
- is unaffected by changing moisture and temperature conditions.
- is dust free—fungus resistant.
- may be used again and again.
- is available in sheets, or die-cut to specified shape.

Other of our materials available for protective packaging are **SPONGEX®** cellular rubber, **SPONGEX CELL-TITE®** with almost zero water absorption and 0.28-0.30 K factor, and **TEXFOAM®** latex foam rubber. Perhaps one of these materials better meet your product's needs.

If you have a protective packaging problem, consult our packaging division. Let our laboratory analyze, and prescribe, the protective requirements for your products for safe shipment anywhere—by land, sea or air.

The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY

469 DERBY PLACE SHELTON, CONNECTICUT

If it's a problem calling for PRECISION POTENTIOMETERS

Bring it to Helipot

For many years The HELIPOT Corporation has been a leader in the development of advanced types of potentiometers. It pioneered the *helical* potentiometer—the potentiometer now so widely used in computer circuits, radar equipment, aviation devices and other military and industrial applications. It pioneered the DUODIAL*—the turns-indicating dial that greatly simplifies the control of multiple-turn potentiometers and other similar devices. And it has also pioneered in the development of many other unique potentiometric advancements where highest skill coupled with ability to mass-produce to close tolerances have been imperative.

In order to meet rigid government specifications on these developments—and at the same time produce them economically—HELIPOT* has perfected unique manufacturing facilities, including high speed machines capable of winding extreme lengths of resistance elements employing wire even less than .001" diameter. These winding machines are further supplemented by special testing facilities and potentiometer "know-how" unsurpassed in the industry.

So if you have a problem requiring *precision potentiometers* your best bet is to bring it to The HELIPOT Corporation. A call or letter outlining your problem will receive immediate attention!

**Trade Marks Registered*

In this panel are illustrated standard models of HELIPOT multi-turn and single-turn precision potentiometers—available in a wide range of resistances and accuracies to fulfill the needs of nearly any potentiometer application. The Beckman DUODIAL is furnished in two designs and four turns-ratios, to add to the HELIPOT usefulness of the HELIPOT by permitting easy and rapid reading or adjustment.

A B C

MODELS A, B, & C HELIPOTS
A—10 turns, 46" coil, 1-13/16" dia., 5 watts—resistances from 10 to 300,000 ohms.
B—15 turns, 140" coil, 3-5/16" dia., 10 watts—resistances from 50 to 500,000 ohms.
C—3 turns, 13-1/2" coil, 1-13/16" dia., 3 watts—resistances from 5 to 50,000 ohms.
—Ask for Bulletin 104—

D E

MODELS D AND E HELIPOTS
Provide extreme accuracy of control and adjustment, with 9,000 and 14,400 degrees of shaft rotation.
D—25 turns, 234" coil, 3-5/16" dia., 15 watts—resistances from 100 to 750,000 ohms.
E—40 turns, 373" coil, 3-5/16" dia., 20 watts—resistances from 200 ohms to one megohm.
—Ask for Bulletin 104—

F G

MODELS F AND G PRECISION SINGLE-TURN POTENTIOMETERS
Feature both continuous and limited mechanical rotation, with maximum effective electrical rotation. Versatility of designs permit a wide variety of special features.
F—3-5/16" dia., 5 watts, electrical rotation 359°—resistances 10 to 100,000 ohms.
G—1-5/16" dia., 2 watts, electrical rotation 356°—resistances 5 to 20,000 ohms.
—Ask for Bulletin 105—

LABORATORY MODEL HELIPOT
The ideal resistance unit for use in laboratory and experimental applications. Also helpful in calibrating and checking test equipment. Combines high accuracy and wide range of 10-turn HELIPOT with precision adjustability of DUODIAL. Available in eight stock resistance values from 100 to 100,000 ohms, and other values on special order.
—Ask for Bulletin 106—

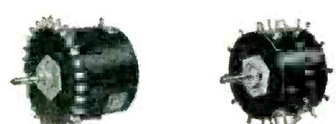
R W

MODELS R AND W DUODIALS
Each model available in standard turns-ratios of 10, 15, 25 and 40 to 1. Inner scale indicates angular position of HELIPOT sliding contact, and outer scale the helical turn on which it is located. Can be driven from knob or shaft end.
R—2" diameter, exclusive of index.
W—4-3/4" diameter, exclusive of index. Features finger hole in knob to speed rotation.
—Ask for Bulletins 104 and 114—

The versatility of the potentiometer designs illustrated above permit a wide variety of modifications and features, including double shaft extensions, ganged assemblies, the addition of a multiplicity of taps, variation of both electrical and mechanical rotation, special shafts and mounting bushings, high and low temperature operation, and close tolerances on both resistance and linearity. Examples of potentiometers modified for unusual applications are pictured at right.

A C

3-GANGED MODEL A HELIPOT AND DOUBLE SHAFT MODEL C HELIPOT
All HELIPOTS, and the Model F Potentiometer, can be furnished with shaft extensions and mounting bushings at each end to facilitate coupling to other equipment.
The Model F, and the A, B, and C HELIPOTS are available in multiple assemblies, ganged at the factory or common shafts, for the control of associated circuits.

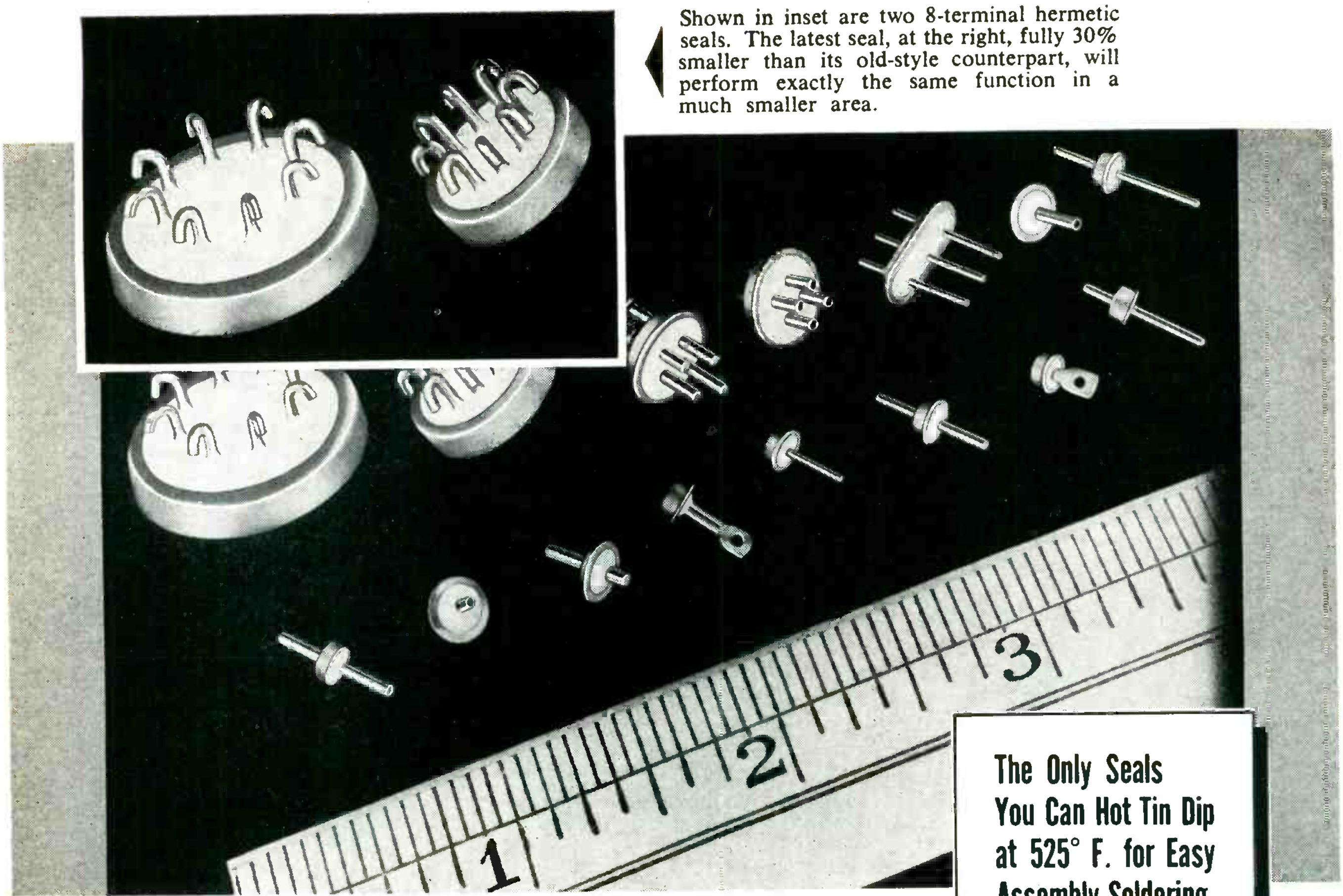


B F

MULTITAPPED MODEL B HELIPOT AND 4-GANGED TAPPED MODEL F
This Model B HELIPOT contains 28 taps, placed as required at specified points on coil. The Four-Gang Model F Potententiometer contains 10 taps on each section. Such taps permit use of padding resistors to create desired non-linear potentiometer functions, with advantage of flexibility, in that curves can be altered as required.

THE Helipot CORPORATION, SOUTH PASADENA 2, CALIFORNIA

Shown in inset are two 8-terminal hermetic seals. The latest seal, at the right, fully 30% smaller than its old-style counterpart, will perform exactly the same function in a much smaller area.



The Only Seals You Can Hot Tin Dip at 525° F. for Easy Assembly Soldering, for a Strain and Fissure-Free Sealed Part with Resistance of over 10,000 Megohms!

NO *Swelled Headers* HERE

Just a Few of Hermetic's Amazing NEW Line of MINIATURE Glass-Metal Headers

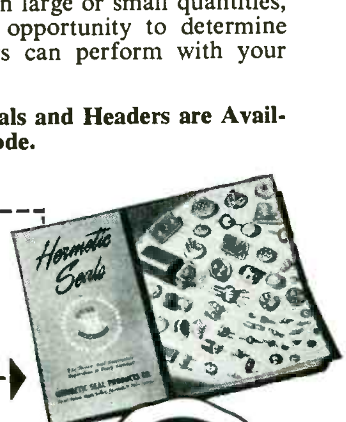
Today's industrial and military production calls for myriad components and controls. The size of each part must, therefore, be kept to a minimum. As a result Hermetic, with its unequalled specialized experience in hermetic seals, has developed and engineered a superb, thoroughly practical line of glass-metal headers in the smallest sizes ever made.

These components have already passed stringent tests, are being used successfully and are ready to go to work for you, too. Available in unlimited shapes, they are unaffected by extremely high or low temperatures, high humidities, vacuums, high operating pressures, swamp test, salt water immersion and spray, etc. They can be produced surprisingly economically in large or small quantities, thus giving you every opportunity to determine how well these headers can perform with your own products.

IMPORTANT: Terminals and Headers are Available in RMA Color Code.

Free!

Write for your copy of the most complete catalog ever produced on hermetic seals.



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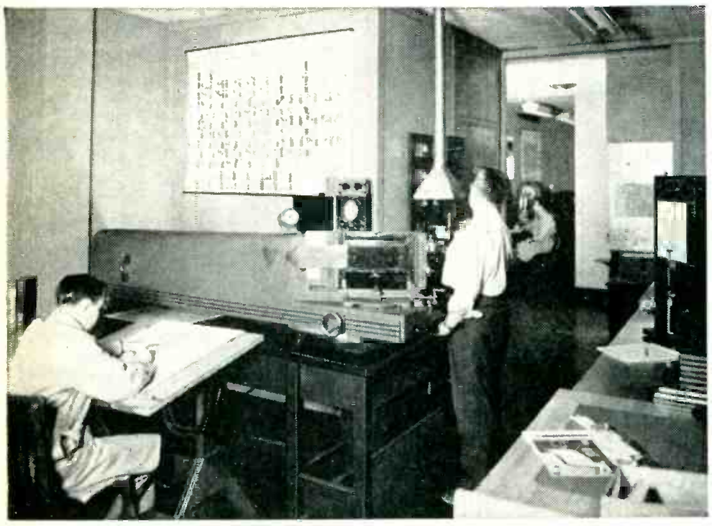
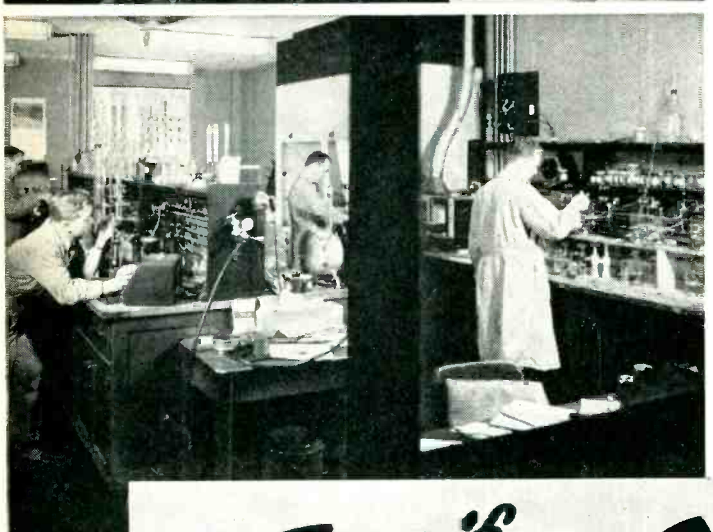
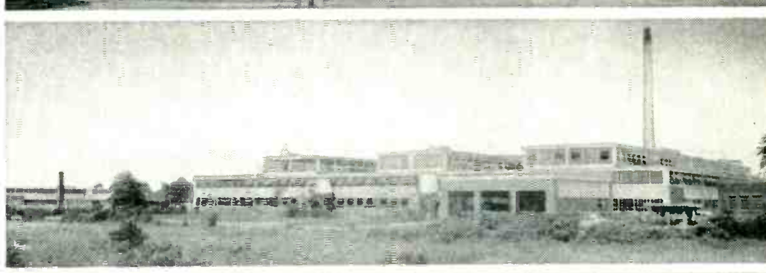
THE HEADER SEAL GUARANTEED IMPERVIOUS TO *EVERY* ELEMENT!

Carboloy Company has led in quality and uniformity of versatile metals for over 22 years

Typical views of our Detroit facilities for the manufacture of cemented carbides.







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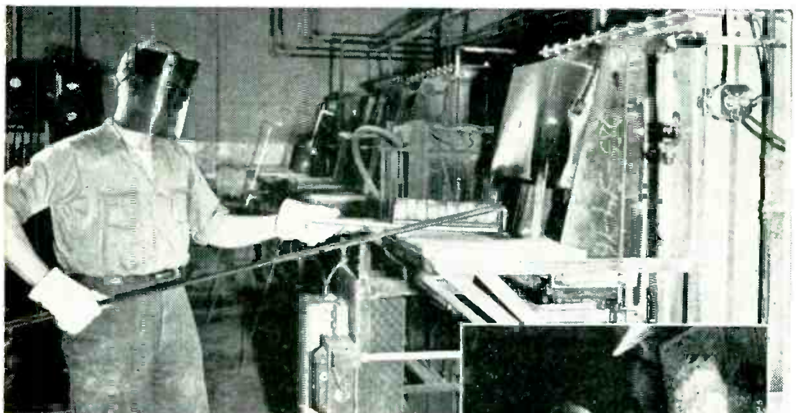
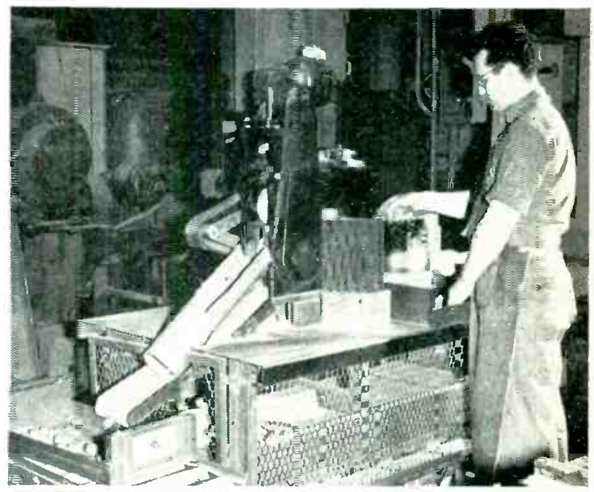
THE QUALITY BRAND

NOW the same rigid standards of quality control are being applied to the production of ALNICO Permanent Magnets



Typical views of our facilities at the Schenectady plant for the manufacture of permanent magnets.



The same rigid quality controls and skilled personnel that made "Carboloy" the leading name in cemented carbides are your assurance of uniform high quality Alnico permanent magnets, too!

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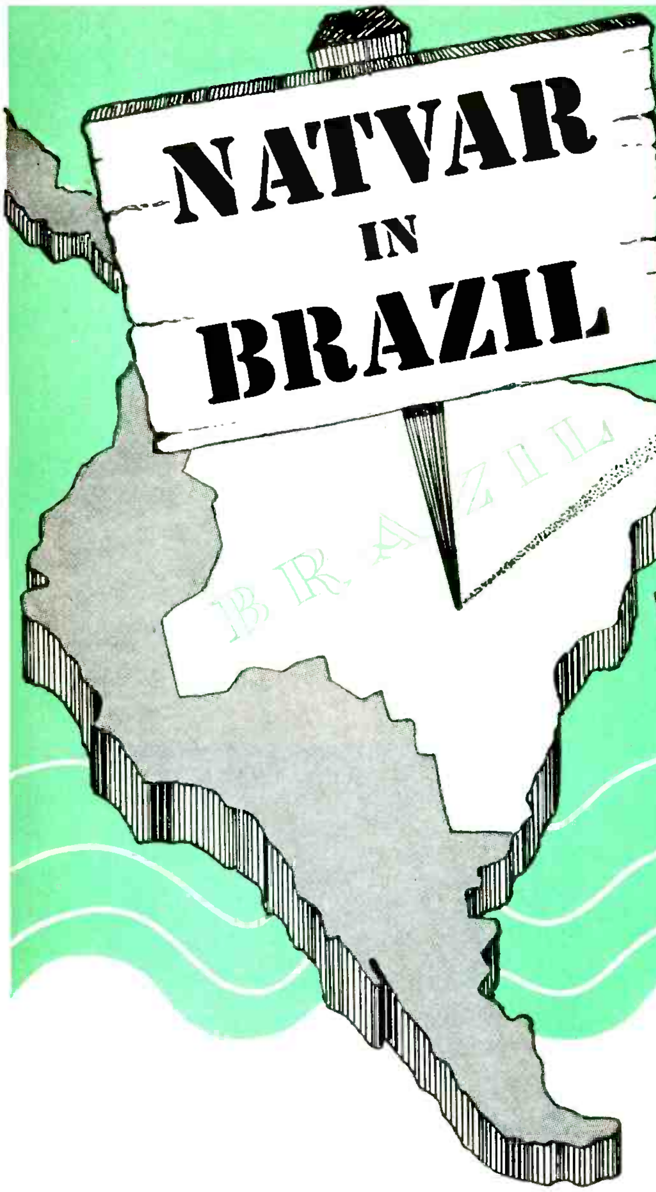
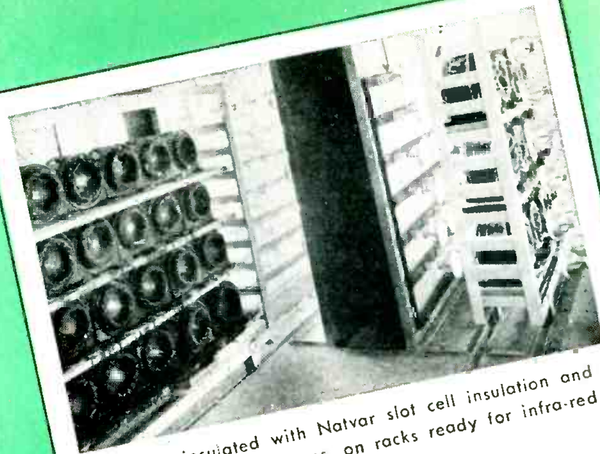
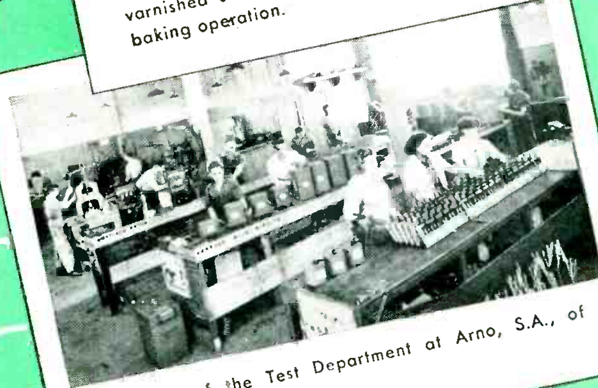
ALNICO PERMANENT MAGNETS





Stators, insulated with Natvar slot cell insulation and varnished cambric tapes, on racks ready for infra-red baking operation.



A corner of the Test Department at Arno, S.A., of Sao Paulo.

This exploded view shows the simple yet rugged construction typical of Arno motors. The motor shown is 1½ hp., three-phase, drip-proof.

Arno, S.A. of Sao Paulo, Brazil, the leading manufacturer of electrical equipment in Brazil, produces most of the motors, and associated power equipment used in South America's largest country.

Like the manufacturers of similar products in North America, Arno realizes the importance of quality electrical insulating materials for unfailing service in the field. It is for this reason they have selected Natvar products for their insulation requirements. Arno motors depend upon Natvar slot cell insulation, varnished cambric tapes.

All Natvar electrical insulating materials are recognized for their high standards of quality and uniformity throughout the world.

- Natvar flexible insulating materials are distributed in Brazil by Casa Rand Comercio E Industria S.A.

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- Varnished cable tape
- Varnished canvas
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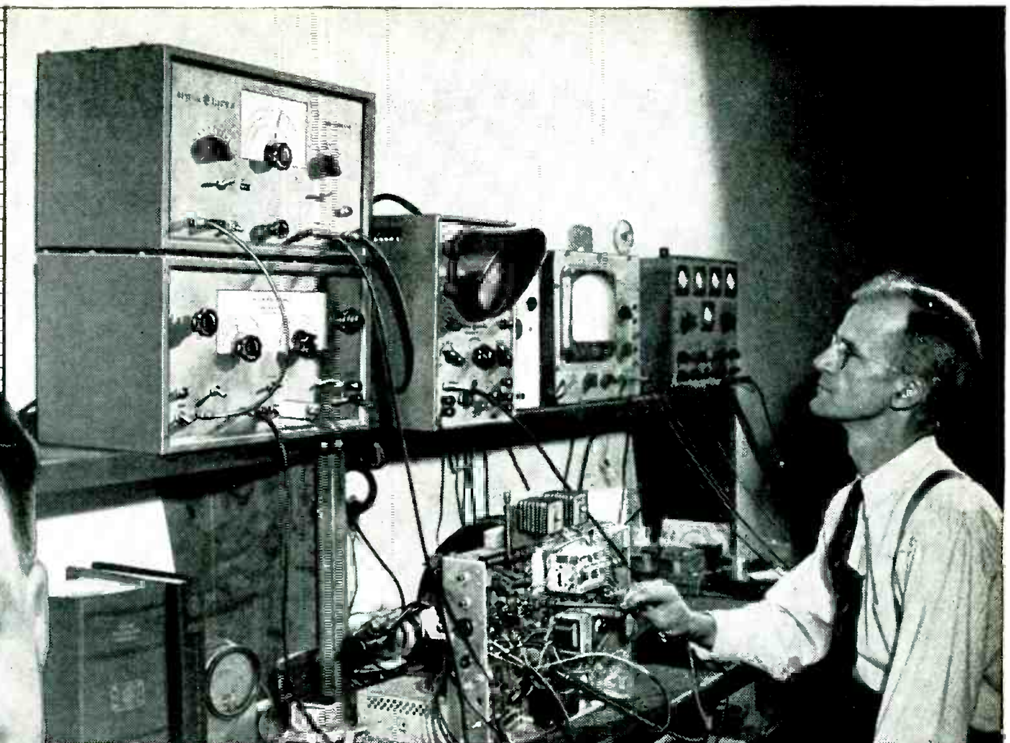
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Slot insulation
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing and tape
- Extruded vinyl identification markers

Ask for Catalog No. 21

TOM JACOBS, Owner
Apex Radio Shop
Detroit, Michigan



"200% MORE TV BUSINESS --NO INCREASE IN OVERHEAD!"

"With no increase in trained personnel, we tripled our TV service business in 6 months. The answer lies in our G-E Test Equipment.

"The *Scope* is the best trouble-shooter on the market . . . it holds a steady trace —it's stable—you can overload it and it recovers instantly. The *Variable Permeability Sweep* is extremely simple to operate, and with the crystal-controlled *Marker Generator* we always get accurate and reliable results. While keeping profits up, the G-E Test Package has cut our service time in half!"

Hundreds of TV dealers and servicemen use G-E Test Equipment to turn out clean, accurate jobs that keep customers satisfied and put money in the till. Call your G-E distributor or mail coupon today for full information.

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Rush me latest bulletins plus price information on General Electric test equipment.

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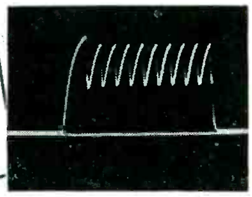
establish
the signal's D-C LEVEL

...and measure its a-c and d-c components directly from the oscillograph

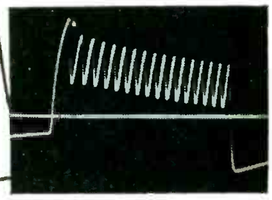
you should see...

this!



Both a-c and d-c components are displayed through the d-c amplifiers of the Type 304-H. Base line represents zero volts.

not this!



The same signal, applied through a-c amplifiers exhibits a shifted reference line and tilt of the signal which make the oscillogram difficult to interpret.

DUMONT type 304-H

...to make direct measurements

THE TYPE 264-B VOLTAGE CALIBRATOR

Simply by applying its square-wave output to the oscillograph and producing a deflection equal to that of the signal, the amplitude of the signal may be read, in volts, directly from the calibrated dial of the Type 264-B. Or the Type 264-B will calibrate your oscillograph to read directly in volts per inch

...to obtain permanent records

THE TYPE 296 OSCILLOGRAPH-RECORD CAMERA

To complete the study of the signal, permanent records, such as those above, are obtained most efficiently with this inexpensive, single-frame 35-mm. camera. Operation of the camera is simple and fool proof; construction is compact and rugged. A high-quality f/2.8 coated lens is used, and focus is fixed for best oscillographic results.

The "Standard of Performance" for general-purpose cathode-ray oscillographs.

To study signals containing both a-c and d-c components, direct-coupled amplifiers such as those of the Type 304-H must be used. D-C amplifiers will maintain the true d-c level of the signal and display the actual relationship between the d-c and a-c components of the signal. Then by calibration of the Type 304-H with the Du Mont Type 264-B Voltage Calibrator, these components may be measured directly from the screen of the instrument.

Features such as driven sweeps, sweep expansion, extremely slow sweep speeds, and stabilized synchronization have made the Type 304-H the outstanding general-purpose cathode-ray oscillograph. Its sensitivity of 10 rms millivolts per inch and its versatility often eliminate the need for a second instrument to perform functions not within the range of the ordinary general-purpose oscillograph.

Portability contributes highly to the usefulness of the Type 304-H, especially in field work requiring good performance and in the laboratory where it serves many benches. The Type 304-H measures 13½" high, 8⅝" wide, 19" deep, and weighs only 50 pounds.

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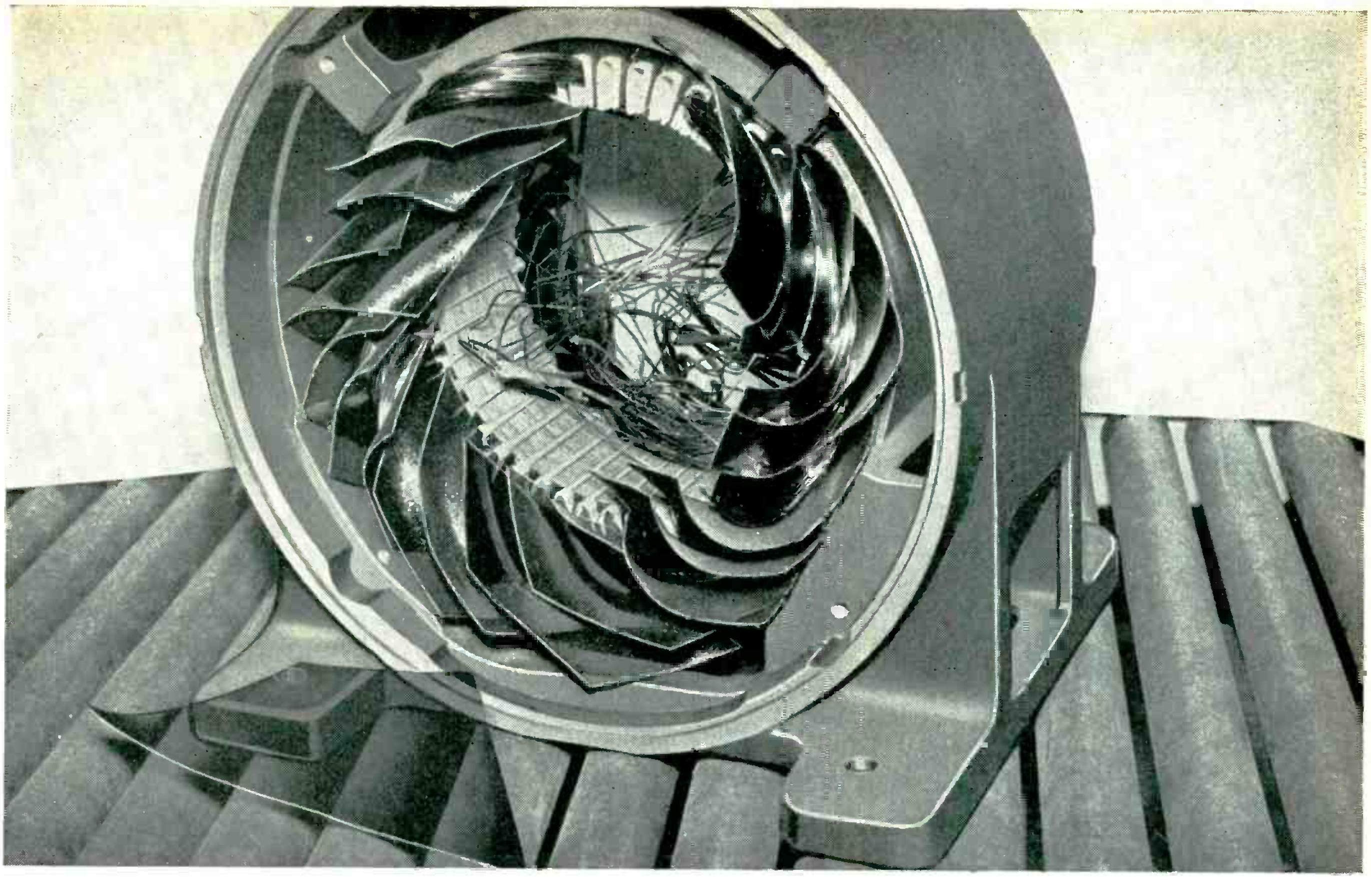
1000 Main Avenue, Clifton, N.J., U.S.A.

DUMONT 20th YEAR AS PIONEER **in Oscillography**



When insulation must stand 500° Heat

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Whether you are winding for service at high ambient temperatures — for increased *continuous* power ratings — for greater *short-time* overload capacity . . .

Or *designing* for space-and-weight savings . . .

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Depending on service requirements, *your* high-temperature insulation job may call for Silicone Varnished Fiberglas*, in yard goods, tape or tubing forms; Silicone Glass Mica; Silicone Saturated or Silicone Coated Asbestos; Silicone Rubber Coated Fiberglas; Silastic**Tape, Teflon Coated Fiberglas.

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BUSINESS BRIEFS

By W. W. MacDONALD

Component-Part Makers are more vulnerable when emphasis shifts from peace to war than the assemblers of electronic equipment for whom we painted a picture of what probably lies ahead (p 82, April) last month. Assemblers can sometimes design and produce simple electronic equipment in 90 days, while it takes the average parts maker six months or more to tool up for a new item. Thus a reduction of civilian business while preparing for production of military items leaves a nasty time gap.

Washington is well aware of this, as it is also aware of the fact that component parts represent the backbone of any military electronic equipment production program. That is why the Services are being weaned away from the use of special components in equipment prototypes as rapidly as possible by their own procurement officers. It also explains why orders for some replacement parts are being placed as much as 36 months ahead, instead of the usual 6 months.

Planning for the manufacture of assembled electronic equipment is difficult enough short of actual war. Planning for the production of component parts from which the equipment must be assembled is still more difficult and it is our impression that Washington is comparatively mum on the subject because the problems are legion and the answers elusive.

More later, when and if the situation jells.

Last Month it seemed as though a shortage of materials might be the television industry's 1951 pain in the bottleneck. Now it looks like sluggish consumer buying may be a companion headache.

The industry got a lot of production under the wire early this year. Sets are backing up in distributors' warehouses and in retail stores. Prices are high. Saturation is now a factor, and markets are prevented from expanding by the continued station freeze.

On the consumer side, war scare, the heavy income-tax take, rising food and clothing costs and tightened time-payment restrictions are causing a pulling in of the pocketbook. Television may this year experience its first really serious summer slump, considered normal in the radio business.

Television is still in a buyer's market, despite the threat of material shortages.

MRO Order issued by NPA to insure availability of Maintenance, Repair and Operating supplies by permitting industry to write its own priority ticket is a wordy document. We're supposed to be adept at interpreting fine print but, so far, have bogged down.

People we've talked to in the field about the order tell us it will take a few test runs to make the meaning clear. When they are made, and when it is, on this subject too, we will report further.

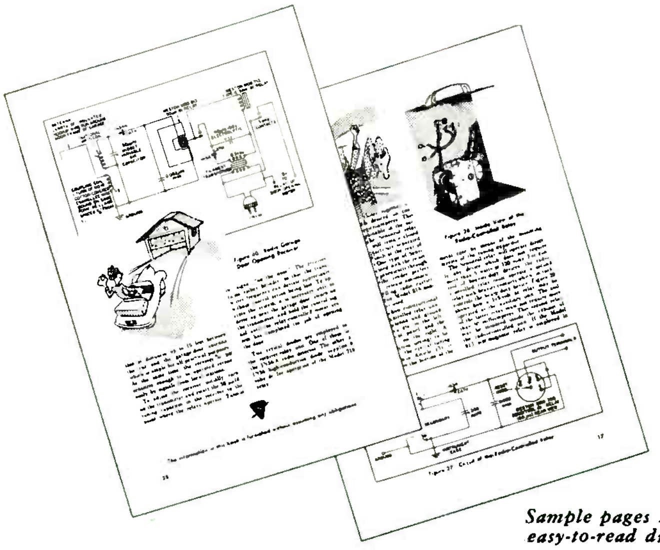
Speaking Of Materials, minerals are most important in the field of electronics. Evan Just of the McGraw-Hill magazine *Engineering & Mining Journal* says this is the way the world's supply is distributed, expressed in percentages of the total:

Mineral	*West. Hem.*	*Aust., New Z.*	*West Eur., S. Af.*	*Mid. Eur., N. Af.*	*East*	*Soviet Sphere*
Antimony	50	2	13	9	1	25
Asbestos	60	..	15	4	1	20
Bauxite	60	..	6	8	8	18
Beryl	55	2	10	..	3	30
Chromite	5	3	34	24	14	20
Cobalt	10	3	80	4	..	?
Columbite	..	..	99	..	..	?
Colum-Tanta	..	..	90	5	..	?
Copper	62	1	20	6	2	9
Diamonds	5	..	95	..	..	..
Fluorspar	50	2	20	13	3	?
Iron Ore	45	..	10	20	5	20
Lead	50	18	10	13	1	8
Manganese	9	..	21	7	18	45
Mercury	16	..	32	40	5	?
Molybdenum	88	..	..	2	..	10
Nickel	80	3	..	..	..	17
Petroleum	66	..	1	1	18	14
Phosphates	40	3	1	25	1	30
Potash	25	..	5	40	..	30
Steel	47	1	11	20	3	18
Tantalite	75	..	..	..	..	?
Tin	20	1	15	..	58	6
Tungsten	21	5	22	3	12	37
Vanadium	78	..	13	?	?	?
Zinc	56	11	6	14	1	12

A Trans-Lux Theatre in downtown Washington displays a Geiger counter borrowed from the National Bureau of Standards in its entrance lobby, invites pensive

Put Electronics to work

IN YOUR HOME!



Sample pages showing easy-to-read diagrams.

HERE'S HOW TO MAKE 24 VALUABLE TIME- AND LABOR-SAVERS

You don't have to be an electronics engineer to build these useful household gadgets. The step-by-step instructions in Sylvania's fascinating new book, "Electronic Shortcuts for Hobbyists," are written expressly for the home hobbyist, model maker and electrical experimenter. With this book you can build:

- **A Radio-Controlled Door Opener.**
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ONLY 25¢

All you need is some inexpensive Sylvania Crystal Diodes and a few everyday materials. Book contains full instructions and easy-to-follow diagrams. Send a quarter along with the coupon for your copy.

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Dept. E-1005, Emporium, Pa.

Enclosed please find my 25¢ for copy of "Electronic Shortcuts for Hobbyists."

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1901-1951 SYLVANIA ELECTRIC PRODUCTS INC. FIVE DECADES 50th ANNIVERSARY OF PROGRESS

SYLVANIA ELECTRIC

ELECTRONIC DEVICES; RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS pedestrians to step up and check their radioactivity.

Engineering Manpower continues to be a critical commodity. We mentioned the growing demand for technicians last month (p 76, April) and, since then, have looked into the subject further.

We've contacted 14 of the 22 manufacturers advertising for help in the classified section of the March issue of ELECTRONICS. These 14 alone say they can use 927 electronic engineers before the end of the year. Nearly half the jobs offered are on the West Coast, largely in aircraft-electronic plants.

Practical Experience on radar design and development plus a thorough educational background appear to be the twin requirements of many manufacturers looking for engineering personnel. Now, radar is only about 10 years old. So there are only a thousand or two engineers in the country who can meet both requirements.

The shortage of experienced engineers is severe. The shortage of men having the right background and capable of being trained for specialized equipment design and development is not. It seems to us that a forced-draft training program in radar and allied military equipment is indicated.

Production Help is plentiful in radio and related fields, according to the U. S. Department of Labor. Total employment over the last four years was as follows:

1947	142,400
1948	123,000
1949	112,700
1950	156,300

There were, according to this same source, 250,000 production workers engaged in the field during the peak war year of 1944.

Philco's Bob Long, commenting on an item concerning the preparation of instruction manuals (p 60, Feb.), says his company has a Technical Publications Department whose sole business is the preparation of manuals to go with its own products and for various branches of the armed forces. The department . . . and this may be startling to manufacturers bidding for the first time on government contracts involving manuals . . . contains over 200 people. This includes writers, editors, artists, draftsmen, photographers, layout men and typists.

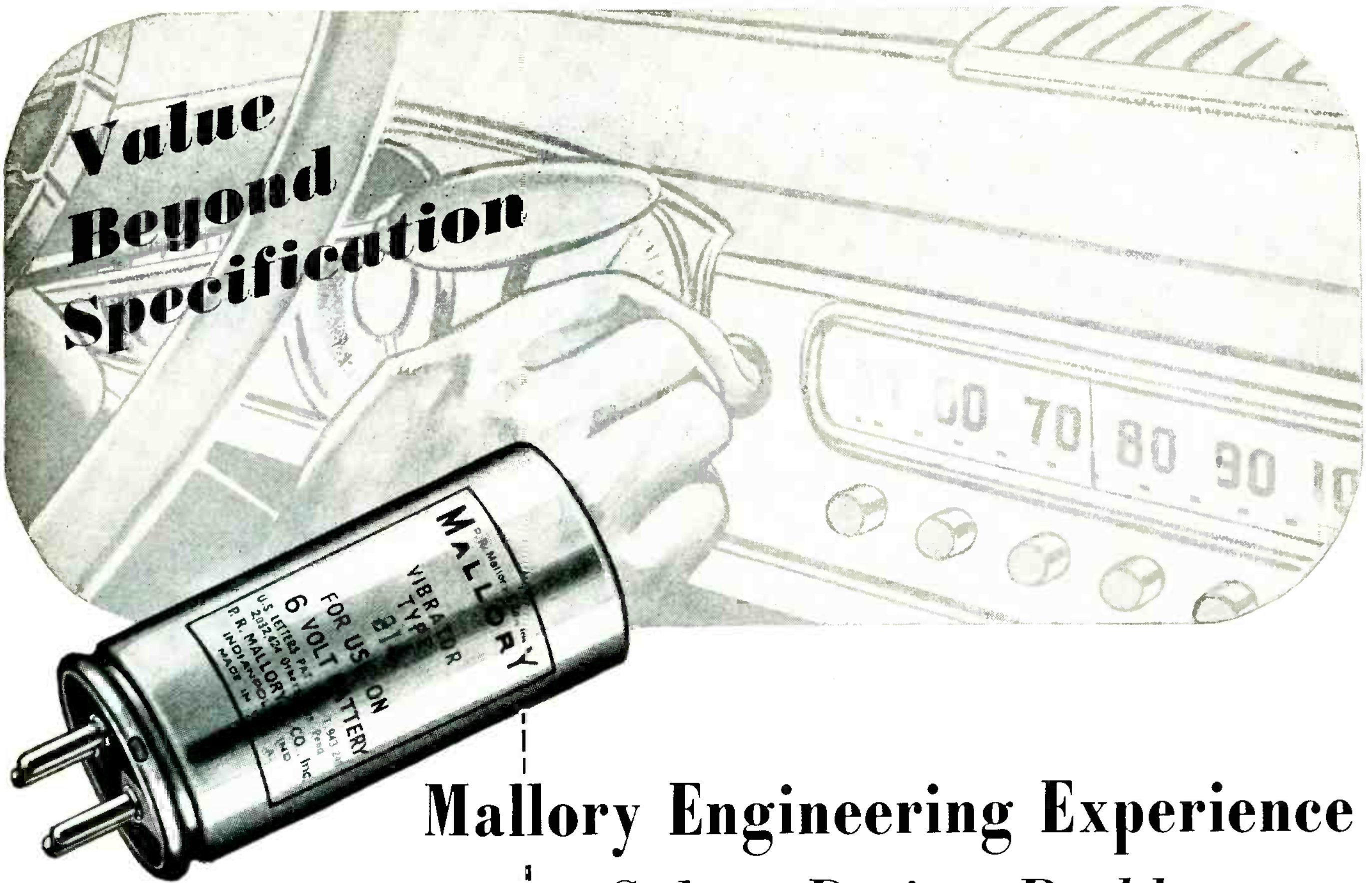
The preparation of manuals is a major publishing venture, not to be dismissed lightly with a wave of the hand. Watch our feature pages next month for a discussion of some of the problems involved, and suggestions for their solution.

Guided Missile Development is by no means confined to airborne apparatus. A great deal of work is currently going into the design of guided torpedoes.

Receiver Sales by licensees during 1950 totaled 20,656,486, worth $1,605,731,113. Here's the way the total broke down:

Electric	Units	Dollars
Table (under $12.50 billing price)	2,472,075	$26,088,004
Table (over $12.50 billing price)		
A-M	3,028,184	53,145,145
A-M/F-M	343,751	10,500,152
F-M (including converters)	11,923	286,181
Consoles		
A-M	6,550	431,088
A-M/F-M	6,050	660,908
Table-Radio-Phonos		
A-M	382,630	16,553,385
A-M/F-M	15,143	975,929
Console-Radio-Phonos		
A-M	76,796	6,700,255
A-M/F-M	495,362	59,919,504
Battery		
Portable A-C/D-C	1,475,738	26,393,887
Table	96,113	1,574,476
Consoles	60	5,451
Auto	4,757,035	123,427,992
Television		
Converters	5,705	754,081
Radio Table Models	2,781,458	393,511,544
Radio Consoles		
Direct-Viewing	3,344,938	645,105,666
Projection	11,739	2,723,745
Radio Phonos		
Direct-Viewing	789,666	217,501,568
Projection	1,258	448,628
Phonographs		
Phono only	405,513	7,125,362
With radio attachment	29,739	963,714
Without Cabinets		
A-M	13,564	343,544
A-M/F-M	19,975	925,054
Television	85,521	9,665,850

Gene Anthony of New York's GE Supply says he has discovered a way to make technicians clean up their habitually littered workbenches. He insists that all benches be shellacked once a month . . . and of course you can't shellac a bench without first removing the last year's birdsnests.



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Saves Customer Money

MALLORY VIBRATORS

Mallory Vibrators are based on exclusive design and manufacturing methods that assure long, trouble-free service. Send the details of your application. Get Mallory's recommendation on the Vibrator or Vibrapack* power supply best suited to your needs.

Mallory contributes more than a fine product to the solution of a customer's problem. With the product comes the intelligent application of experienced engineering knowledge that cuts costs and eliminates delays.

For example, a large electrical manufacturer, designing a new automobile radio, was unable to match certain elements in the circuit. This company turned to Mallory for advice. The problem was solved quickly . . . with a redesigned transformer, a timing condenser and a Mallory Vibrator. Tests showed excellent results, and a great saving to the customer in engineering time.

That's value beyond specification!

Mallory electronic know-how is at your disposal. What Mallory has done for others can be done for you.

Vibrators and Vibrapack* Power Supplies

P. R. MALLORY & CO., Inc.

MALLORY

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

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Electromechanical Products
Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

Metallurgical Products
Contacts *Special Metals*
Welding Materials

*Reg. U.S. Pat. Off.

CROSS TALK

▶FCC . . . Having been sharply critical of the technical judgment recently exhibited by the FCC, it is a pleasure to come out in praise of the high standard of engineering foresight exhibited in the proposed allocation of vhf and uhf television channels. The choice of mileage separation between stations, the adoption of standard intermediate frequencies, the mandatory use of offset carrier operation, the increase in maximum transmitter power, the removal of power limitations due to radiator height—all are calculated to give the public a better grade of service, more uniformly distributed, than it now enjoys even in the most favored localities. At a time when government and industry had seemed lined up on opposite sides of an ideological fence, it is reassuring to note that these features of the allocation plan had wide support from the same engineers who were so largely ignored in the color decision. Since the allocation plan must serve both color and black-and-white transmissions, it is doubly important that there be general agreement on its basic features.

▶SERIES . . . We are happy to record the completion of the MIT Radiation Laboratory Series, a monumental set of books on the theory and practice of pulses and microwaves, with particular emphasis on radar techniques. The 27th volume of the series, the Waveguide Handbook (Volume 10), made its appearance last month.

At a celebration honoring the completion of the Series, a soiree arranged by the publishers, we renewed with pleasure the acquaintance of many former associates who served as its editors and authors. The conversation turned inevitably to the question of military security, particularly since a purported sketch of the Nagasaki atom bomb had just been published in connection with the espionage trial of Sobell and the Rosenbergs. One editor observed that the staggeringly detailed and copious content of the Rad Lab books could never have been passed to the enemy by spies. This being the case, the availability of the Series to all and sundry is no doubt a source of considerable comfort on the other side of the Iron Curtain. But, it was agreed, the comfort was vastly greater on this side, in view of the greater number of technicians and facilities available to make use of the published knowledge.

Over 150,000 copies of these books have been distributed, an average of over 5,000 per volume. One eminent consultant told us at the IRE Convention that certain volumes were used so hard by his staff that they wore right out, despite the fact that the bindings are as rugged as the book trade knows how to produce. This consultant, who would have warmed the heart of Frederick W. Taylor, decided to replace the worn-out copies by gifts of personal copies to key technicians!

▶BIG . . . The final count of registrants at the 1951 IRE Annual Convention and Show was 23,451, an increase of more than 5,000 over the previous record of 1950. This appears to be the largest registration in history at a meeting of a technical society, a record at which all IRE members are justly proud. Although the total attendance at the annual show of the American Chemical Society has reached 65,000, the largest A.C.S. registration was of the order of 10,000 people.

The convention copped the prize for unadulterated amplitude, also, in the technical sessions: 210 papers in six simultaneous sessions held sequentially seven times in three locations. As we have observed in a small voice before, this is too many papers in too many places to suit anyone but the most specialized of specialists, namely the guy who is interested in not more than one paper. If he goes early, he has a chance. Anyone with a more catholic taste is very likely out of luck.

The last time we brought this up, confreres at IRE headquarters asked what constructive steps we had to suggest. The proposal for a number of smaller conventions on narrower bases is obvious and has been adopted by many other societies. If things go on at the present pace, this may be the only out. A more immediate step, with less disastrous fiscal implications, is to apply a sharp and heavy axe to the technical program.

Electronic Research in the

Today's needs are quite different from those just before World War II. There may be little parallel even in the event of a new all-out conflict. Future safety suggests careful use of available laboratory facilities

CONSIDER the several ways in which today's research program differs from the 1938–1939 period, when preparedness was also an all-important activity.

In the first place, nearly a quarter of a century elapsed between World War I and 1938. Not only had there been an almost complete change in all personnel involved, but during that interval applied science had become a vastly more important element in warfare. As a second factor, we entered both World War I and World War II after they had been under way for some time in Europe. The general nature of each conflict, as well as many of the accompanying technical and scientific problems which involved electronics, was fairly apparent.

Today, in contrast, only five years have elapsed since the end of World War II and the broad technical aspects of warfare are much the same. Many of the men who did research and development work in electronics during Wold War II are not only still active but are in closely related fields. Military action during the past year, however, has been in a primitive country, against a foe that uses few of the highly technical devices developed or greatly improved during the last war. Examples of such devices are radar, proximity fuses, improved submarines, long-distance missiles and atomic explosives. Experience in Korea does not make clear just what would be our basic technical problems in case of a new war.

The most important research needed in a full-scale war against any enemy with highly developed technical skills is not yet fully apparent. Much effort, of course, is being put into such obvious things as improvements in radar, guided missiles and the use of and defense against atomic weapons. It is nevertheless conceivable that in the case of war we would be faced with unexpected opportunities as well as serious new threats.

Offensive military action might require some wholly new technical devices. If this occurs, research would be an all-important activity. Imaginary projects of this nature might be antisabotage devices and complete broadcasting systems involving antijamming features to reach large masses of people behind enemy lines. The latter might include receivers dropped in very large numbers by parachutes far inside an enemy country.

The point to be remembered is that at present we simply cannot predict the nature of much of the required research work in any actual future world war.

BOTTLENECK

- Most military projects involve refinements of existing gear, rather than basically new things.
- Today's crop of men from the universities seems to have a better theoretical background than that of 15 years ago, but less interest in converting ideas into finished items.
- There are probably a dozen men who can devise a new circuit for every one who can translate it into a piece of equipment that will do a good military job in all respects.
- If the emergency continues or becomes more serious, some drastic measures may be necessary to shift men interested in basic research into design and development

Today's Research Facilities

As regards research in electronics, probably the most important

EMERGENCY PROGRAM

By W. C. WHITE
Electronics Engineer
General Electric Research Laboratory
The Knolls
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Industry's facilities have been tremendously expanded since the last war. Here is just part of the key research personnel in a new GE laboratory

change since 1939 is the tremendous increase in laboratory facilities and personnel, particularly in government-operated laboratories. Not only have the then existing laboratories been greatly expanded, but new and larger ones have been organized and are in active operation.

In addition, many millions of dollars in research contracts involving electronics have been awarded by the government to a large number of university and industrial laboratories. These contracts cover projects which the various branches of the services believe offer opportunities for new devices and worthwhile improvements in existing military equipment.

An example of what just one government agency was doing in 1949 in this direction is given in an interesting article in ELECTRONICS for that year.[1] A publication[2] of the Engineering College Research Council also indicates the nature of research being carried on by the group of some 80 universities listed.

Such contracts have greatly changed university research. Fifteen years ago, in the case of most universities, an expenditure of $100 for equipment for a research project, or the expense for the attendance of some member of the staff at an out-of-town scientific society meeting, was a serious problem. It might even have required action by the trustees. Today, in contrast, it might almost be said that no expense is spared in matters such as these.

The present shortage of available engineers is caused to a considerable extent by the great increase in university and government research. As a result of this change, as well as some other factors, it is doubtful whether a new organization along the lines of the National Defense Research Committee, with its several large and highly specialized laboratories such as the Radiation Laboratory, MIT, will again be organized. Of course, some wholly new problem or scientific discovery not now foreseen could change this picture.

In one important aspect, industrial research differs greatly from that carried on in university and government laboratories. In industry the development, design and manufacturing methods based on results of research laboratory findings have by necessity become highly developed and closely coordinated procedures. In government and university laboratories, there is not a similar situation because they seldom manufacture and sell equipment. This fact makes industrial laboratories relatively efficient in a practical sense.

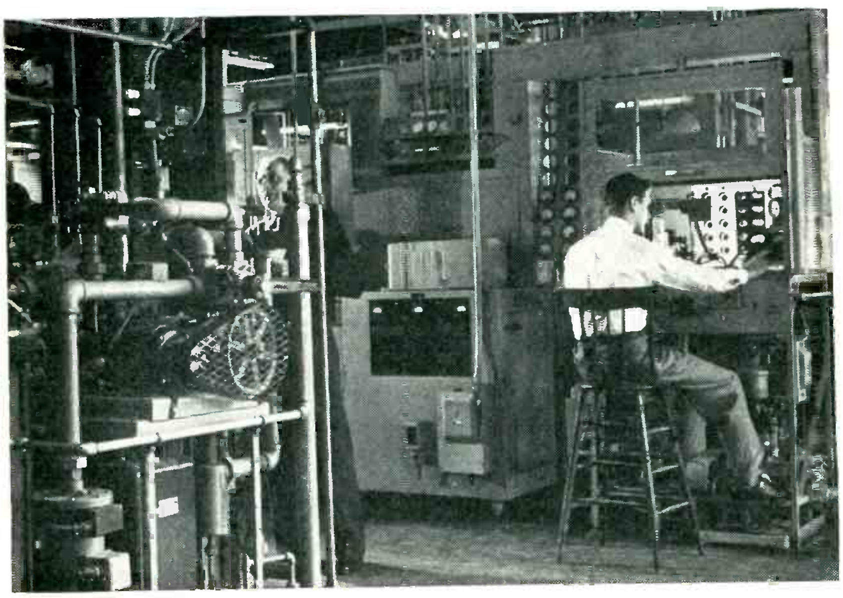
Current Military Requirements

The increase in manpower that has gone into research in electronics in the past ten years is far greater than that devoted to practical design of electronic equipment. This contributes to one of the most serious problems facing the science of electronics, the matter of more reliable operation of complicated electronic gear. There are probably a dozen capable research and development engineers who can devise a new circuit to accomplish a certain result, for each engineer who can translate a perfectly practical idea into a piece of equipment that will stand up under the severity of military use and give a long life of trouble-free service. The disparity is least severe in industry.

The growth of the science of electronics has widened the gap between the basic research man and the manufacturing man. When the ideas and equipment involved were relatively simple, these two groups saw more of each other. Now refinements and complications have entered the picture and often necessitate middlemen in the form of advanced development groups, engineering laboratories or pilot-plants. There is in some places a tendency to expect of a research laboratory only the job of making investigations and reporting on the results, which involves uncovering new phenomena but does not include seeing a project through to a new product. This is not necessarily a fault, but it must be taken into consideration when research findings must quickly be translated into practical equipment.

Whether it is a cause or a result of the various trends mentioned, today's crop of research men from the universities seems to have a better theoretical background (including skill in mathematics) but less interest in the practical application of research than their predecessors of 15 or more years ago.

Military contracts in force since the last war and now being placed in increased number have enabled many laboratories, both in universities and in industry, to buy needed instruments



Equipment involved in the development of new tubes, the heart of electronic apparatus, can be quite elaborate

The Manpower Problem

So much for some of the factors that may influence the nature of research in electronics in the near future. What are some of the probable effects?

In an adequately financed research laboratory, there are two ever-present, all-important problems. The first is getting individuals who as a group have all the necessary abilities for getting the desired result. The second is the choice of projects to be undertaken or continued. The available manpower question is undoubtedly the one that will be the controlling factor on both counts, and there are two relatively new aspects to the manpower problem.

In most universities the staffs had been greatly enlarged at the close of World War II to take care of the increased influx of students resulting from so-called GI Educational Rights. Now not only has GI registration dropped, but draft rules and policies may drastically cut down the flow of other students. Under these conditions, the natural tendency for the universities is to seek government research contracts in order to retain as many of their staff as possible.

It is a common error to underestimate the amount of manpower required for a given research project and, as a result, take on more work than can be handled with existing staffs. Thus we will probably find in some cases that a university is in the market for additional engineers for research work rather than being a source of supply to outside laboratories. As a corollary, some university placement men may become recruiters.

Project Screening Needed

As regards the problem of choice of research projects, there is no question but that a military economy will greatly curtail the freedom of choice. This is to be expected, because many projects for civilian products should not be started or continued. Also, in such an economy, not only does the threat of drafting of men for military service preclude some civilian-product research and development but a great many engineers, regardless of age or eligibility for active military duty, feel very strongly that they should be doing work to aid the mobilization effort.

The choice of new projects, therefore, pretty much narrows down to military ones and thus consists of those offered or contracts which can be obtained on the basis of previous results, present activities or special equipment and skills.

There is one great danger. Key men in all groups inside government, as well as outside, often have pet projects held in abeyance for lack of funds or opportunity. Sometimes a military situation provides both the funds and the opportunity and some laboratory group is persuaded to go into a project that is not really needed and which later will be forced out of the picture when more vital problems are well defined. This means a waste of manpower and a chance that the work will be reclassified as nonessential. The men engaged on it might be subject to military service. It is well to be coldly analytical of some of the projects suggested or offered by early eager beavers.

There is also bound to be a natural tendency for research groups to hang on to an active current contract at least until new ones are available. Undoubtedly as the manpower problem becomes more acute and new needs develop, many of the now active contracts will be discontinued. Certainly some should be.

Electronic research today involves many problems associated with nuclear physics

Design and Development Bottleneck

If some new and now unforeseen highly technical and large-scale military project arises requiring very large amounts of research manpower, it is probable that the real bottleneck will be in its engineering rather than research phases. There is a great reservoir of facilities and manpower in government and university laboratories available for new investigations and basic research projects. The real problem in obtaining procurement of new designs of satisfactory military electronic equipment will be in the design and development of components and complete units or systems. Particularly, there will be a problem in producing equipment that will satisfactorily meet all the varied requirements in a practical way as well as electronically and at the same time be suitable for efficient quantity manufacture.

It would thus appear that the role of the industrial research laboratory to an increasing extent will be one of aiding its engineering and manufacturing groups to meet promises of delivery and reliability of performance. It is believed that this trend will be accentuated by the fact that much of the activity in military electronics will consist of refinements and improvements rather than basic developments faced ten years ago such as radar, loran and proximity fuzes. Refinements and improvements may have a much higher engineering content than new projects.

The requirement that industrial research laboratories come to the aid of their engineering and manufacturing departments, rather than devoting all their time to what might be termed basic research will probably not be to the liking of many men involved, but it seems more or less inevitable when a real emergency arises. Therefore, because research is now a sort of magic word, appeals to so many engineers, and is so relatively easy to organize and carry on, there is danger that the supply of engineers capable of really getting things done from the procurement viewpoint will be further depleted. Research men will struggle to stay in research.

If the emergency continues or becomes more serious, some drastic measures may be necessary to supply added development and design engineering manpower to manufacturers. Much of it will probably have to come from qualified men who are at present doing research work in universities as well as in industry.

REFERENCES

(1) K. R. Spangenberg and W. E. Green, Basic Research Projects Under ONR Contracts, ELECTRONICS, p 66, June 1949.

(2) Review of Current Research, E.C.R.C. of the American Society for Engineering Education at the College of Engineering, State University of Iowa, Iowa City, Iowa, 1949.

CONSTRUCTING the

Recent release of manufacturing information to tube licensees gives industry first detailed description of internal structure and processing of color-tv kinescope. Photoengraving and gelatin-stencil printing processes are employed to insure precise alignment of phosphor dots and apertures

EARLY IN MARCH the Radio Corporation of America released to its tube-manufacturing licensees a bulletin giving manufacturing information on the RCA three-gun tricolor picture tube. This tube, the only direct-view color television tube yet demonstrated, was shown to the press on December 5, 1950, as reported in the February issue, page 80. Although the bulletin was not released to the press, the interest in its contents was so high that the word was quickly passed throughout the technical fraternity. This report has been collected from several such informed sources.

Figure 1 shows the assembly of the tricolor tube. At the right, three electron guns are mounted with their axes parallel to the center line of the tube. Since the guns operate at high voltage (typically 15 to 25 kv), the edges of the cylindrical electrodes are rolled. The outermost cylinder in each gun is welded to a convergence electrode. This is a large cup, with its open side toward the phosphor screen, which exerts a focusing force on all three electron beams, bringing them to a common focus at all points of the scanned surface.

At the opposite end of the tube is the screen assembly, which consists of a pierced metal plate ("aperture mask") and the glass viewing screen ("phosphor-dot screen"). The mask and screen are mounted parallel to each other and about one-half inch apart, on a metal frame ("spacer frame"); see Fig. 2. The assembly of mask and screen must be very precise, to insure that the apertures in the mask line up exactly with the clusters of phosphor dots on the screen. The screen assembly is bolted to four posts, mounted on the inner surface of the metal shell of the tube.

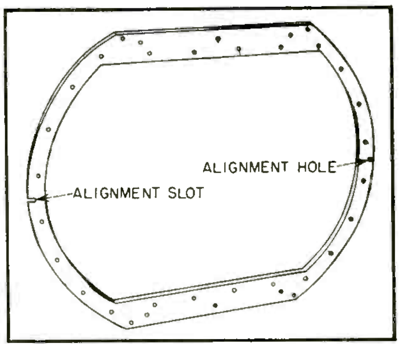


FIG. 2—Spacer frame. Aperture mask is bolted to one side of this frame, glass plate, carrying phosphor dots, to other side. Screen assembly is then bolted inside metal shell

Within the shell, also supported on these posts, is a high-permeability magnetic shield which extends from the aperture mask to the neck of the tube. A black mask, which frames the phosphor screen and hides the frame bolts, is mounted directly in front of the screen, as shown.

After the screen assembly and magnetic shield are mounted within the metal shell, the front portion ("cap assembly") of the tube is welded to the shell on the flanged seal shown. The cap assembly consists of a conical metal shell, blackened on the inner surface to reduce reflected light, and a curved clear-glass face plate.

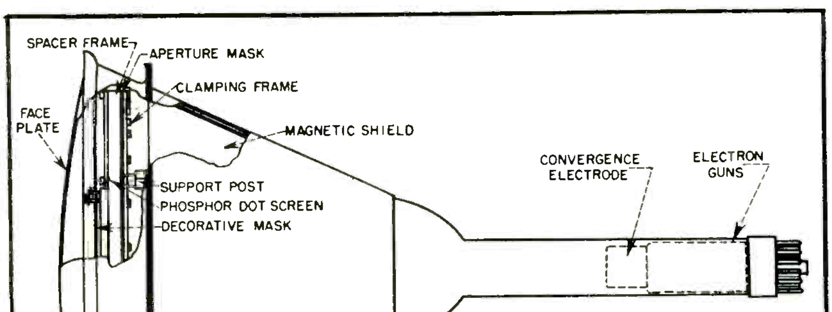


FIG. 1—Internal elements of the tricolor tube. The metal shell has approximately the same dimensions as the 16AP4 black-and-white kinescope

Fabrication of the Aperture Mask

The aperture mask is a sheet of copper-nickel alloy, 4 mils thick.

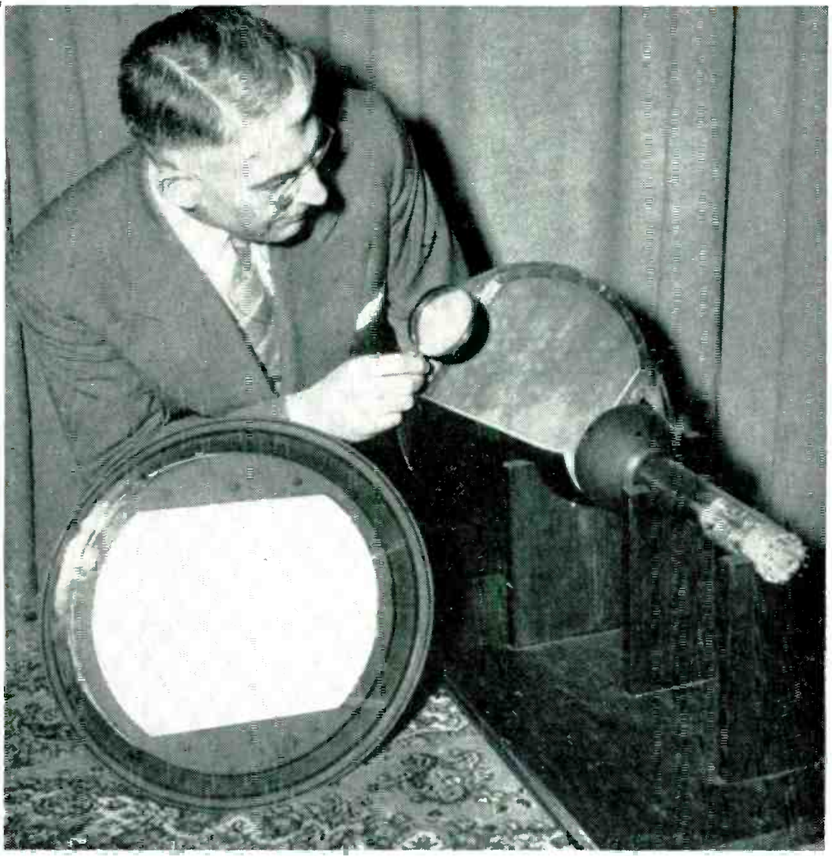
TRICOLOR PICTURE TUBE

By means of a photoengraving process, 200,000 holes are etched in this sheet according to the dimensions shown in Fig. 3. Although the details of the photoengraving process are not given, the following description of commercial photoengraving is illustrative of the general principles involved.

The metal sheet is coated with a solution of fish glue and ammonium bichromate which renders it photosensitive. The sheet is then exposed to light through a dotscreen negative. The negative in turn is made by exposure through a screen plate, consisting of two glass plates, each engraved with fine parallel lines filled with an opaque substance. The glass plates are bound together so that the two sets of opaque lines cross at 60 degrees, forming transparent dots between the sets of lines. The light, passing through the screen plate to the negative, exposes the negative material in a series of closely spaced dots. The negative consists, then, of an array of black dots having the spacing and arrangement shown in detail in Fig. 3.

The metal sheet is placed in contact with this dot negative and exposed. The sheet is then developed in water, which removes the coating where it was unexposed to light (in the dots). The rear (untreated) surface of the metal sheet is coated with asphalt, and the sheet is placed in a bath of iron perchloride, which etches the metal in the unexposed (dot) regions. The etch is allowed to proceed until the metal is eaten through, the holes thereby formed being exact replicas of the dots in the negative. The metal sheet is then cleaned to remove all traces of bichromate, asphalt and iron perchloride.

The aperture mask is mounted on the spacer frame so that it fits snugly over two guide pins. To assure that the mask is perfectly flat when mounted, it is heated to about



Cutaway view of tricolor tube from rear, showing aperture mask. Holes in mask, 200,000 of them each 9 mils in diameter, are formed by photoengraving process

External view of tricolor kinescope. Phosphor screen and aperture mask are assembled as a unit before mounting within metal shell

85 degrees centigrade and the mounting screws are driven home while the mask is hot. When it cools, the mask becomes stretched taut over the spacer frame. The guide pins are then removed from the spacer frame, to allow light to pass through the guide-pin holes, as outlined below.

Photographic Gelatin Stencil

When the aperture mask and spacer frame are assembled, they are used to produce a gelatin printing stencil, by which the phosphor dots are laid down on the viewing screen. The method is as follows: The mask and spacer frame are covered with a glass photographic Kodalith plate. The plate takes the position later to be occupied by the phosphor-dot screen. A very brilliant point source of light (the Western Union zirconium concentrated-arc lamp is suitable) is then placed, as shown in Fig. 4, so that its light passes through the holes in the mask to the Kodalith plate. The lamp is placed precisely where the blue electron gun will be located, relative to the screen assembly, in the completed tube. Consequently, the Kodalith plate is exposed, through the holes in the mask, at precisely the places where the blue phosphor dots are to appear. Two separate light sources expose the plate through the guide-pin holes.

The photographic plate is then developed and opaque spots appear on it, one for each hole in the mask, as well as two larger stencil marks which mark precisely the location of the guide pins. The gelatin is then made from the Kodalith plate as follows: A paper-backed gelatin sheet, photosensitized with ammonium bichromate, is covered with a 5-mil sheet of clear Vinylite plastic and exposed in contact with the Kodalith plate.

The paper backing of the gelatin is removed, and the gelatin developed by washing in warm water. This removes the gelatin where it was unexposed. Consequently the gelatin takes the form of a stencil, that is, a sheet with 200,000 holes in it, corresponding to the holes in the aperture mask.

The gelatin stencil, still in contact with the vinylite sheet, is then placed face down on a metal wire mesh, which acts as a carrier and preserves the shape and dimensions of the sheet. The vinylite sheet is peeled off, leaving the gelatin stencil on the wire mesh.

Printing the Phosphor-Dot Screen

The phosphor-dot screen is printed on a flat glass plate which has been accurately drilled to accept the guide pins previously mentioned. This plate is placed on a printing table and the gelatin stencil placed on top of it, with the gelatin in contact with the glass. The guide-pin holes in the glass are very precisely lined up with the corresponding holes in the gelatin stencil. A paste, made up of the blue phosphor in a binder of ethylcellulose in amyl alcohol, is then pressed through the wire-mesh backing and thence through the holes in the stencil and onto the plate. The viscosity of the paste must be carefully controlled to insure that the phosphor dots are of the proper size.

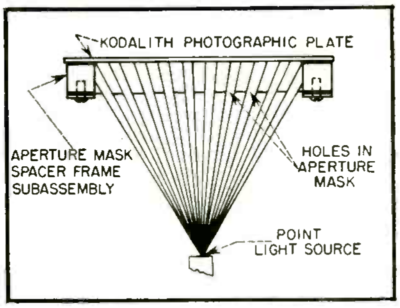


FIG. 4—Method of exposing photosensitive plate (Kodalith) through mask apertures to secure exact register

The stencil is then removed, cleaned and replaced over the glass plate. This time, however, the glass plate is moved by a calibrated cross-fed screw arrangement under the table, with respect to the stencil, until the holes in the stencil take up the proper position for the red dots. The red phosphor paste is then applied in the same manner. Finally, the stencil is cleaned, replaced, and the glass plate moved to the proper position for the green dots. The green phosphor paste is then applied. The process may then be repeated, printing each set of dots two or three times to build up the proper thickness of phosphor.

The phosphor screen is then baked in air to remove the binder, and the plate is sprayed with potassium silicate to bind the phosphor to the glass. The screen is then aluminized and rebaked. Finally, the completed screen is assembled to the spacer frame, using the guide pins to insure accurate alignment. The screen assembly is then mounted as a unit within the metal shell, as previously described, and the cap assembly welded in place.

The glass neck of the tube, containing the electron guns, is fastened to the metal cone with the aid of a mandrel which maintains the bore of the tubing in exact alignment with the screen assembly. The tube is evacuated through an exhaust tubulation at the base-end of the tube. The base itself is a 14-pin (diheptal) structure which provides separate connections to the cathodes, control electrodes, and focusing electrodes.—D.G.F.

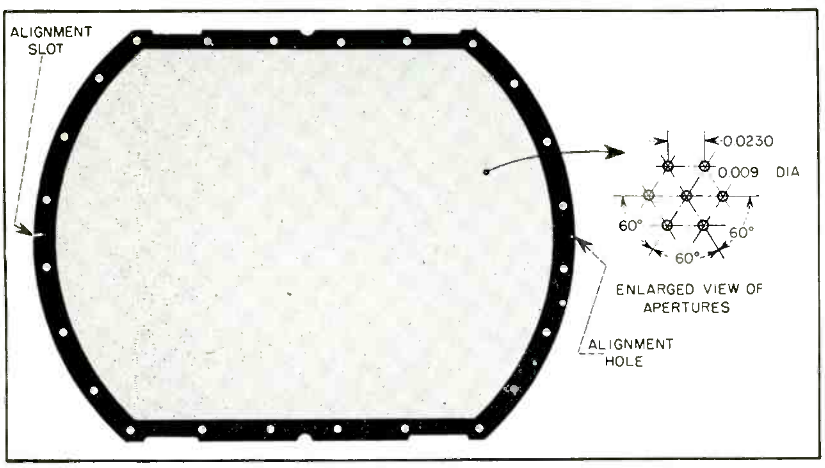


FIG. 3—Dimensions and arrangement of holes in aperture mask

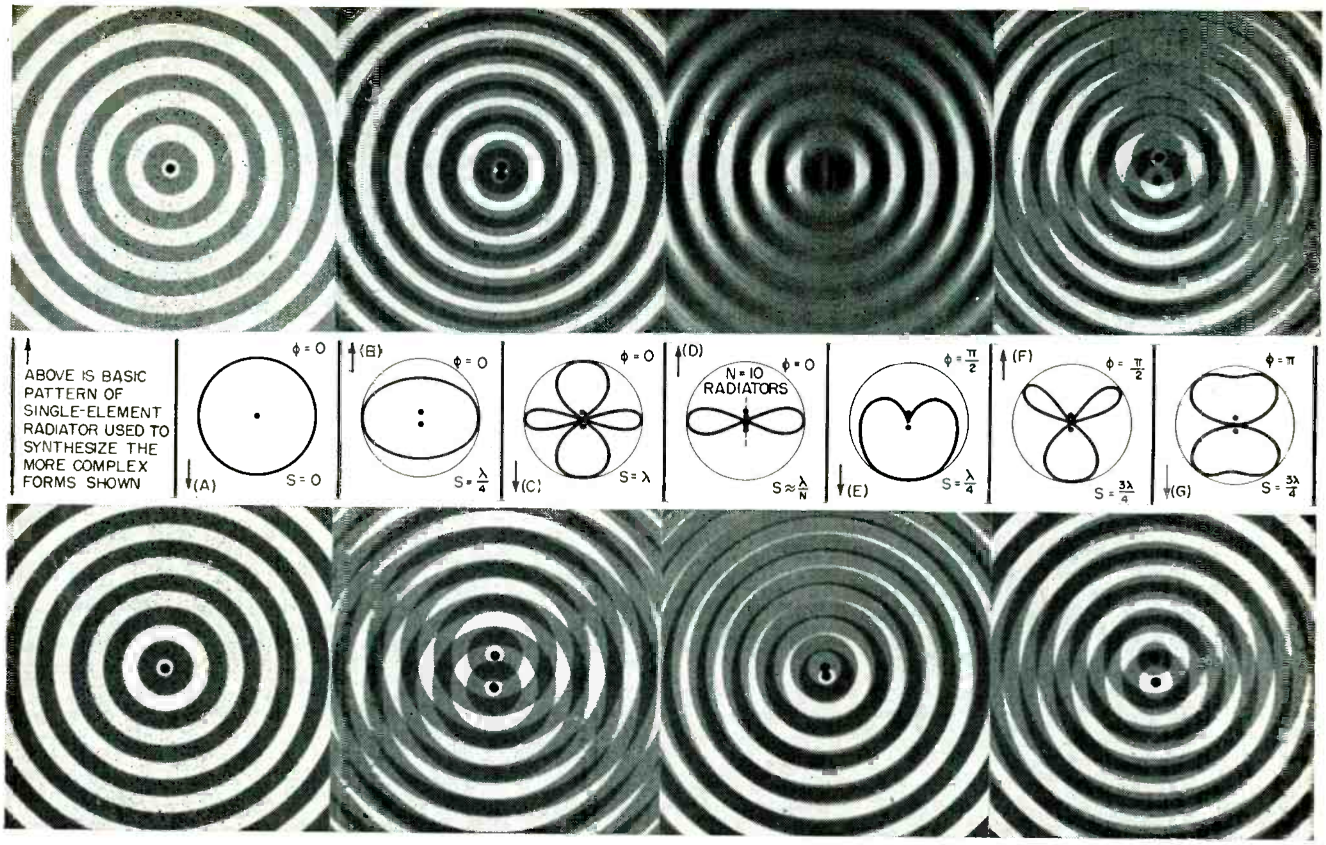


Photo Radiation Patterns

Two-dimensional wave interference patterns of two or more radiators of same frequency and polarization can be synthesized quickly and economically by superimposing bullseye patterns photographically. Examples are shown above

By **GERHART W. GOEBEL**

Telecomns Central Office
German Post Department
Darmstadt, Germany

PHENOMENA of wave propagation, reflection and refraction are best demonstrated by the ripple tank. In cases where the extreme versatility of the ripple tank and its high cost and complexity are not justified, the simple and economical photographic process described may be used. The system provides two-dimension patterns of two or more radiators of the same frequency and polarization.

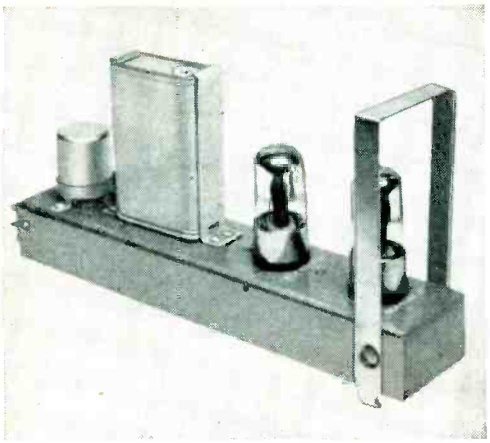
The image of a wave in a plane normal to the radiator is first drawn in the form of concentric circles centered on the radiating source which appears as a point. The lines represent either a minimum or a maximum; thus they are made equal in thickness to the spaces between them, which represent the opposite wave condition. A photographic negative prepared from the target-shaped drawing is then printed on soft photographic paper with an exposure value of one-half normal. This produces the basic pattern of grey and white.

Pattern Synthesis

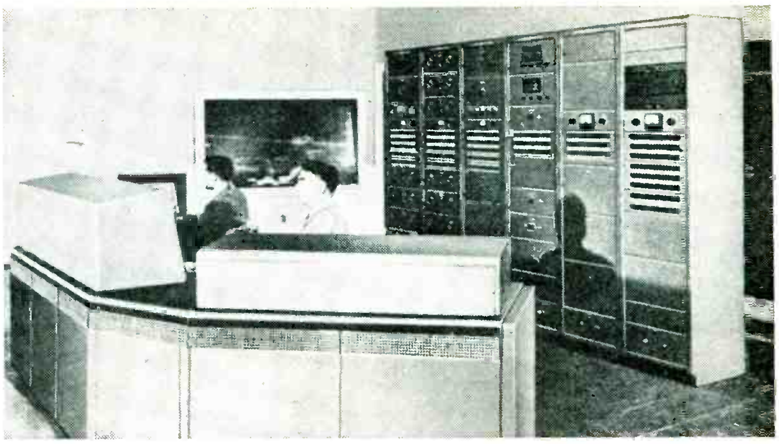
In the radiation pattern of two radiators spaced S degrees and having phase difference ϕ (where $S = 0$ and $\phi = 0$), the negative is printed twice with the same exposure. The result is an image of two grey-and-white patterns superimposed to form a black-and-white pattern as illustrated in (A). The double density of the dark portion indicates reinforcement.

For various phase differences, separate sets of basic patterns are required, with phase angles shown as increased distances from the center to the first grey circle.

The method described is especially useful in helping students visualize the effects of spacing and phase changes on radiation patterns. Extremely vivid illustrative material can be prepared by taking cartoon-type movie exposures of patterns with gradually changing conditions of phase and/or spacing.



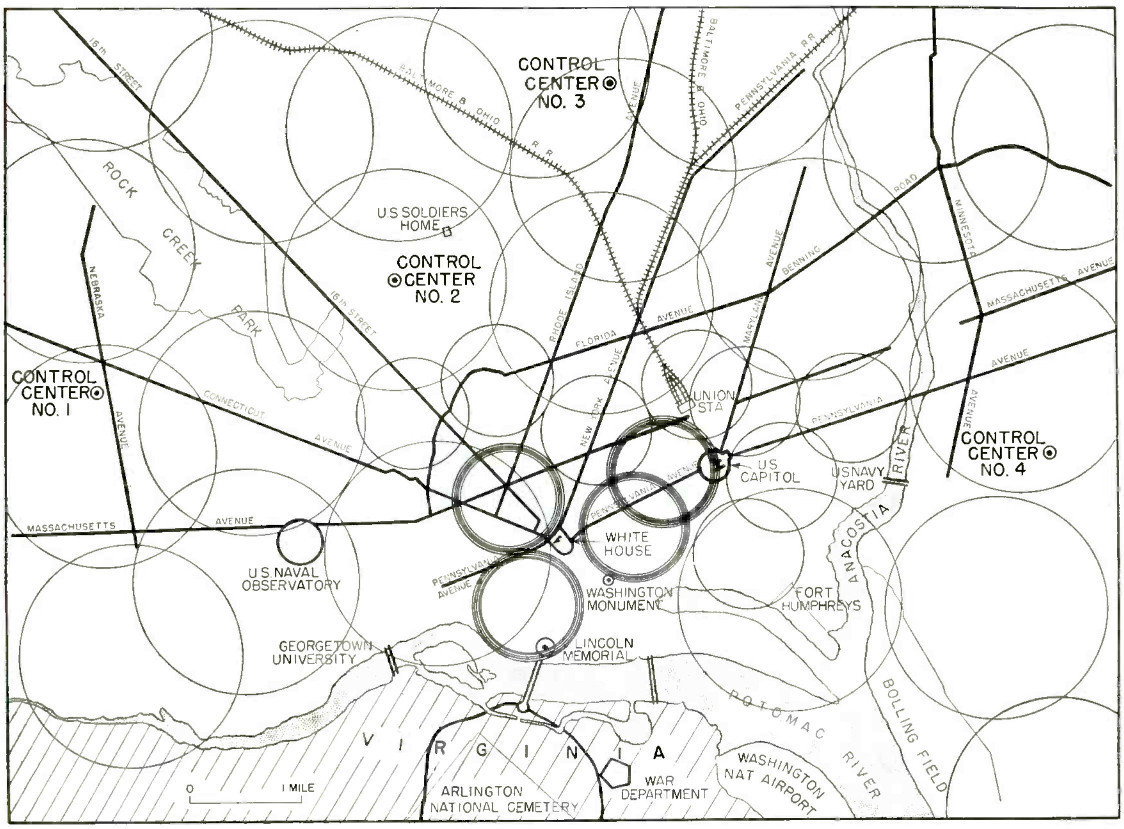
Electronic siren at control-transmitter location generates alarm signals for all receiver locations

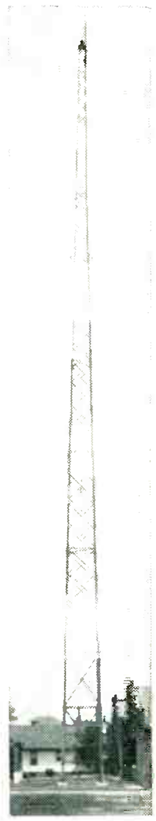


Entire populace can be warned from central control station which can broadcast both alert signals and verbal instructions during and after an attack

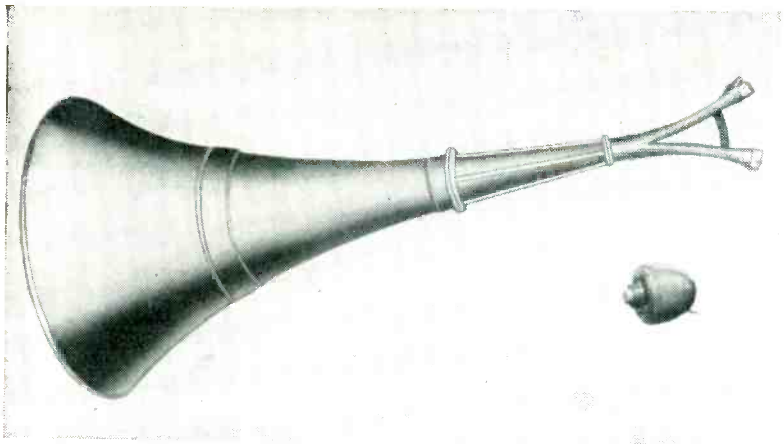
WASHINGTON ADOPTS Automatic

F-M transmitters at control locations send coded messages to strategically-located alarm positions. Decoding receivers and high-powered amplifiers broadcast transmitted alarms instantaneously. System can also disseminate verbal instructions

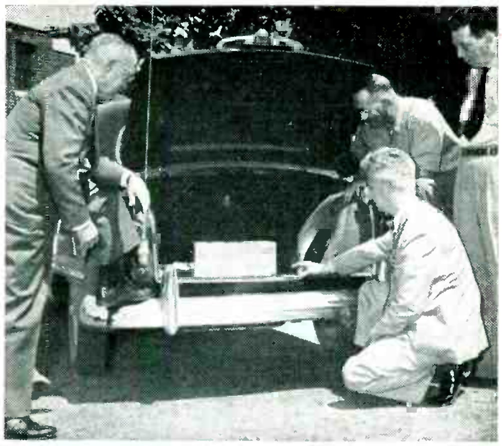




Each alarm position (center of each circle on District of Columbia map at left) receives coded signals from control center antenna (shown at right). Heavy circles in vicinity of White House and U. S. Capitol indicate alarm positions that have already been installed



Warnings are broadcast by six-foot horn loudspeakers, each of which is fitted with two driving units, and capable of providing 75-db signals at one mile



Mobile units are also tied in with District of Columbia emergency-communications system

C-D Warning System

By HERBERT A. FRIEDE

Deputy Director of Civil Defense
Government of the District of Columbia
Washington, D. C.

SUCCESSFUL operation of a city's civil-defense organization depends on the existence of a dependable communications system.

Warning centers are faced with two communications problems: (1) air-raid-warning signalling, and (2) civil-defense communications for operational purposes. For various reasons, land lines cannot be relied upon as the sole means of signalling and communicating. Radio lends itself to the problem in many ways and can, in fact, be used as the basic mutual-aid communications system after a warning has been activated by the Air Force.

The system described here has been approved for use in the District of Columbia for the protection of Washington and much of the area surrounding it. Every known safety precaution has been incorporated. In the event of an alarm, the pushing of a single button will immediately alert the entire populace, and the same equipment can be used subsequently for issuing verbal instructions to the public.

Coding System

The warning system makes use of f-m transmitter control stations so designed that special coded signals are transmitted which automatically turn on loudspeaker horns located throughout the city. Each horn is equipped with an automatic decoding device that can be operated only by the controlling transmitter, and then only when the properly coded signals are transmitted, thus preventing any horn from issuing a false alarm. As an additional safety factor, and to facilitate maintenance and possible future signal changes, the actual 400 to 1,000-cps alarm tones are generated by an electronic siren at the control headquarters. The siren has a distinctive tone that distinguishes it from fire and police alarms. Provisions are made for transmitting alerts, the all clear and such verbal instructions as may be desired. All main equipment at a command center, including auxiliary power supplies, is in duplicate.

The accompanying map shows the general locations of the various alarm units. Each circle designates one alarm unit, the multiple circles indicating installations that have already been made. Alarm units are capable of providing a minimum of 125 db at 100 feet, or 75 db at a distance of one mile.

Each alarm unit contains a receiver, a decoder, and four 70-watt amplifiers that are capable of continuous operation. Each of these amplifiers is connected to a 6-foot horn speaker equipped with two driving units, as illustrated in the photographs. These horns broadcast information transmitted by the main station transmitter, whether actual alarm signal or voice.

The power amplifiers have less than 5-percent distortion. In full operation, they consume over 220 watts. Push-pull 807's in class AB_1 provide the desired amplification, when used with 10-db inverse feedback. Standard output impedances are provided. Self-contained power supplies operate on standard line power. The response curve of the amplifiers is essentially flat from 20 to 20,000 cps, gradually tapering off at both ends. The receivers used are conventional.

Alarm-position equipment is designed to perform under all conditions of weather, and all components are electrically and mechanically interchangeable.

New Photoelectric

By GEORGE M. CHUTE

Application Engineer, Apparatus Dept. General Electric Co., Detroit, Mich.

AUTOMATIC PACKAGING at eye-blurring speed is today an essential complement to mechanized production of consumer goods. Only by eliminating manual handling, filling and sealing operations can an attractively packaged product be turned out at prices low enough to meet competition and achieve the required sales volume.

In order for a machine to convert a web of printed paper and a stream of finished products into a production of wrapped or boxed consumer goods, with each printed design accurately centered on the face of the package, some type of photoelectric web-register control is needed. In the early days of electronics a single phototube fed a few conventional amplifier tubes that actuated the solenoid of the cutter bar. This sufficed for slow-speed equipment and simple package designs, but today much more elaborate control equipment is required. Thyratrons, saturable reactors and selsyns now appear in the circuits, and some even use as many as three phototubes to obtain the required accuracy of register control.

With minor modifications, the same electronic control equipment can be used also for side-register control. This insures that paper, rubber, metal or other sheet material is wound evenly onto a roll at high speed. Here the electronic equipment must actuate a motor that shifts the winding arbor in either direction as required to make the wound edges of the rolled product smooth.

Simple Two-Point Side-Register Control

In this article, a number of new control circuits developed for side-register control and web-register control will be presented and analyzed in detail.

In the photoelectric side-register control circuit of Fig. 1, the phototube is aimed at the edge of a continuous web or strip of paper or metal that is being wound onto a roll. Any small sidewise movement of the strip is detected by the phototube, which in turn actuates the electronic control circuit that makes a motor move the whole roll axially so its wound edge will be smooth. This control unit is used when the rate at which the edge of the strip changes position is not more than 10 inches per minute.

At the desired strip position, the beam of light from the light source is half cut off by the edge of the strip, and neither V_{4A} nor V_{4B} pass enough plate current to pick up their relays. If this edge moves in the direction wherein less light reaches the phototube, the increased phototube resistance drives the grid of V_{2A} more negative. The resulting lower plate current in this tube means reduced voltage drop across R_1, making the grid of V_{4A} more positive so that this tube's increased plate current picks up relay 1. The relay contacts then make the roll-shifting motor move the roll axially in the proper direction so half of the light beam again reaches the phototube. If the roll moves too far in this correcting direction, or if the initial error was such that more than half the light beam reached the phototube, V_{2A} and V_{2B} act as a long-tailed pair to operate relay 2 and make web correction in the opposite direction.

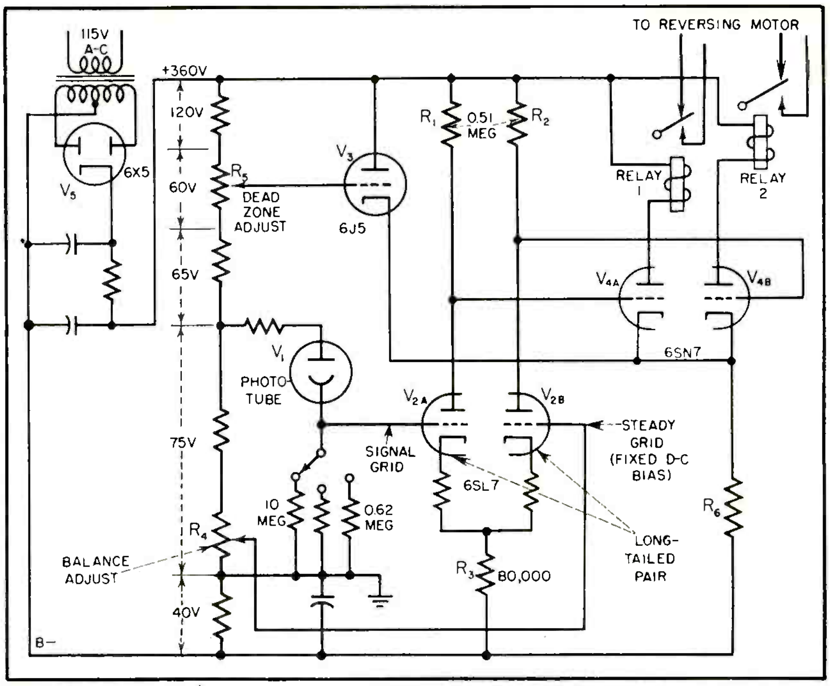


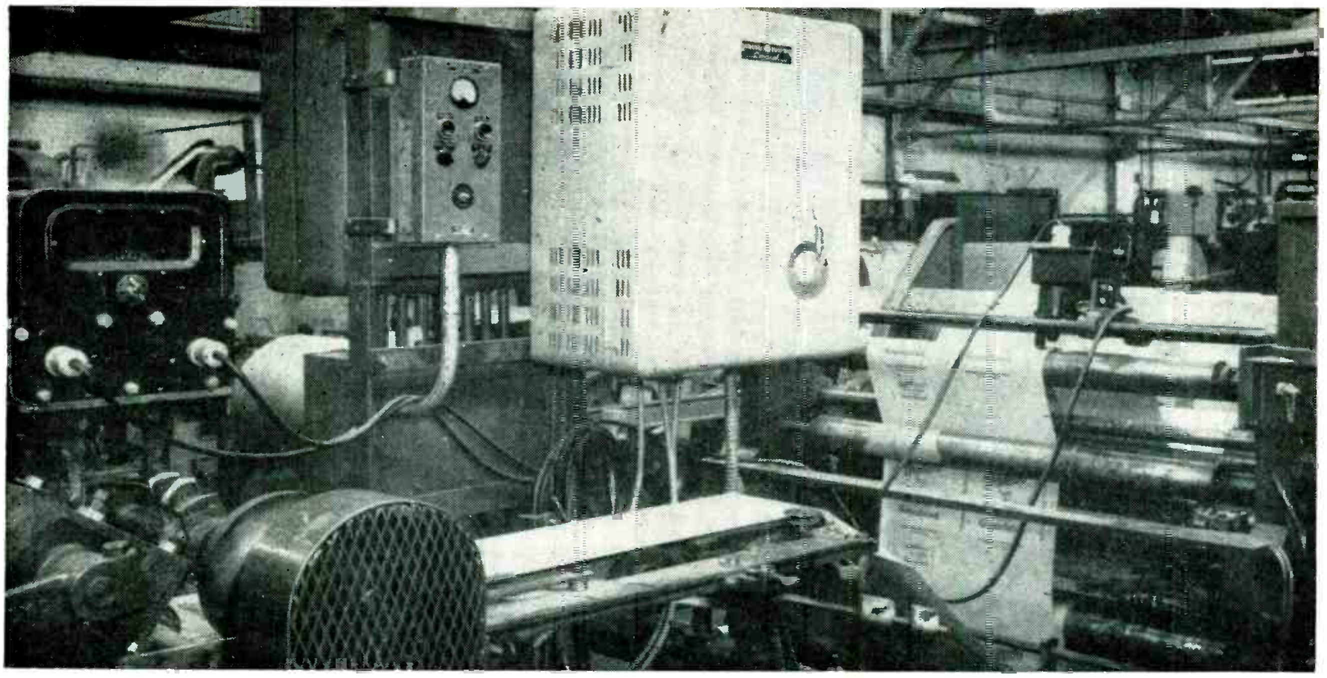
FIG. 1—Simplified circuit of two-point side-register control for lining up ends of roll of sheet material while it is being wound at high speed. Relays in the output stage control reversing motor directly or through contactors

Long-Tailed Pair

As a long-tailed pair, V_{2A} and V_{2B} (usually exactly alike and in the same enclosure) have equal plate resistors R_1 and R_2 and have their cathodes connected to a single resistor R_3. Any current through either triode must pass through R_3, which is the long tail for this pair of tubes. The grid potential of V_{2B} does not change once it has been set by balance adjustment R_4.

The long-tailed pair of tubes receives just one signal, at the grid of V_{2A}, and changes this into two equal and opposite output signals. When the circuit is in balance, so that the signal grid is at exactly the same potential as the steady

This article is based on material contained in a forthcoming book by the author, "Electronic Motor and Welder Controls," to be published by McGraw-Hill Book Co.



Photoelectric cutoff web-register control installed on bag-making machine. Scanning head that views register marks is just over printed paper on machine at right. Unit with two cables (left center) is photoelectric selector switch that checks position of cutter knife and compares with register marks

REGISTER CONTROLS

Three recently developed automatic side-register and web-register circuits boost output and improve quality of high-speed winding and packaging machines using sheet material. Unique circuit features are long-tailed pairs, thyratrons feeding correction motor directly, and three-phototube arrangement for precise cutting of moving patterns

grid, the plate currents are equal and the voltage drops across equal-value plate resistors R_1 and R_2 are equal. If the combined plate current flow of the two tubes is 0.6 ma, it produces a 48-volt drop across the 80,000-ohm cathode resistor R_3. The balance control might be set typically to make the grids 46 volts above B−, giving grid-to-cathode voltages of −2 volts at balance.

If now the signal grid becomes more positive, as when the phototube receives more light, the increased plate current in V_{2A} and R_1 makes the grid of V_{4A} more negative. The increased V_{2A} plate current also increases the voltage drop across R_3 so that the cathode of V_{2B} rises slightly, perhaps to 48½ volts above ground. Since the grid potential of V_{2B} is fixed at 46 volts, the grid voltage of V_{2B} becomes −2½ volts instead of −2 volts, thus decreasing the current in V_{2B} and R_2. The resulting decreased voltage drop across R_2 makes the grid of V_{4B} more negative, giving the desired opposite output signal here. The large plate current increase in V_{2A} is nearly offset by the large plate current decrease in V_{2B}, so the total current in R_3 has increased very little; this long-tailed pair draws nearly constant current from the d-c supply.

Dead Zone Adjustment

When a motor moves a heavy roll to the right or left to seek a central position, the roll may coast beyond the center; before it stops moving to the left, the control circuit may give a signal to move it back to the right. To decrease this hunting action or back-and-forth movement of the roll, a dead-zone adjustment R_5 is included. This acts with V_3 to let the roll overshoot the central position without causing an opposite correction.

If the R_5 slider is moved away from B+ until the grid of V_3 is say 200 volts above ground, enough current will flow through cathode resistor R_6 to make the cathodes of V_3, V_{4A} and V_{4B} about 205 volts above B−. The latter two tubes may be passing a small amount of current, but not quite enough to pick up the relays inasmuch as their grids are also about 200 volts above B−. With this setting of R_5, a very small

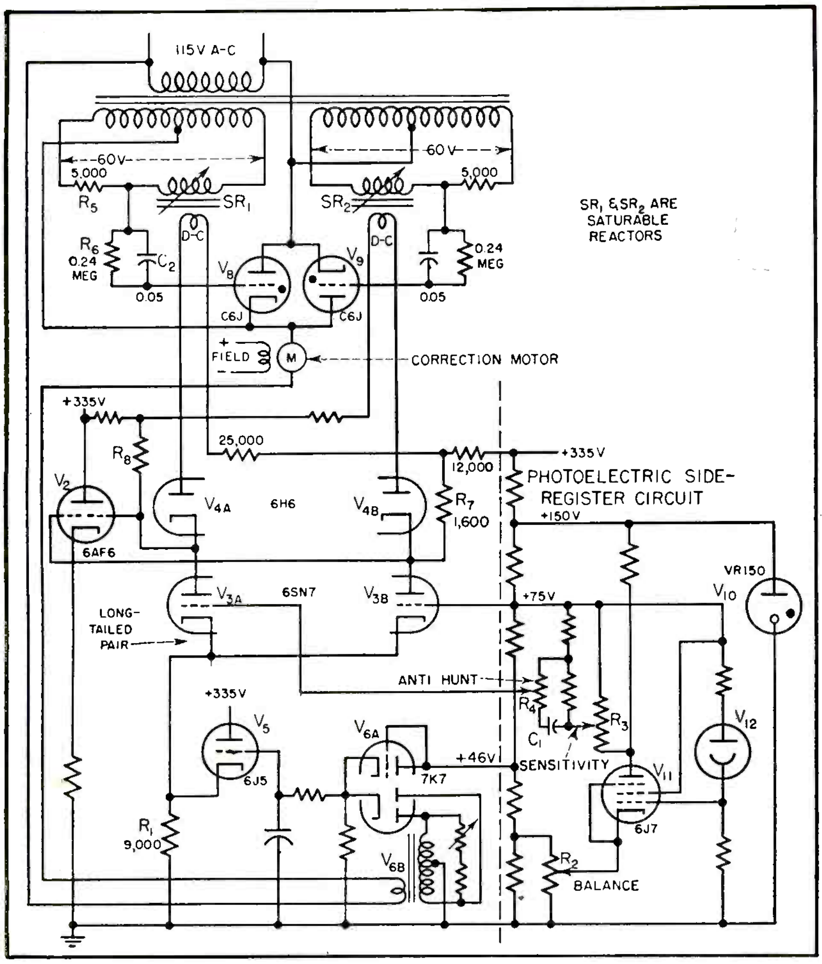


FIG. 2—Side-register control with thyratron output tubes that supply armature current directly to correction motor. Each thyratron furnishes current for one direction of rotation of correction motor

movement of the strip edge or small change of light will cause the plate current of either V_{4A} or V_{4B} to increase slightly and pick up a relay. Such close adjustment may be expected to cause hunting or continued back-and-forth motion of the roll.

If the slider of R_5 is moved about 10 volts closer to B+, the increased V_3 plate current raises the voltage drop across R_6 by nearly 10 volts so that the cathodes of V_{4A} and V_{4B} are about 215 volts above B−. This makes the tube grids about 15 volts negative with respect to their cathodes. A greater change of light is therefore needed at the phototube in order to drive the grids the extra 10 to 12 volts positive before a relay can cause a correction. In this way a dead zone is formed; when the wound roll approaches the central position and both relays are dropped out, the roll, while coming to rest, may overshoot by the amount of this dead zone without causing another correction. Of course the wider dead zone is obtained at a sacrifice in smoothness of wound roll.

Side-Register Control with Thyratron Drive

In the all-electronic side-register control of Fig. 2, thyratrons V_8 and V_9 supply current directly to the correction motor, hence no relays are used. Thyratron V_8 fires to make the motor move the roll sidewise in one direction, while V_9 causes roll movement in the opposite direction.

Triodes V_{3A} and V_{3B} respond to signals received from the phototube amplifier tube V_{11}. When the grid of V_{3A} is made more negative, less current flows through the tube and its cathode resistor R_1. Since these two triodes and R_1 operate as a long-tailed pair, reducing the voltage drop across R_1 has the same result as a rise in the grid potential of V_{3B}; greater current flows in V_{3B}, V_{4B} and the d-c winding of saturable reactor SR_2, and no current flows in SR_1. The greater current in SR_2 fires V_9 earlier in its half-cycle of a-c plate voltage, while V_8 fires later or not at all. The current pulses from V_9 (flowing always in the same direction) pass through the armature of a d-c correction motor, turning this motor so as to give the desired movement to keep the roll or web in register. No tubes in the circuit are capacitor-coupled.

Before studying the thyratron circuits in detail, let us see how the photoelectric side-register circuit produces a signal that lowers the grid potential of V_{3A} as outlined above.

Phototube Action

When the web roll is in the correct position, no motion of the correction motor is desired. At this position, the phototube receives a certain amount of light that determines the value of the steady control grid voltage on V_{11}. The amount of V_{11} plate current can be adjusted with R_2, which determines the cathode potential of the tube. There will be one correct setting of R_2 at which both V_{3A} and V_{3B} pass very little current, so that both thyratrons are held off equally and the correction motor does not turn.

When the web shifts sidewise and increases the light on the phototube, V_{11} passes more current; as a result, the potential at the plate of V_{11} is lowered. This potential change acts on the grid of V_{3A} through sensitivity control R_3. Advancing R_3 to pass on a larger portion of the V_{11} plate signal makes the circuit more sensitive, for the correction motor responds to a very small shift of the web. With such quick action the equipment may hunt. To decrease such hunting, part of the output voltage of the sensitivity control is applied to an antihunt circuit consisting of R_4 and C_1. When light increases at the phototube, lowering the signal voltage applied to the antihunt circuit, the voltage across C_1 does not change at once; the grid of V_{3A} is forced negative as though connected directly to the plate of V_{11}, but it then returns more positive as C_1 discharges. In this way, the d-c correction motor is forced to turn quickly at first, then it slows down or stops until the effect of its correction can be seen at the phototube.

Now let us see in detail how the circuits in Fig. 2 use this signal at the grid of V_{3A} to control the speed and direction in which the motor turns.

Steady-State Condition

When no correction signal is received at V_{3A} or V_{3B}, the grids of both these triodes are at the same potential (about 75 volts positive to ground), as finally adjusted by balance potentiometer R_2. Under this steady-state condition the triodes are passing about 5 ma each, and their cathodes are perhaps 80 volts above ground, as also is the cathode of V_5. The grid of V_5 is 30 or 40 volts more negative than its cathode now, hence V_5 passes no current.

Part of the plate current of V_{3B} flows through V_{4B} and the d-c winding of saturable reactor SR_2 on its way to B+. Similarly, a part of the plate current of V_{3A} flows through V_{4A} and the d-c winding of SR_1. These small direct currents, flowing equally through the two saturable reactors under balanced steady-state conditions, make both thyratrons fire late in their half-cycles. Since the thyratrons are connected back to back across the a-c supply, only a small a-c voltage appears across the motor armature when they pass the same amount of current. There is no d-c voltage to make the motor turn either way, even though the motor receives full field current (from a 5U4 full-wave unfiltered rectifier circuit, not shown).

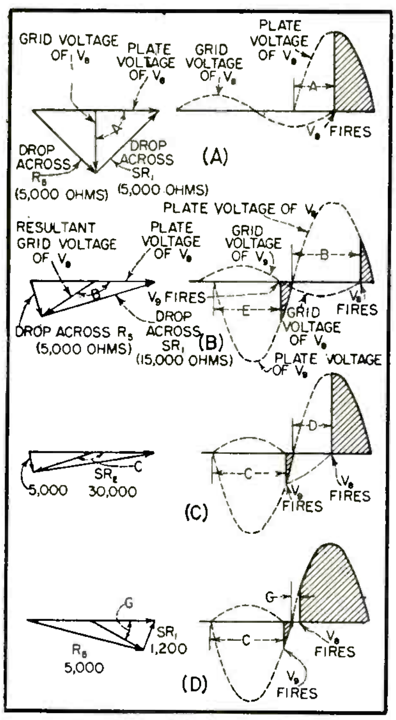


FIG. 3—Thyratron firing actions for various voltage conditions in circuit of Fig. 2

To make the motor turn one way, the current through V_8 must be made greater than that through V_9. The thyratron current is gradually increased or decreased by the phase-shifting bridge circuit that includes a fixed resistor R_5 and a variable inductance provided by saturable reactor SR_1. The 60-cycle impedance of this reactor ranges from 30,000 ohms (for zero current through the d-c winding of SR_1) down to 1,000 ohms for 2 ma direct current.

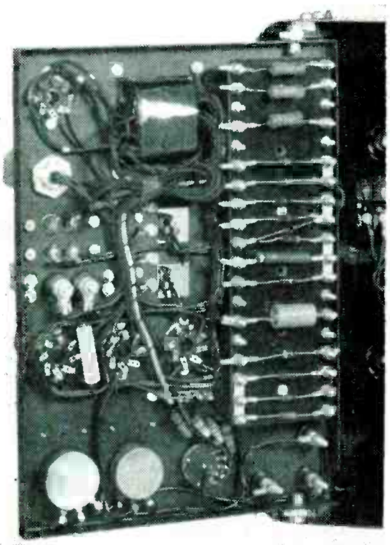
If less than 1 ma of direct current flows in SR_1, so that it has 5,000 ohms impedance, the result is as shown in Fig. 3A. Since SR_1 and R_5 each have 5,000 ohms, the grid voltage of V_8 lags 90 deg behind this thyratron's plate voltage (or behind the power transformer secondary voltage which is in phase with the plate voltage). Firing of V_8 is then delayed by the angle A, so that this thyratron applies voltage to the motor armature for about half of its positive half-cycle.

To prevent accidental firing of V_8 at the start of its half-cycle, R_6 and C_2 are inserted in the grid circuit. By grid rectification, the power transformer secondary forces current through R_6, charging C_2 so that it is more negative at the grid connection. The effect is most important when the a-c hold-off wave is nearly 180 deg out of phase with the plate voltage.

In the balanced condition where only small equal direct currents flow through the d-c windings of the saturable reactors, the impedance of the a-c winding of SR_1 is perhaps 15,000 ohms, as shown in Fig. 3B. The grid voltage of V_8 then lags the plate voltage by the angle B, so V_8 fires very late, and applies voltage to the motor armature for a small part of the half cycle. While the circuit is in balance, SR_2 also receives this same small amount of direct current, so V_9 also fires after an equal delay E behind its own plate voltage; the thyratrons pass the same amount of current, but in opposite directions, so the d-c motor does not turn.

Correction Signal Action

Now see what happens when a correction signal swings the grid of



Two-point side-register control, showing type of chassis assembly used on industrial electronic equipment. Trend is toward use of screw and nut terminals so that repairs in factory can be made without need for soldering

V_{3A} more negative and decreases the plate current of the tube. First of all, the plate potential of the tube rises and the cathode potential drops because the lower current means lower voltage drops across the plate and cathode resistors. Meanwhile the grid of V_{3B} is held at steady potential by the phototube circuit; since the cathode potential of this tube dropped with that of V_{3A}, plate current increases in V_{3B}. The resulting increased voltage drops across plate supply resistor R_7 means more voltage across diode V_{4B} and hence more direct current through this diode and SR_2. Because the upper end of R_7 has dropped in potential and the plate of V_{3A} has gone up, there is very much less voltage between these two points and no current flows through SR_1. This gives the condition shown in Fig. 3C, where firing of V_9 is delayed by the large angle C (almost 180 deg) so that the plate current flowing in this thyratron is negligible. Meanwhile the increased direct current in SR_1 has caused earlier firing of V_8, delayed only by the angle D. Since the positive voltage applied to the armature by V_8 is greater than the negative voltage (below the line in Fig. 3C) applied by V_9, the motor armature turns at medium speed (to retard the web or to move the roll, say, to the left).

If a stronger correction signal further decreases the plate current of V_{3A}, it cannot shut off V_9 further but can increase the plate current of V_{3B} and thereby increase the direct current through SR_1. Under this new condition, shown in Fig. 3D, V_8 fires after a small delay angle G; much greater voltage is applied to the motor armature, which turns at high speed to cause faster correction.

To produce an opposite correction, the grid of V_{3A} is driven more positive by the correction signal so that the direct current decreases in SR_2 and increases in SR_1. Then V_8 fires very late but V_9 fires early, applying a large voltage of opposite polarity (below the line) to the armature so that the motor advances the web or moves the roll, say, to the right. Electron-ray indicator tube V_2 shows what web correction is being made.

Two-Way Cutoff Web-Register Control

Replacing the phototube circuit of Fig. 2 (at the right of the dashed line) with the three-phototube arrangement of Fig. 4 gives a high-speed web-register control for cutting off material precisely at printed register marks as the material is drawn off a roll at high speed.

The general arrangement of the photoelectric sensing system is shown at the lower right in Fig. 4. The draw rolls pull the sheet or web off of a roll of material, previously printed with a design and accurately spaced register marks. This web is fed between cutter rolls that try to cut the web in line with a register mark. The cutters are driven at constant speed, but the speed of the draw rolls is changed or controlled by the correction motor in Fig. 2 so as to feed the web forward just fast enough to bring a register mark at each cutoff point. A beam of light X is so located that a preceding register mark decreases the light reaching phototube V_{18} at the exact instant when a register mark reaches the cutoff point. If the register mark is early, so that this decrease in light occurs before the cutoff knives have turned to the cutting position, the phototube circuit of Fig. 4 makes V_8 of Fig. 2 pass current; the correction motor turns and through a differential gear slows the draw rolls to retard the web.

Just as phototube V_{18} sees when the register mark reaches the cutoff point, phototubes V_{15} and V_{16} see when the knife makes its cut. In the selector-switch assembly that includes these phototubes there is a turning disk, driven by chain or gear from the cutoff roll; through pairs of holes in this disk, beams of light may reach the phototubes. For an instant before the cut is made, light beam Y reaches phototube V_{16}, trying to turn on V_{11} and thyratron V_8. Just after the cut is made, light beam Z reaches phototube V_{15}, trying to turn on V_{12} and thyratron V_9. By a mechanical dead-zone adjustment, the holes in the turning disk may be located so that no light reaches these phototubes at the time of cutting. If the register-mark light dip at phototube V_{18} occurs during this dead zone, then neither V_{11} nor V_{12} passes current and the correction motor does not turn; web speed is right.

Briefly, phototube V_{18} controls pentode V_{17} and the control grids of mixer tubes V_{11} and V_{12}; phototubes V_{15} and V_{16} control V_{14A} and V_{14B} and the third grids of mixer tubes V_{11} and V_{12}. This mixer type of tube passes current only when both its first and third grids are positive;

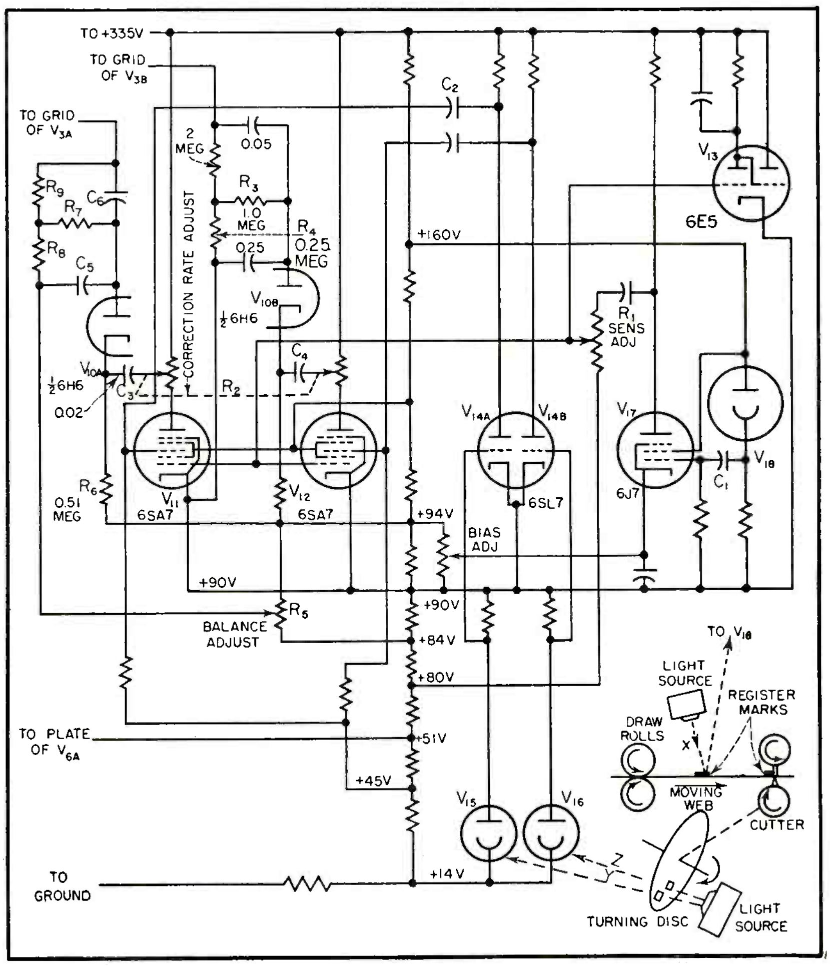


FIG. 4—Two-way cutoff web-register control using three phototubes, replacing single-phototube circuit at right of dashed line in Fig. 2

other grids prevent any interaction between the signals received at the first and third grids. When V_{11} passes current, the potential fed to the grid of V_{3A} drops, increasing the current of thyratron V_8 in Fig. 2 to retard the web. When V_{12} passes current, a similar drop in the potential fed to the grid of V_{3B} increases the current of thyratron V_9 to advance the web.

Action While in Register

Phototube V_{18} and pentode amplifier V_{17} in Fig. 4 are coupled through capacitor C_1; only a sudden light change can thus affect V_{17}. Each dark register mark on the web dips the grid voltage of V_{17}, reducing its plate current and correspondingly increasing the potential at all parts of sensitivity adjuster R_1. This raises the control grid potentials of V_{11}, V_{12} and V_{13}, and therefore each passing register mark makes electron-ray tube V_{13} wink and tries to turn on V_{11} and V_{12}. This turn-on impulse, at A in Fig. 5A, will not turn on V_{11} or V_{12} as long as the impulse occurs during dead zone B. During B, the third grids of V_{11} and V_{12} are both so negative that neither tube can fire, even when the first grids are positive.

The holes in the turning disk are adjusted so that no light reaches phototubes V_{15} or V_{16} during zone B. With no current through these phototubes, the grids of double-triode V_{14} are at cathode potential so V_{14} passes current through both of its plate supply resistors, causing voltage drops that make both plate potentials low. The third grids are about 45 volts more negative.

Earlier than zone B, a disk hole lets light reach phototube V_{15}; the resulting phototube current produces a voltage drop across R_9 that lowers the grid potential of V_{14A} and turns off this triode section. The plate potential of V_{14A} then rises, and through C_2 raises the third grid of V_{11} also, as shown during zone G in Fig. 5A. The time constant of C_2 and the third-grid resistor of V_{11} is about $\frac{1}{8}$ sec, so the voltage across C_2 changes little during zone G.

Also, later than zone B a different disk hole lets light reach phototube V_{16}; current through R_{10} lowers the control grid potential of V_{14B} so its

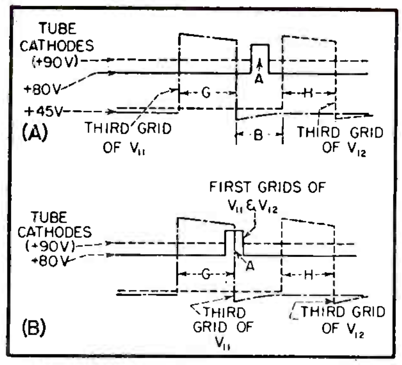


FIG. 5—Voltage relationships in cutoff web-register control under two conditions of operation

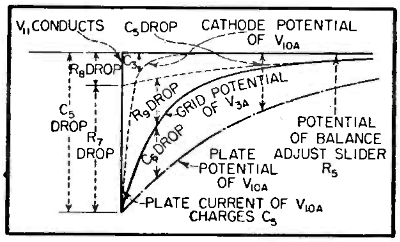


FIG. 6—Action of diodes in providing momentarily a large correction signal

plate potential rises and the third grid of V_{12} is driven positive, during zone H. Neither of these actions turns on V_{11} or V_{12}, for their first grids are too negative to permit electrons to flow. As long as signal A from the register mark stays within zone B, these tubes pass no current and give no correction signal.

So long as V_{11} and V_{12} pass no current, the sliders of correction-rate adjuster R_2 are at B + potential (about 335 v). The cathodes of diode sections V_{10A} and V_{10B} are at a lower potential (about 94 v), so capacitors C_3 and C_4 are charged to the difference voltage (about 241 v). The plate of diode V_{10B} is connected through R_3 and R_4 to + 90 v; since this is 4 volts negative with respect to the cathode, diode V_{10B} passes no current. The grid of V_{3B} in Fig. 2 is therefore held about 90 volts above ground; similarly, the grid of V_{3A}, adjusted by balance dial R_5, holds the grid of V_{3A} also about 90 volts above ground, so that the plate currents of thyratrons V_8 and V_9 are equal and the correction motor does not turn.

Web Correction

Suppose that the web is moving too fast, so that the register mark produces signal A too early, as shown in Fig. 5B. At A the control grid of V_{11} becomes positive while its third grid is still positive; with both grids positive, V_{11} passes current and its plate potential drops. This sudden lowering of the positive or R_2 side of C_3 drives the cathode of V_{10A} far more negative than + 94 v or the R_5 slider. Tube V_{10A} then passes current, and its plate also is pulled negative; this negative pulse passes through an R-C network that holds the grid of V_{3A} negative for a time long enough to let the correction motor reduce the web speed.

Even though the register mark is large or is moving slowly, thereby making V_{11} pass current for say 1/10 sec, the short time constant (1/100 sec) of C_3 and R_6 lets the cathode of V_{10A} recover or rise quickly after V_{11} has lowered its plate potential. Therefore, to provide a correction signal that is not affected by the size or speed of the register mark, diode V_{10A} passes current for perhaps only 1/1,000 sec, to charge C_5. Although charged so quickly, C_5 discharges more slowly through R_7 and R_8 ($\frac{1}{3}$ sec time constant). Moreover, to provide a large correction signal for an instant at the control grid of V_{3A}, followed by a lesser signal for a longer time, C_6 and R_9 are added (1/10 sec time constant). As is shown in Fig. 6, plate current of V_{10A} at once pulls the plate of this diode far negative; since C_6 cannot charge at once, the grid of V_{3A} also is pulled far negative for the first instant. As C_6 charges through R_9 to the voltage across R_7, the grid of V_{3A} rises quickly until it remains negative only because of the voltage across R_8. When C_5 has discharged, this grid returns to the potential at the R_5 slider, ready for the next correction signal.

When the register mark arrives too late, impulse A makes the first grids of V_{11} and V_{12} positive while the third grid of V_{12} is also positive. Current passes through V_{12} and R_2; for an instant the charge on C_4 drives negative the cathode of V_{10B}. In the same manner as for the too-early condition, the grid potential of V_{3B} is driven negative, and the current of V_9 increases so that the correction motor raises the draw-roll speed and advances the web.

Army Walkie-Talkie in Mass Production

Lilliputian f-m set developed by RCA is one of first small military electronic units to roll off assembly lines. Subminiaturization techniques give new vhf unit half the size and weight of former model but twice the range

MASS production of the AN/PRC-10 walkie-talkie, designed by RCA for the U. S. Army Signal Corps, is under way. It is one of the first new military electronic units lending itself to radio-tv-type mass-production methods.

The unit, which contains 290 components furnished by 181 suppliers, went into production under a priority calling for completion of initial sets in 44 weeks, compared to the 55 weeks normally allowed for such a job. Engineers and production men worked closely together to complete the work in less time. They did it in 36 weeks.

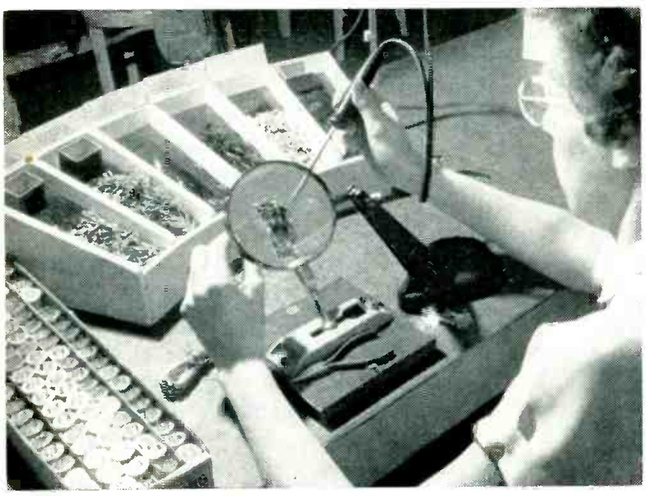
Many things were involved in the production of the needed unit in a hurry. Among them, the following stand out: expediting, subassemblies, subminiaturization and dip soldering.

Procurement specialists located sources of supply and placed orders for needed materials by following design growth on the engineers' drafting boards. Each step in the production cycle was given an early boost by having key men all along the line anticipate requirements and start their phase before the preceding one was completed.

Subassemblies consisting of complete i-f and f-m discriminator stages have been reduced in size so that they can be contained in a metal cylinder about the size of a single miniature tube.

Germanium crystal diodes are used in place of tubes where feasible and subminiature tubes are used elsewhere except for the power output tube, which is of miniature size. Tiny circuit components such as transformer coils less than a quarter-inch deep and half an inch in diameter, yet having a Q near 100, necessitate the use of magnifying lenses by workers in the production line.

One of the most important manufacturing techniques used to turn out the equipment in a minimum of



Magnifying lens being used in assembly-line production of a subassembly of the new walkie-talkie

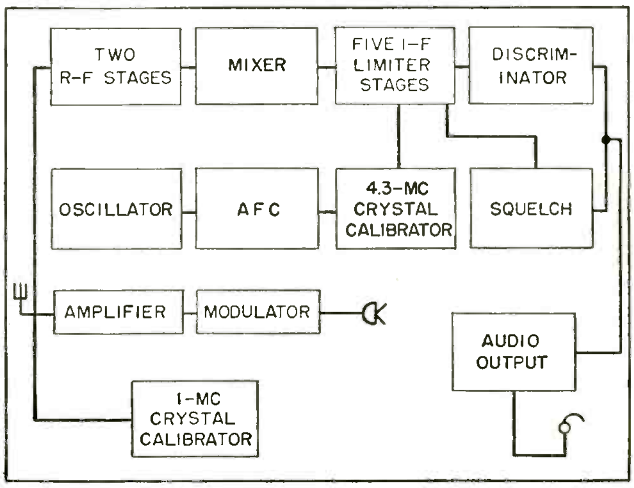
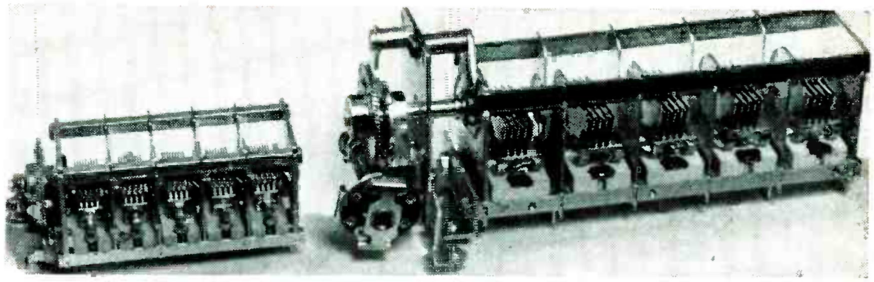
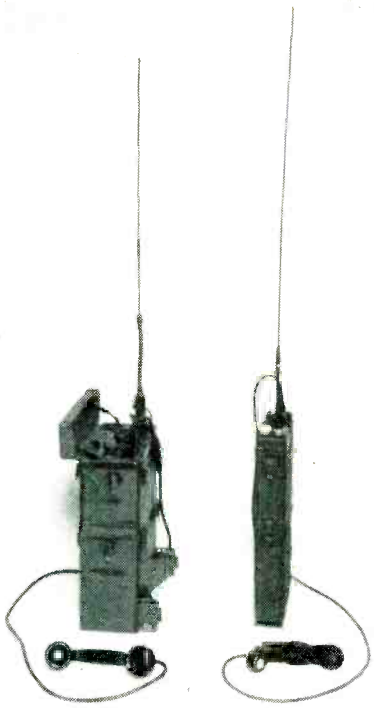


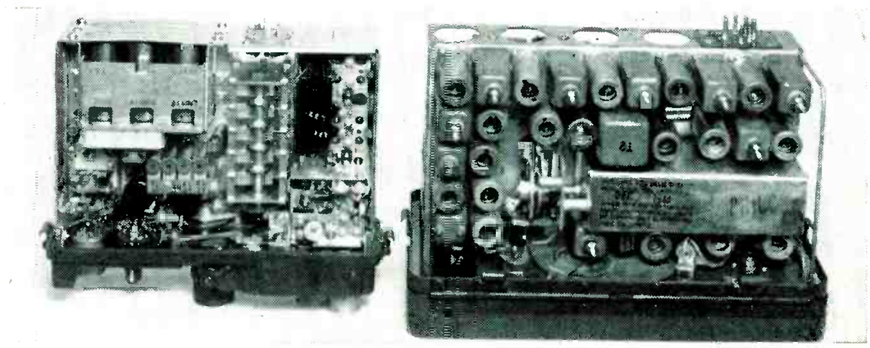
FIG. 1—Block diagram of the AN/PRC-10 walkie-talkie. Effective range is about five miles



Reduced size of ganged tuning capacitor is shown at left as compared with old unit at right



Comparison of larger old model with the new at right. Transmitter-receiver unit is in top case, power supply in bottom



Side-by-side view of new chassis on left and old at right. Miniature components and compact construction permit packing 16 tubes into new model with resulting reduction in size and weight

time is resistance-weld type soldering employed in the i-f stages and other small components.

Description of Equipment

The AN/PRC-10 is half the size and weight of its predecessor and has twice the range. The transmitter-receiver unit is 9½ inches high, 10½ inches wide, 3 inches deep and weighs 9 pounds. The entire equipment, including power supply and spare parts, weighs only 25 pounds. Reduction in size and weight has not only made the set more portable but has also effected savings in critical materials.

The new unit has increased stability which permits operation of many more walkie-talkies in a given area without interference than could formerly be tolerated.

Provision is made by the 16-tube equipment for two-way voice communication over a range of about five miles on frequencies within the vhf band. It can be used as portable gear strapped to the back of the operator or as a semipermanent installation in a vehicle or on the ground.

Remote operation and unattended relay operation are important features made possible by using two units back to back with interconnections enabling them to pick up and retransmit messages in both directions. This type of operation enables communication to be established between two stations separated by high ground by having two relay sets located on the intervening elevation.

The equipment is housed in two waterproof cases, held together by spring clamps. The top case contains the receiver-transmitter unit and the bottom case contains the battery pack. An eight-wire cable connects the transmitter-receiver with the battery.

Transmitting and receiving circuits are both adjusted to operating frequency by the same tuning knob. The dial-drive mechanism is an antibacklash gear train with the antenna tuning components mounted on and operated by it. Other important adjustments are the volume and squelch controls.

The r-f, mixer and oscillator circuits are individual subassemblies consisting of decoupling resistors, a small coil, capacitors and a subminiature tube and socket. Each subassembly is located in a small box. The antenna coil is common to both transmitter and receiver.

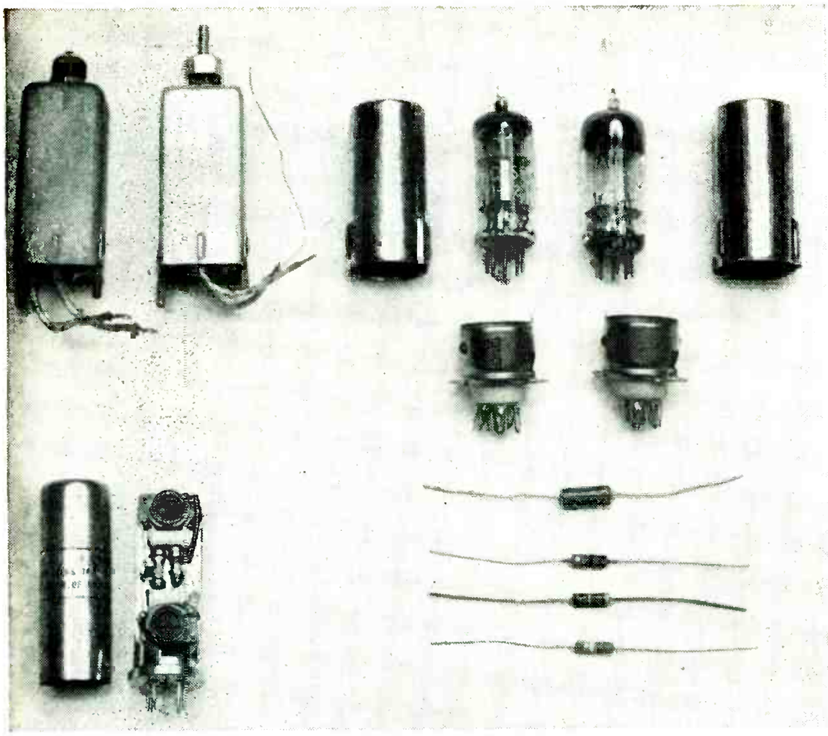
Each i-f amplifier subassembly includes the tube and is hermetically sealed in a can about ¾ of an inch in diameter and 2 inches long. The cans are made with 7-prong plug bases which plug into sockets on the chassis. A similar can contains the discriminator unit which uses two germanium diodes instead of a subminiature tube.

Location of Parts

The squelch and audio tubes and the crystal calibrator are mounted vertically in the left-center portion of the chassis. The microphone and output transformers are located in front of these tubes and a calibration crystal is located at each end of the row of tubes.

The modulator tube is mounted on the box containing the transmitter oscillator. The grid coil, trimmer and coupling capacitors are all located inside the box. Coils, tuning capacitors, decoupling circuits, coupling capacitors and germanium diodes are located inside the afc box.

Two types of antennas are provided with each equipment. For



New army walkie-talkie discriminator assembly and cover at lower left replace all the other pictured discriminator-stage components, used in old World War II model

maximum range, stationary use and two-way unattended relay operation, a seven-section whip-type antenna is used. Each section of this antenna fits into the ferrule of the previous section. To protect the long antenna from damage by bending if it should strike an object, a spring-section is provided.

For general operation, a short semirigid steel antenna is used, made up of lengths of flexible steel tape riveted together at the base and at various points along the length of the antenna. This tapered antenna is about three feet long and can be folded into a small area without damage.

Location of the equipment naturally affects its range of operation because of the high frequency and low power used. If a semipermanent antenna is mounted on a high elevation point, the effective range of the equipment is greatly extended. The AN/PRC-10 can be used in liaison-type aircraft by making a slight change in the antenna system.

The receiver sensitivity is 0.5 μv with 2.5-mw output, 15-kc deviation and a 10-db signal-to-noise ratio. Selectivity is 80 kc at 6 db down.

A received signal is resonated in both the antenna and the antenna coil and then amplified in the two r-f stages gang-tuned to the operating frequency, as shown in Fig. 1. The amplified r-f signal is fed to a mixer stage together with the local oscillator signal to produce the intermediate frequency in the plate circuit of the mixer.

Five identical cascaded i-f stages follow the mixer and are connected as grid limiters. If the signal from the mixer is strong enough, the i-f stages operate as cascade limiters.

Following the five i-f stages is a discriminator and a single audio stage feeding the handset receiver. The discriminator uses two germanium diodes instead of tubes.

When no signal is being received and the squelch circuit is turned on, the discriminator output is shorted by a relay operated by the squelch tube. This tube is controlled by the grid voltage of the last i-f limiter. The grid voltage cuts off the squelch tube, releases the relay and thereby removes the short on the audio input.

The equipment is calibrated by two crystal-controlled oscillators. The constant-frequency output of one oscillator feeds into the antenna coil. Certain harmonics of this oscillator frequency beat with the intermediate frequency of the second calibration oscillator to produce a calibration signal at every megacycle point on the calibration dial.

The transmitter contains an electron-coupled oscillator whose freqency is controlled by comparing it with the local-oscillator frequency of the receiver. The antenna coil common to both the transmitter and receiver makes up the output circuit for the transmitter.

Frequency modulation is accomplished by varying the magnetic flux through the ferrite core of an inductance coil shunting the grid coil in the tank circuit of the transmitter. The microphone signal and the constant output voltage from the afc circuits are both fed into the modulator stage.

AFC Operation

Automatic frequency control is provided by an amplifier driver tube followed by a discriminator employing germanium diodes. Zero output is obtained from the discriminator at the intermediate frequency because the discriminator center frequency is tuned exactly to the intermediate frequency. At other frequencies, a positive or negative output voltage is obtained, depending on whether the input frequency is higher or lower than the intermediate frequency. The transmitter center frequency is controlled by the discriminator output voltage which is fed to the modulator stage.

While the transmitter is operating, some of the output signal is by-passed by the first r-f stage, which is inoperative during transmission, and is amplified by the second r-f stage. The amplified transmitter signal is then mixed with the local oscillator signal to produce a given intermediate frequency. The closer this frequency is to the center intermediate frequency the smaller the voltage developed in the afc discriminator. Consequently, the transmitter frequency is controlled to the local oscillator frequency less the given i-f signal frequency. Output from the walkie-talkie is approximately one watt.—R. J.

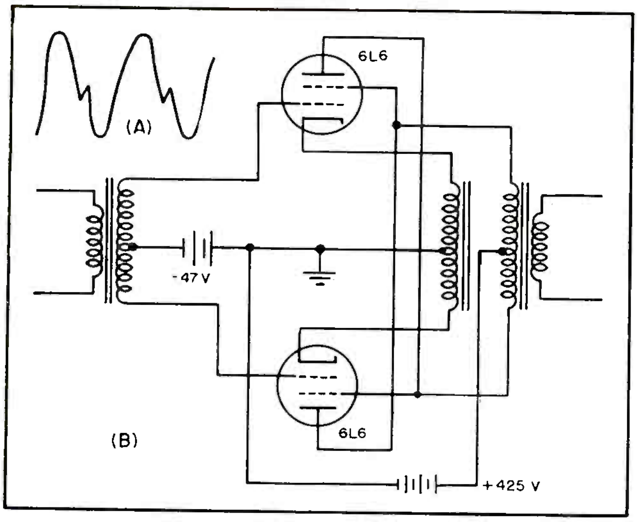


FIG. 1—Typical distortion due to switching transient in class-B amplifier, and McIntosh amplifier circuit

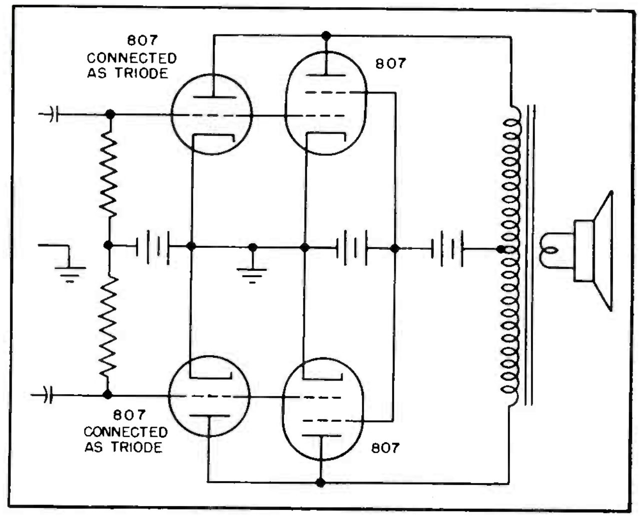


FIG. 2—New extended class-A amplifier circuit, in which the tetrodes are cut off at low operating levels

Extended Class-A Audio

Combining triode and tetrode operation in each half of a push-pull output stage gives almost 50 watts from four 807's, without special transformers. At low levels only the triode-connected tubes conduct, reducing the house-heating effect

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THE PROBLEMS involved in providing power amplification, essentially free of distortion, over the wide range of frequency and amplitude required of a high-fidelity audio system have challenged the ingenuity of engineers for many years. This paper describes a method of combining the familiar advantages of both triodes and tetrodes in such a way as to extend the range of class-A operation to peak power levels heretofore achieved only with class-AB and class-B operation.

The principal disadvantage of class-A operation lies in the relatively high idling or no-signal plate power involved, since for class-A operation the input power will remain nearly constant, regardless of signal level. The power supply accordingly must be designed to provide the power normally required for maximum-signal operation at all times. Many an engineer has designed and built that "amplifier to end all amplifiers" along these lines, only to discover that he has achieved what is primarily a new method for heating the house.

Regardless of the efficiency of a system at maximum level, its no-signal efficiency is still zero. Efficiency figures for full output tell us nothing about idling power. And unfortunately (for the efficiency-minded), the nature of music is such that full power capability is rarely required. Even the noisiest kind of music (like *Rite of Spring*) hits maximum level only occasionally; most of the peaks will be down about 10 db from maximum, and the average level of the full orchestra will be down about 20 db. This assumes that one is listening at full volume levels. Most of the time one is forced, by wives or neighbors, to turn down the level, and then the excessive power consumption required to accommodate those occasional peaks at full volume is wasted.

Class-B Distortion

For many years, the answer to this problem of efficiency has been the use of class-AB or class-B operation. For relatively uncritical applications this has been satisfactory. However, with increasing interest in extremely high-quality

This article is based on a paper presented by the author at the 1950 convention of the Audio Engineering Society in New York City.

amplifier design, minor sources of distortion have become more significant. For example, attention has recently been drawn to an inherent distortion due to the switching transients that occur as the plate current in either side of a class-AB or class-B amplifier is driven to cutoff. The nature of this distortion can be seen in Fig. 1A. Work by Sah[1] shows this notch in the curve to be a function of the leakage inductance in the output transformer. Since this distortion is due to the transformer and not the tubes, it does not appear in the distortion figures for this type of operation in the tube manuals. It increases with frequency, and becomes serious above a few thousand cycles.

McIntosh Circuit

An ingenious method of reducing the inherent distortion of the class-AB or B amplifier was introduced by McIntosh and Gow,[2] using a special transformer in the circuit of Fig. 1B. The close coupling permitted by this configuration minimizes the distortion resulting from the switching transient, by reducing the effective leakage reactance and thereby reducing the magnitude of the transient.

The McIntosh circuit is further distinguished by the presence of a large amount of direct feedback, with β equal to one-half. In this respect there is a similarity to the cathode-follower circuits recently discussed in the literature, and the distortion is correspondingly low.[3] On the other hand, correspondingly high driving voltages are required, calling for special driver design.

As Fig. 1 indicates, both plates and cathodes of the output tetrodes in the McIntosh circuit are connected to appropriate windings on the output transformer. The cathode and plate windings are phased so that the signal currents aid, and the close coupling gives feedback with excellent phase-shift characteristics. By splitting the load between plate and cathode, the impedance of the individual primaries is reduced, so that a smaller turns ratio is required. The screens are so connected that as the cathode voltage of each tube rises with the signal, its screen, being connected

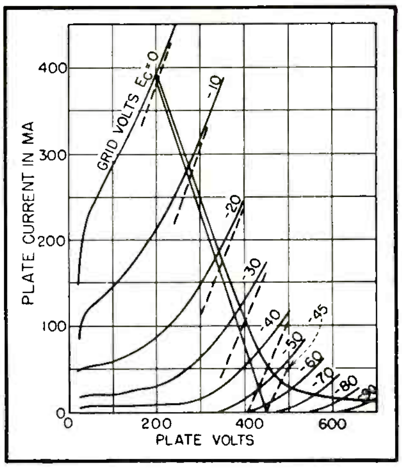

FIG. 3—Composite plate characteristics for 807's operated in extended class A, for 450 volts on the plates and 45-volt bias. Tetrode screen voltage is 300 volts

to the opposite plate, rises in potential with it. The screen-to-cathode potential difference thus remains constant, and high transconductance is maintained throughout the cycle.

What is not generally recognized is that the high power capability of this circuit—50 watts using 6L6's, without grid current—is not a function of the circuit, but is due to operation of the screens at over 400 volts; this is well above normal voltage ratings, though within allowable dissipation limits.

Extended Class-A Operation

The advantages of class-A operation over class B, however, must be considered. Since plate current flows throughout the cycle, there is no distortion due to switching transients.

In conventional class-A operation of triodes, the output power—and hence the efficiency—is limited by the voltage and current excursions permissible within the restrictions of class A. The peak plate-voltage swing is limited by the fact that the plate current of a triode decreases with plate voltage. Large voltage swings are possible with lead lines of fairly flat slope, but the current swing is then limited.

The triode has the desirable characteristic, though, that as the plate voltage swings positive, greater negative grid voltages are required for cutoff. As a result, the corresponding negative grid swing has further to go to reach cutoff, and class-A operation is maintained for large values of signal.

Tetrodes and pentodes, on the other hand, are distinguished by relatively high conductance (high plate current at low plate voltage) and by the fact that plate current is essentially independent of plate voltage. High peak currents can therefore be drawn by these tubes, but the cutoff point is fixed. This seriously limits the allowable total grid swing for class-A operation.

Much more satisfactory class-A operation might result if it were possible to combine the large signal-handling capabilities of the triode (where large positive plate-voltage swings effectively extend the cutoff point) with the tetrode's characteristic of high peak current at low plate voltage. For some reason, the characteristics of triodes and tetrodes have always been considered mutually exclusive. The question of how best to combine them posed an interesting problem. A number of solutions were considered, including the development of some sort of hybrid tube. Finally, it appeared that the simplest way to combine these two completely different methods of operation was to make use of both in the circuit shown in Fig. 2.

In this circuit, the triodes are biased for normal class-A operation. This amount of bias will normally cut off the tetrodes. The grid voltage swing becomes positive enough to activate the tetrodes only when it reaches about one-third of its maximum value—about 10 db below maximum power. By operating triodes and tetrodes with the same bias, they reach the grid-current point at the same time. However, at that point the greater current capability of the tetrode results in so large a plate voltage swing that the current from the triode is much less than it would normally be at the grid-current point, since the instantaneous plate voltage is so much lower.

Figure 3 shows the type of combined characteristic obtained. The curves are drawn for 807's, which can be conveniently used as either triodes or tetrodes. The dashed lines in the drawing are the composite grid lines for push-pull operation.

The first and most important

point of interest is the path of operation for one side. Even with maximum grid swing, operation is class A; in fact, the path of operation is nowhere near the zero axis. The load line is drawn for 2,500 ohms plate-to-plate, and its slope is the negative of the slope of the composite plate resistance, thus fulfilling the classic requirements for optimum load. In effect, the triode characteristics are simply elevated by the current drawn by the tetrode, and throughout the region traversed by the load line the performance is typical of the triode. This assures the characteristically low damping impedance which is such a distinctive feature of triodes.

Figure 4 shows half of a typical transfer characteristic for this mode of operation. The slight curvature of the characteristic has been intentionally exaggerated by choice of operating conditions, to show the transition from triode operation to triode-plus-tetrode operation. Careful choice of tubes and operating conditions will serve to minimize this curvature and the resulting distortion.

There is no inherent feedback in this circuit, as there is in the McIntosh-Gow arrangement. Normal use of feedback will have its usual beneficial effects in reducing distortion and improving damping.

Characteristic of this new mode of operation, which we propose to call extended class A, is the broad linearity at low levels typical of normal class-A operation, as distinct from most high-efficiency circuits where low-level operation is close to the cutoff region. In class-B circuits, where feedback is used, at low levels the feedback must attempt to control plate current in a tube which is cut off. This difficult situation is avoided here, and the feedback is fully effective at all levels.

Economy of Operation

The idling plate current in the extended class-A system is typical of that of a class-A amplifier of about one-third the power capability. The maximum-signal d-c plate current will exceed this idling value by a factor of about three. The power-supply components must be capable of supplying this higher current, but only on an intermittent basis, since actual peak power demands in normal speech or music reproduction occur so rarely. Thus, what is probably the least desirable result of high-power class-A operation, the house-heating effect, has been reduced by a factor of three, with no loss in music-power capability.

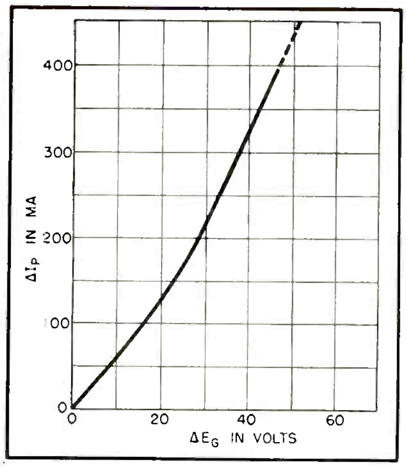

FIG. 4—Transfer characteristic for extended class-A operation. The slight curvature has been intentionally exaggerated by choice of operating conditions

One point should be made: the time-honored bogey of operation in the grid-current region is not one that need seriously be considered. While the graphical construction shown is for operation without grid current, the dashed portion of the transfer characteristic (Fig. 4) shows the extension of this operation to a grid swing running positive by 5 volts. This represents a 20-percent increase in power, with a peak grid current of the order of 10 milliamperes. This value of grid current can readily be provided by cathode-follower drive using such tubes as the 6SN7.

Although this system uses four tubes instead of two, it provides about three times the output power that those four tubes would in normal operation. Type 807 tubes, as they are used in most current amplifier designs, will deliver about 8 watts per pair class A, or 16 watts in push-pull-parallel. The same tubes operated in extended class A deliver almost 50 watts at the grid-current point, about three times as much. In addition, of course, there is a substantial saving in idling power.

In addition, the tetrodes are cut off while the amplifier is idling or operating at low level so their life will be significantly prolonged. Furthermore, the tetrodes may be removed from the circuit entirely without affecting low-level operation, the loading being still about optimum; in fact, they can even be considered as spares in case of emergency. This suggests another variation: here is the convenient place for a high-level low-level switch for those passionately interested in numerical efficiency. The tetrode heaters may be switched off except when the maximum power capability is required.

The use of 807's in this discussion does not mean that they are the best tubes for the job. They were chosen for their relative popularity, and because with the operating conditions indicated they demonstrate the knee in the transfer characteristic showing the transition to extended class-A operation.

In a more conventional amplifier design, Electronic Workshop has employed the 6AR6. This tube, currently made by Tung-Sol, is a tetrode somewhat like the 6L6, but designed to handle much higher plate currents at comparable bias voltages. As a triode, the 6AR6 will deliver considerably higher power than the 807 or 2A3, since triode operation at voltages of the order of 400 is within allowable operating conditions. The 6AR6 is very well suited for use in this extended class-A circuit, and will be used in a commercial model.

To summarize briefly: By this kind of parallel operation of triodes and tetrodes, it is possible to realize the significant advantages of both, and to maintain class-A triode operation to a power level and to a degree of efficiency heretofore obtained only in class-AB and class-B operation (usually of tetrodes). As soon as patent arrangements, now in progress, are completed, a commercial version of this circuit will be made available.

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(2) F. H. McIntosh and G. J. Gow, Description and Analysis of a New 50-watt Amplifier Circuit, *Audio Engineering*, Dec. 1949.

(3) H. T. Sterling, The Cathode Follower as Audio Power Amplifier, *Audio Engineering*, Dec. 1949.

Improving Industrial Control

To make electronic control more universally acceptable in heavy industries, design engineers must provide more rugged appearance, longer tube life and stable performance. Equipment should be designed for psychological effect and ease of maintenance

PRESENT-DAY electronic design practices are only partially satisfactory in many industrial applications. Acceptance of control units will increase only as they become competitive in cost, performance and reliability with other methods. In only limited fields is electronic control the one practical method.

Long-term reliability and ease of maintenance are the two basic requirements of any electrical apparatus used in continuous-process mills. Many mills operate continuously for many months and shut down for major maintenance only once in several months or a year. Performance of the mill is measured in tonnage and accurate logs of down time chargeable to electrical and mechanical outages go to top management periodically. Outage time is usually measured in minutes per month.

Such a mill may have six motor-driven sections which are electronically regulated. Each section may have six electronic tubes and 30 or more other electrical components. Considering the tubes alone, there are 36 expendable items with a definite life. For no more than one tube failure per month of 720 hours, there must be an average tube life of about 26,000 hours. Such tubes do not exist today.

Ease of maintenance or lack of it results from a combined effort of component and apparatus designers. A mill electrican whose experience has been primarily with heavy devices may not favor flimsy electronic equipment. The problem is not only to make apparatus more in keeping with the average electrican's experience, but also to exert extra effort toward educating the user on proper care of the strange things with which he considers himself afflicted. The process of education can be made easier by designing apparatus that is mechanically more in keeping with mill practice.

We electronic engineers should remind ourselves frequently that whether we like it or not our products are compared with magnetic control which is almost invariably more sturdily built.

Construction

Electronic control applications range all the way from full electronic to nearly all magnetic. This poses a dilemma for the designer.

Mixed control is difficult because the two kinds of apparatus are so different physically. To a large extent, this particular problem is psychological. Either method of control may appear plausible by itself but may not when placed side by side in the same cabinet with the other type. Many rather poor dodges are used. One of these is to enclose the lighter electronic equipment in a cabinet within the main control cubicle. This usually leaves a poor impression.

One of the outstanding differences between magnetic and electronic control practices is in panel wiring. The identical wire can seldom be used for both purposes. It has been found that when two kinds of wire are used, the heavier must be used for interconnection between the two panels, otherwise, the whole unit is made to look cheap.

Most electronic apparatus is built on steel panels. Magnetic control, especially for d-c machines, is built on insulating panels. This leads to the necessity of proper arrangement to prevent a patchy appearance in the finished product.

The light weight of electronic control is very helpful to the designer because it permits convenient plug-in subassemblies. This is advantageous to the purchaser because of quick availability of a great variety of special combinations for quick maintenance. It also permits convenient bench assembly with less-skilled labor than would be required for a more complex complete assembly. One of the outstanding examples of the use of subassemblies is in resistance-welding control where 20 subassemblies can make hundreds of different units.

Many electronic units are packed into a small space by means of hinged panels. In many cases this is desirable but often a large cubicle with stationary panels would be more desirable and less costly.

Because of the small terminal spacings used on standard components, electronic apparatus is more subject to trouble from dirt than magnetic control. This makes it necessary, in many cases, to use nonventilated enclosures. Since some parts of electronic control equipment, such as ignitrons, are more comparable in design to heavy control, it is less necessary to protect them from dirty atmosphere.

Scanners for register regulators and other photoelectric devices have tended to be of sheet-metal construction. The trend now is toward the use of cast enclosures. This is especially important when the device is to be used on a machine having in itself a massive appearance. A cast housing blends well into the over-all machine design.

Components

The electrical parts that make up electronic control are the building

This article is based on a paper presented at the 1950 National Electronics Conference. The Conference paper will appear in *Proceedings of the NEC.*

Design

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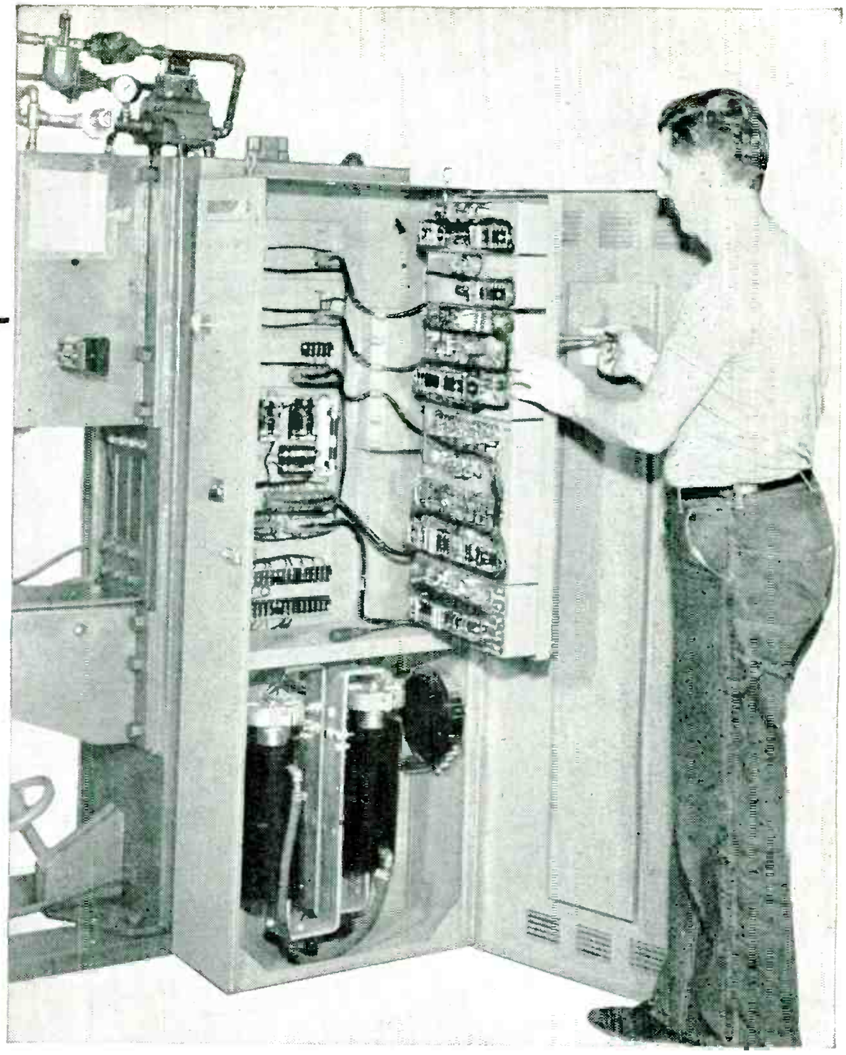
blocks from which the designer must produce a device that will please the user. Most industrial electronic designers will agree that available electronic components are, at best, only partially satisfactory.

The one problem common to all components is one of terminal spacings. Many components are now quite satisfactory in this respect. Among the better ones are capacitors, resistors and transformers. On the other hand, potentiometers and sockets need improvement. Some improvement has been made in sockets by a few manufacturers but little has been done with potentiometers. Only minor changes in design would provide much improvement and should not increase cost or make them less desirable for radio use. For instance, enlarging the terminal clearance hole in the metal case would be a big improvement and mean only a tool change in production.

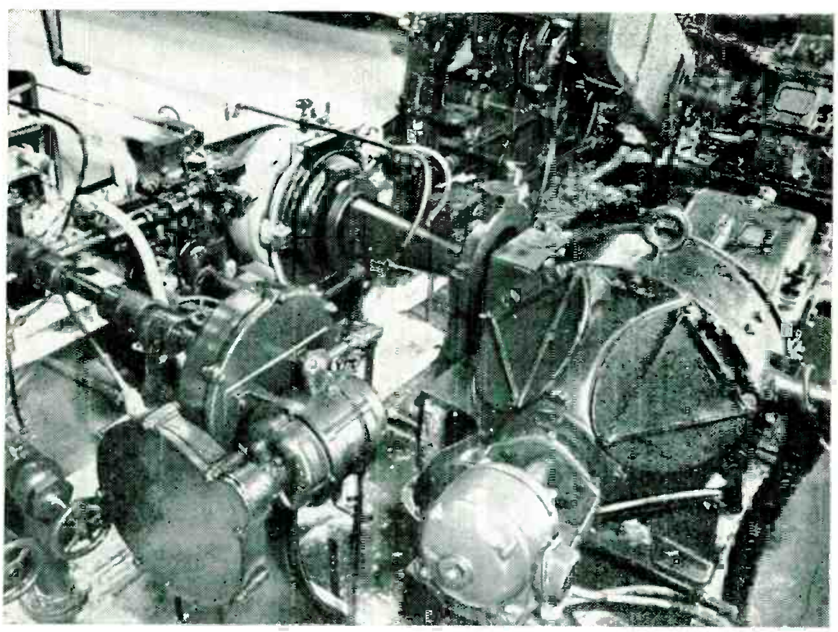


A typical fully electronic resistance-welding control, showing good hinged panel design, ignitrons in separate compartment and accessible components

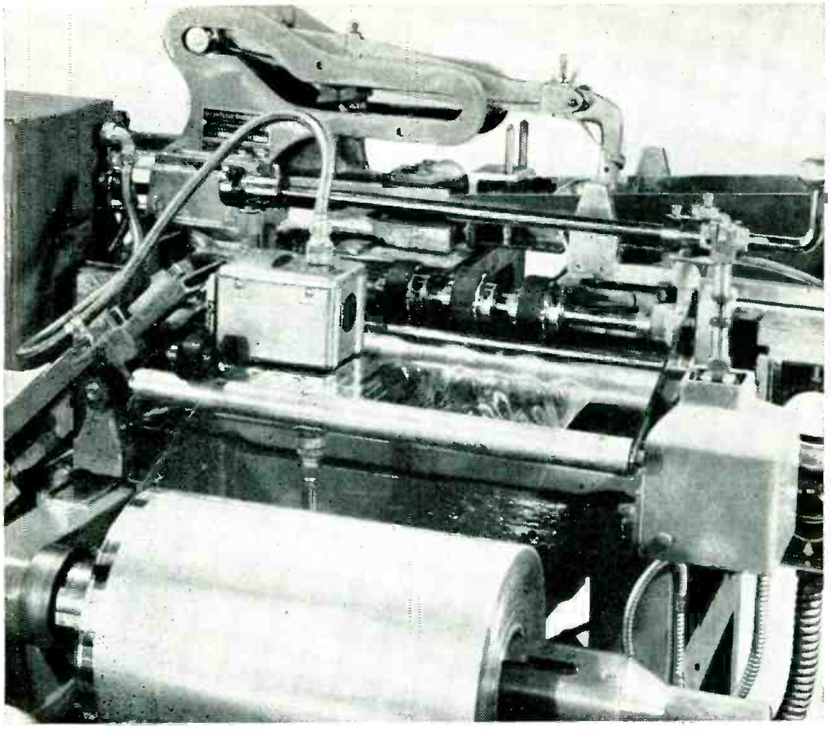
Tubes

The root of all electronic design and performance is the tube itself, which is not riveted or bolted in place and soldered permanently. Sockets have to be provided for tubes so that they can be replaced easily. This is in itself an admission of expendability. Telephone engineers put tubes in undersea repeaters and expect a five-year life. Is the reliability of a steel mill less important?

This is the very situation which is encouraging the use of magnetic amplifiers. Many electronic enthusiasts are beginning to wonder whether, for industrial purposes, emphasis should not be shifted to magnetic amplifiers. The two things needed in an electronic system are a tube life of at least 10,000 hours and completely stable, reli-



Massive machines in a paper mill typify the environment to which the maintenance electrician is accustomed



Cast-aluminum housing on the photoelectric scanner of a packaging machine illustrates how an electron tube assembly can be given a rugged appearance

able performance during that time. Efforts are being made by some manufacturers but the concept needs wide acceptance by all electronic engineers. Management in the tube industry should get behind this movement.

Closely related to tube design is the need for better tube data. There are many ways of applying a tube, each resulting in different performance. Most regulators depend on calibrated characteristics of the first amplifier tube. Many other applications do not need to rely on this at all. The circuit designer certainly needs to know what can be expected of various available tubes if he is to do an intelligent job. Unfortunately, he is now confronted in most cases with a mere statement by the tube manufacturer that tubes shouldn't be used so as to depend on close calibration of characteristics.

Actually, we know that tubes do work remarkably well. Is it not putting too much burden on the circuit designer to find out his limits by cut and try? This dilemma is one that can probably be resolved best by joint committees of those interested in tube design and others in apparatus design.

Progress has been made by NEMA and the Joint Electron Tube Council in regard to thyratrons and they have worked in this direction on small high-vacuum tubes. This failed largely because of lack of support by enough tube manufacturers. This effort should be revived.

Sockets are a weak link in the reliability chain. Experience has shown that the best socket contact is made with a separate spring backing to apply pressure. Most other available contacts distort because after repeated insertion of tubes with maximum pin diameters, tubes with minimum pin diameters do not make reliable contact. A loose contact buried in a molded socket is difficult for a mill electrician to find and is costly at $1,000 or more per hour. There are those who prefer solder-type terminals and others who prefer the screw type. However, this difference is minor compared with the matter of contact reliability. The important point is that terminals should be physically spaced so that an average wireman can work on them easily.

Fortunately for the designer, there is a fair selection of resistors, capacitors, plugs, switches and transformers. This permits a design which looks reasonably rugged and is in reality quite reliable except for the points previously discussed. The industry has been slowly moving toward better components but not fast enough to silence critics of electronic control.

Circuits

Control designers could improve their designs greatly, using parts now available. There are several principles which can be applied to nearly all industrial control which will be just as productive of improved apparatus as will improved components.

Perhaps one of the most common faults of circuit designers is not to recognize the reality of published tolerances on tubes. This may result in marginal performance. Three of the most commonly abused tube tolerance values are temperature, phototube sensitivity and high-vacuum tube plate current limits. One contributing reason for this is the difficulty of getting limit tubes for test purposes. However, this does not excuse the circuit designer from making proper allowances for tolerances.

Because of the generally short electrical spacings used on components, the circuit should be designed with as low voltages in the circuit and to ground as possible. Careful design now allows many circuits to operate at less than 200 volts even though the tubes and other components are rated much higher. This is certainly necessary when some available components will not withstand ground tests of over 1,000 volts.

The desire to reduce costs has a strong tendency to force the designer to select less expensive and, in many cases, low-quality components. This is a vicious circle in our competitive system which in many cases prevents our making the proper quality of apparatus for the job. We must have the courage to do the job right, even though more costly. In the long run, the reduced maintenance and improved user acceptance will justify our action.

If control and component manufacturers will work together to move in the direction discussed we can have a wide range of very dependable control accepted by industrialists who will not do so today.

Experimental plasmatron

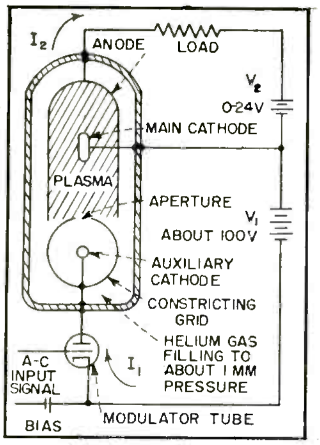


FIG. 1—Tube cross-section and associated external circuit

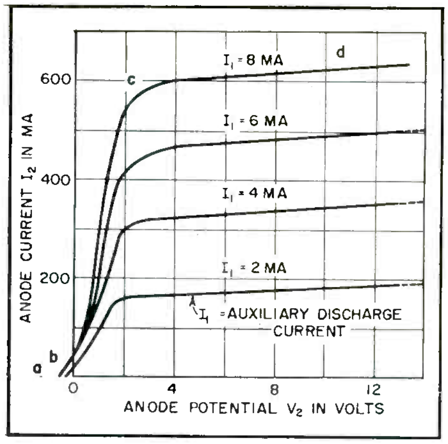


FIG. 2—Current-voltage characteristic with auxiliary discharge current as parameter

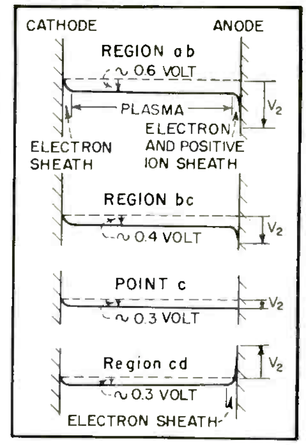


FIG. 3—Potentials between cathode and anode

Controllable Gas Diode

Construction and characteristics of the plasmatron, a hot-cathode helium-filled diode capable of controlling large currents continuously at low voltages. Small control current acts on auxiliary discharge that provides ionization to neutralize space charge

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THE TYPICAL grid-controlled vacuum tube, by virtue of its space-charge-limited anode current, is a relatively high-impedance device which is most effective in high-impedance circuits. Since a grid-controlled gas tube such as the thyratron is a low-impedance device as a consequence of its neutralized space charge, it has limited applicability in low-impedance circuits because of its lack of continuous grid control. Need exists for an electron tube which has both the continuous control feature of the vacuum tube and the low-impedance characteristic of the thyratron.

The "plasmatron", a developmental tube, gives good promise of helping to fulfill this need. It operates at anode potentials as low as several volts and has a continuously controllable output current of hundreds of milliamperes.

The tube's name is derived from the word "plasma", which designates a unique part of a gas discharge's anatomy that is instrumental in providing the tube with these unusual characteristics. A plasma[1] is a region which contains high but approximately equal densities of free electrons and positive ions, and is usually evidenced by the familiar glow which can be seen in gas discharge tubes. The charge neutrality plus the high electron density and mobility make the plasma a good conductor of electron current; in addition, this conductivity is proportional to the plasma density. Thus, in the plasmatron, an independently produced plasma is used as a conductor between a hot cathode and an anode. By controlling the small discharge current which generates this plasma, we can effect a continuous control of the plasma conductivity and hence of the cathode-anode current.

A cross-section of a plasmatron tube, accompanied by its associated circuit, is shown in Fig. 1. Potential V_1 creates a discharge between the auxiliary cathode and the main electrodes, giving rise to an auxiliary current I_1 whose magnitude is limited by the modulator tube. This tube is an ordinary vacuum tube such as the 6J5. The discharge is responsible for a high degree of ionization, as manifested by the formation of a plasma in the region between the main cathode and the anode.

The plasma density is enhanced, for any given value of I_1, by forcing the auxiliary discharge to pass through the narrow aperture in the constricting grid. The increase in the plasma density follows from the fact that the constriction in the discharge path raises the voltage drop across the auxiliary discharge. This in turn gives the discharge electrons more energy so that they ionize more effectively.

The free positive ions and electrons in the plasma, generated by the auxiliary current I_1, diffuse to the end micas and other available surfaces where they are lost by recombination. (The recombination of the charged particles in the interelectrode spaces of these structures, at the 1-mm pressure of helium used, is relatively negligible.) The steady-state density of the charged particles in the plasma is then a function of the generation and loss rates and turns out to be approximately proportional to the magnitude of the auxiliary current I_1. Thus the input signal, by exercising an essentially linear control over I_1, can effect an approximately linear control over the plasma density and hence its conductivity.

The presence of the plasma in the region of the main electrodes now makes possible the passage of large currents between the main cathode and anode even though the anode voltage may be as low as several volts. Since the effective conductivity of the plasma is directly proportional to its density, the anode current can be controlled by means of the input signal to the grid of the modulator tube.

Anode supply voltage V_2 must never be high enough to cause ionization. This restricts V_2 to a maximum value of about 24 volts when the tube contains helium. Voltages higher than this would result in a discharge between the main cathode and anode in a manner similar to that encountered in an ordinary gas diode. The controlling ability of the auxiliary current is then lost.

The auxiliary cathode is an ordinary oxide-coated cathode with an area of about one square centimeter. However, since it need only supply small currents, it could have been several times smaller in size. The main cathode is also a standard oxide-coated cathode and has an effective area of about three square centimeters. For normal operation the size of this cathode must be sufficient to provide a total emission current which is at least twice the maximum required anode current.

Plasma Behavior

Since the plasma is a good conductor and as such is essentially

Demounted internal structure of plasmatron. Auxiliary cathode is inside cylinder, and oval-shaped main cathode is inside U-shaped anode. Electrode sizes are not critical, and tube works just as well in miniature sizes as in proportions for handling amperes of plate current. Available main cathode emission limits anode current

a uni-potential entity, we need only take into account its behavior at the boundaries where it contacts the anode and cathode surface. At such boundaries the plasma reacts to the electric field from the electrode by setting up a narrow region, termed a sheath, which absorbs this electric field. As a consequence of this protective action the main body of the plasma is not penetrated by the field and so in almost all cases is never appreciably affected by electrode potentials.

The sheath contains the field and is characterized by the presence of a considerable net space charge that is comprised of particles in transit to the electrode. These particles can be of either sign depending on the electrode potential. Thus, when the electrode is negative with respect to the plasma most of the electrons will be repelled and the sheath will contain mostly positive ions. The converse is also true.

When the sheath contains particles of one sign, its thickness is related to the potential across the sheath and the particle current through it by the familiar 3/2 power law. For the plane case this is

$$j = \frac{2.33 \times 10^{-6}}{\sqrt{M/m}} \frac{V^{3/2}}{d^2} \qquad (1)$$

Here j is the particle current density in amperes per square centimeter, V is the potential across the sheath in volts, d is the sheath thickness in centimeters, M is the particle mass and m is the mass of an electron.

The magnitude of the current density j is fixed by the plasma density adjacent to the sheath edge and can be expressed as

$$j = Ne\bar{v} \qquad (2)$$

Here N is the particle density in particles per cubic centimeter, e is the electronic charge in coulombs, and $\bar{v}$ is the average particle velocity, due to conditions within the plasma, in a direction normal to the sheath boundary. This velocity can be computed from kinetic theory in terms of temperature and the mass of the particle. For electrons in a typical plasma, $\bar{v} = 7.7 \times 10^6$ centimeters per second. Thus, in our plasma, where $N = 10^{11}$, $j = 10^{11} \times (1.6 \times 10^{-19})\ (7.7 \times 10^6) = 120$ ma per sq cm. For the same volume density of positive ions the current would turn out to be less than a hundredth of this. This follows primarily from the fact that the larger mass of the ion gives it a much smaller value of $\bar{v}$. Consequently, in discussing the plasmatron currents we will deal only with those due to the electrons.

It is important to notice that Eq. 2 implies that the current j is independent of the electrode potential. Thus, if an electrode is made more positive with respect to the plasma the electron current to it remains unchanged.

Current-Voltage Characteristic

A typical current-voltage characteristic is shown in Fig. 2. The characteristic is seen to be very similar in form to that of a pentode vacuum tube. This interesting result can be understood by considering the potential distributions which exist in the tube for different applied anode voltages. Shown in Fig. 3 are the different modes of this distribution which correspond to the various regions ab, bc and cd of the 8-milliampere characteristic.

In region ab, the electron current to the anode is negligible because of the large retarding field in the anode sheath. At the cathode we can consider two currents as flowing. One is an electron current from the plasma into the cathode according to Eq. 2. The other is a current from the cathode into the plasma. For equilibrium these must be equal.

Since the total temperature-limited cathode emission current is normally much greater than the first current, a small retarding field, in the direction shown, must appear at the cathode to bring the currents into equality. The resulting potential depression is found to have a magnitude of about one-half volt, the actual value depending primarily upon the total cathode emission and the plasma density.

As the anode potential is raised to put the system in region *bc* of the characteristic, the retarding field at the anode is diminished to the point where a considerable electron current can flow to the anode. This current increases rapidly with voltage, as is shown by the curves. Meanwhile, at the cathode, the retarding field must be less so that more current from the cathode can enter the plasma to supply the drain to the anode. Since the current-voltage relationship at the cathode is of an exponential nature the slight changes in the plasma potential, as indicated in the diagram, are sufficient to account for the large current changes.

When the system is at point *c* the anode has reached plasma potential and collects an electron current whose density is given by Eq. 2. Further increases in anode potential, corresponding to operation in region *cd*, leave the anode current virtually unaffected, as evidenced by the nearly horizontal slopes of the characteristic. These increases in the anode potential will serve only to expand the electron sheath at the anode in accordance with Eq. 1 in which j is given by Eq. 2.

When operation is in this saturated current region the device can be treated as a close-spaced vacuum diode with its cathode at the plasma edge of the anode sheath. The emission current density of this virtual cathode is then given by Eq. 2 and the diode spacing by Eq. 1.

The fact that the point of current saturation does not occur at negative anode voltages, as indicated by Fig. 3, can be accounted for by the contact potential differences acting in the tube along with the potential drop in the plasma.

Current Gain

The relationship between the auxiliary and main currents is shown in Fig. 4. The average slope corresponds to a current amplification of about 90:1 and is seen to be fairly linear. However, if the currents are pushed beyond the point where the retarding field at the cathode is eliminated, the cathode emission approaches the temperature-limited state and the curve saturates to a value equal to the temperature-limited emission current from the cathode.

The relations which express the rate of ion generation and loss in the plasma, in terms of the auxiliary current, fix the value of N in Eq. 2 which determines the anode current. As implied previously, the approximate linearity of the relationship between the currents arises from the fact that N and hence I_2 are approximately linearly related to I_1.

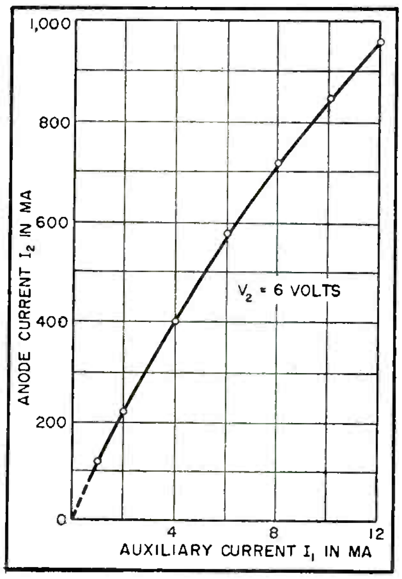

FIG. 4—Current amplification characteristic of new tube

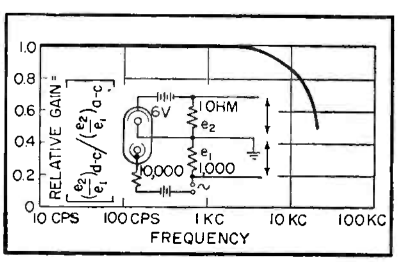

FIG. 5—Frequency response characteristic

The frequency response, normalized to the d-c current amplification, is shown in Fig. 5. The rapid reduction in gain which occurs at frequencies higher than 10 kc can be attributed to the fact that a definite time is required for changes in plasma density to take place. The times involved are determined by the rate of diffusion of the participating charged particles to the available boundary surfaces. This time is comparable to the plasma decay time constant and is readily computable.[2] Its value is such as to account for the observed frequency response. This time constant of plasma decay varies directly as the gas pressure, directly as the square root of the mass of the gas atoms and directly as the square of the geometrical dimensions of the plasma region.

Applications

Experimental forms of the tube have been used with encouraging results in audio output stages with direct speaker drive, in motor control circuits, in oscillators, and in pulse circuits.

Whereas such factors as life and uniformity have yet to be studied in detail, no difficulties beyond those usually experienced in ordinary hot-cathode gas tubes are anticipated. In fact, since the tube is never subjected to the large voltages often experienced by tubes such as thyratrons, it is expected that the gas cleanup and cathode life problems should be relatively simpler. The main cathode seems to be well protected from ion bombardment by the retarding field which exists around it during normal operation.

Summarizing, it can be said that the plasmatron offers excellent promise for low-frequency, low-impedance applications which require a continuously controllable current.

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(2) M. A. Biondi and S. C. Brown, *Physical Review*, 75, p 1700, 1949.

FIELD-SEQUENTIAL

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Tele-color converter attached to a black-and-white Teletone receiver at the CBS showings in New York City

THE FCC DECISION which approved the CBS field-sequential system of color television presented the problem of how best to meet the inevitable demand for a commercial device which, operating in conjunction with existing black-and-white receivers, would produce good color reception from stations transmitting programs in color. The companion color unit was to bridge the gap between standard monochrome and the new field-sequential color television until there developed sufficient economic justification for complete color or color and black-and-white receivers. In this manner the consumer was protected against complete obsolescence of his monochrome equipment and at the same time could purchase the means of securing color television.

The standards set by management and engineering pointed out the necessity for a universal package converter of the slave type. This would be a self-contained cabinet-enclosed unit which would plug into one of the tube sockets in the existing receiver by means of an adapter plug without any chassis reworking. This could be a customer rather than a serviceman operation.

The slave converter receives a composite video signal from the black-and-white receiver through the interconnecting cable. A block diagram of the complete system is shown in Fig. 1.

Connection to the black-and-white receiver is made by a plug, or color accommodator. This is inserted in the input video amplifier socket of the black-and-white receiver. The pins are connected to another tube socket at the top of the plug in which the video amplifier tube fits. A 6J6 cathode-loaded stage inside the plug couples the composite video signal from the grid of the video amplifier through 70-ohm cable to the color converter. The circuit of the cathode follower and the video amplifier of the color converter is shown in Fig. 2.

The input loading of the cathode follower is extremely small. Plate and filament power is fed to the cathode follower from the color converter.

The color accommodator plug is built in four different forms to accommodate seven-pin miniature, nine-pin miniature, octal or loctal

COLOR COMPANION

Designed for connection to video amplifier of any monochrome television receiver, this slave converter provides color pictures from CBS field-sequential transmissions. Complete circuitry is given, including motor control system for speed and phase correction of color disk, which would be required by this system

video amplifier tubes in the black-and-white receiver.

Overall Circuit

The signal is amplified in the two-stage video amplifier system and is applied to the picture-tube grid. A polarity switch in the input circuit accounts for the difference in signal polarity that exists in some monochrome receivers. Part of the output of the video amplifier is fed in a conventional manner to the sync separator which in turn feeds a syncroguide type horizontal oscillator at 29,160 cps and an impulse-triggered vertical oscillator at 144 cps, which feeds the vertical output amplifier. A flyback high-voltage doubler system is used.

The color disk is turned by a speed-controlled induction motor. The speed control circuit consists of a balanced phase and frequency comparator that compares the sine-wave output of a six-pole alternator, which is mechanically coupled to the motor, with pulses derived from the vertical output circuit. The control voltage is amplified in a d-c amplifier which varies the inductance of a saturable reactor and which in turn varies the a-c voltage applied to the induction motor for speed control.

Breakdown of Circuit

The video amplifier requirements are similar to that of a monochrome design but are more exacting. Since the composite signal derived from the black-and-white receiver could be either positive or negative depending on the type of receiver, provision had to be made for switching circuitry so that the polarity of the signal at the color converter kinescope grid was always sync negative.

The gain and frequency responses were to be independent of switch setting. The high-frequency response was to be 4-mc wide so that the geometric resolution would be as good as the i-f response of the black-and-white receiver would allow. A rising characteristic is also desirable to obtain some video overshoot to add crispness to the picture and to compensate for the slight smear present in the transient response of many i-f systems.

The low-frequency response has to be approximately 3 db at 48 cps which is the primary color rate. Poor low-frequency response will result in misrepresentation of the background color tones in the different frames, whereas in monochrome reception it would only result in a slight shading from top to bottom of the picture.

It was considered that a gain of approximately 70 with a drive of

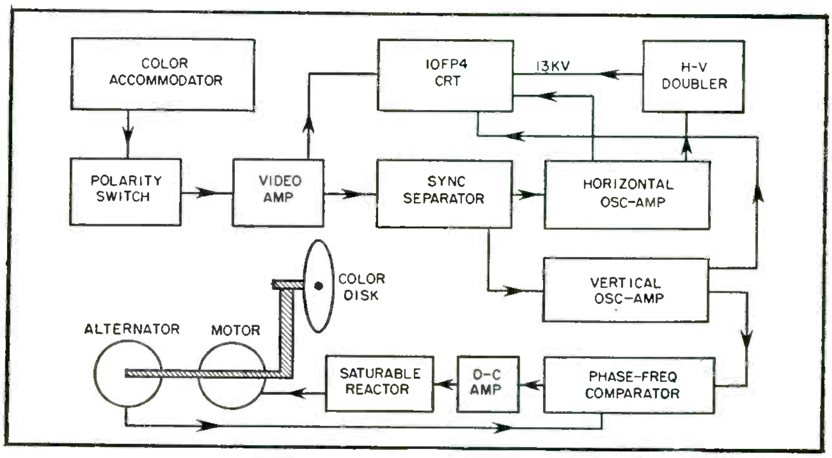

FIG. 1—Arrangement of stages of the slave color viewer

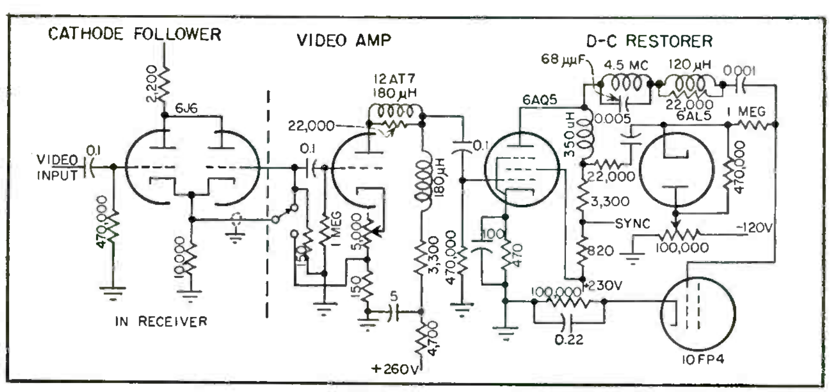

FIG. 2—Composite video signal from the black-and-white receiver is handled by this circuit. Choice of signal polarity is provided by the switch

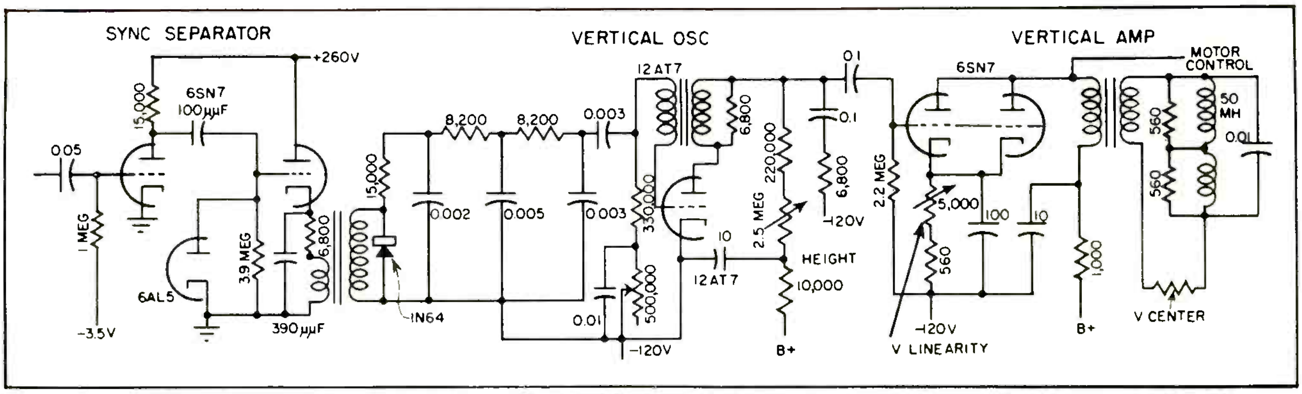

FIG. 3—Sync separator and vertical deflection circuits

approximately 100 volts peak to peak was necessary to have sufficient reserve drive for the 10FP4 picture tube under all conditions of operation. Another aspect to be closely watched in the video system was amplitude distortion which would give rise to color distortion, since different colors are transmitted during different frames and any compression of levels would affect one color more than others.

Thus, the amplifier has to be substantially linear over its entire range of operation, unlike monochrome reception where nonlinearity is often introduced to obtain a more pleasing ratio between average and peak brightness at high contrast settings. Since the majority of present black-and-white receivers have intercarrier sound, good 4.5-mc rejection is needed before the crt grid to avoid the fine beat affect which would be caused by excessive 4.5-mc signal on the kinescope grid.

Figure 2 indicates a simple way in which polarity switching is accomplished. The first video amplifier is either cathode or grid coupled depending on the input polarity. For most installations the tube will be grid coupled because a majority of the black-and-white television sets in use have their video detector arranged to yield a composite video signal with sync tips negative.

Contrast variation is accomplished by means of a degenerative control in the cathode of the first video amplifier. This stage is a high-gain triode and the second stage is a beam power output tube to provide sufficient drive and linear operation. Good frequency response is provided for by the two-section constant-k filter in the first video stage and a combination of series and shunt peaking in the second video stage. Good low-frequency response is accomplished by means of the low-frequency R-C boost network in the first video, and the use of 0.1 μf coupling capacitors as well as the maximum possible grid leak resistors wherever possible.

The background control varies the negative voltage to which the d-c restorer diode plate is returned.

The video amplifier is linear, has a gain of approximately 70, provides 100 volts peak to peak drive at a bandwidth of 48 cycles to 4 mc and has provisions to supply d-c restored signal of negative polarity to the crt grid for either polarity video input to the system.

Sync Separator

The sync separator requirements are similar to those in monochrome reception, and the type of separator used is a fast-time-constant cathode-follower type, using a separate diode to keep sync tips at ground level. This is a standard type illustrated in Fig. 3, and need not be discussed further. There is a definite need for better noise immunity in the color system than in black-and-white transmission. Loss of horizontal synchronization for a few lines is more noticeable than in monochrome transmission because the tearout will appear in the color of the frame during which it occurs. Loss of vertical synchronization is extremely bad, because unless the recovery time is faster than the inertia of the speed control circuit, the color disc will also go out of synchronization.

The field rate, the frequency at which the kinescope face is scanned vertically, is 144 cps. Vertical retrace must be accomplished in 0.05 of a field which is approximately 350 μsec. This is approximately 40 percent of the time allotted in monochrome transmission. The self-resonant frequency of vertical output transformers and yoke circuits now used for monochrome receivers is good enough to permit direct conversion to the new frequencies.

Vertical Deflection

A 53-degree, 50-mh vertical yoke is used. The yoke impedence being mainly resistive, the same output transformer can be used to match the yoke to the vertical output tube with very little loss in efficiency. As shown in Fig. 3, a single-triode blocking oscillator was chosen to act as a combined vertical oscillator and discharge tube. The transition to 144 cycles permits a decrease in plate-time constant to give the necessary drive for the output tube without any loss in linearity.

The percentage of step to sawtooth is larger in color operation necessitating a larger step resistor in series with the discharge capacitor. The reason for this is apparent when it is realized that the purpose of the additional step to the sawtooth grid drive is to compensate for the voltage drop across the inductive portion of the yoke. The retrace time being much faster than before will cause the voltage drop $L_{di}/_{dt}$ to be larger.

The problem of interlace is basically a 30-cycle phenomena in monochrome transmission and is therefore relatively unaffected by 60 or

120-cycle power supply and line hum because of its harmonic nature.

In color transmission, interlace is basically a 72-cycle phenomena and is easily deteriorated by 60 and 120-cycle hum. Sixty-cycle hum for example will cause the pattern to go in and out of interlace at a 12-cycle rate. It is extremely important that the integrated vertical sync pulse be free of all hum voltages. As will be noted in Fig. 3, the output of the sync separator is transformer coupled to the integrating pads to remove the hum voltages from the negative supply. Care must be taken so that the power line leads or filament leads do not come too close to the vertical oscillator circuitry.

The usual care must be taken to remove all horizontal pickup from the vertical oscillator circuit. This can be helped considerably in the chassis layout by putting the vertical oscillator as far as possible from the horizontal oscillator and output circuit. The major problem in the vertical circuit seems to be to obtain good interlace rather than that of height and linearity.

Horizontal Deflection and High Voltage

The horizontal scanning rate is 29,160 cps (405 horizontal lines interlaced every two fields). This is almost twice the rate used in monochrome transmission. The maximum retrace time allowable is 0.14 H where H is the period of the horizontal scan. This figure is the minimum value that the width of horizontal sync pulse plus back porch may fall to. This calls for a maximum retrace time of 5 μsec as against almost 10 μsec in monochrome transmission. The losses in the yoke and transformer which are a function of frequency such as hysteresis and eddy currents tend to decrease the efficiency at this new frequency. A high voltage of 13 kv is desirable which in conjunction with a 10FP4 53-degree aluminum-backed tube produces sufficient light output in spite of the light losses in the color disc and lens.

The horizontal synchroguide has to be readjusted to operate at the new frequencies and the capacitor across the stabilizing coil is set so it too can operate at the new frequencies.

To improve the retrace time, the horizontal output transformer has much less than the customary number of turns on the high-voltage winding. To make up for the loss in high voltage, a two-tube voltage doubler is used in the circuit of Fig. 4. The use of an auto-transformer permits more high voltage and subsequently less retrace time because the secondary winding is then in series with the primary and high-voltage winding.

A device borrowed from the CBS engineering department was to a-c couple the secondary winding to the primary with the yoke being returned to the low side and the damper tube being returned to the high side. This provides electrical centering which is normally unfeasible in an auto-transformer type of system. The filament of the damper tube is connected through a resistor to the boost voltage. The cathode-to-heater rating of this tube for pulses as well as for inverse peak plate to cathode voltages allows safe operation of the circuit.

Horizontal centering is accomplished by a 50-ohm control which varies the amount of B plus current which goes through the yoke. A tapped potentiometer is used so that this control is bidirectional.

The power input to the horizontal output 6BG6 tube (370 volts at 70 ma) is 33 watts and is not proposed as the most efficient method of scanning a 53-degree tube operating at 13 kv. It does however give good linearity, good retrace time, plenty of width and a high voltage of 13 kv with a regulation of 500 volts per 100 microamperes. The yoke is a 53-degree 8.3-mh type with a powdered iron core.

Power Supplies

The power supply (Fig. 5) design problem is no different generally from that existing in normal monochrome receivers except for the fact that the maximum allowable ripple voltage must be severely restricted. The hum voltages whether 60 or

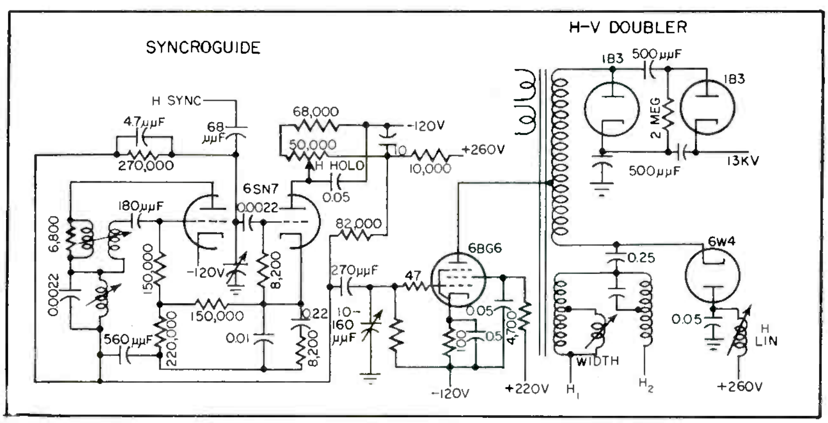

FIG. 4—Horizontal deflection circuits and voltage doubler

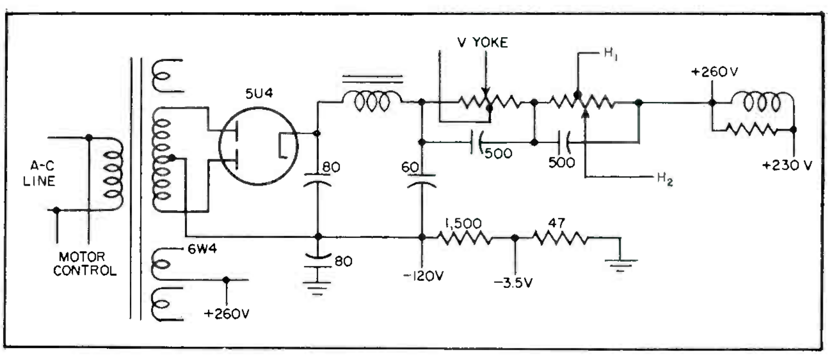

FIG. 5—Sources of positive and negative voltage feed points required by the other circuits

120 cycles, are extremely harmful because of the nonsynchronous relationship between the 60-cycle power line and the 144-cycle field rate of the color transmission.

A full-wave rectifier 5U4 in conjunction with a capacitor-input filter yields a positive B-plus voltage of 280 volts at 175 ma. A negative supply of approximately 120 volts is obtained across a bleeder resistor between secondary center-tap and ground.

Care must be taken in the physical placement of the power transformer and other iron-core components to minimize the effect of any stray magnetic fields on video and vertical circuitry and the kinescope. Although the filter circuit is not unduly elaborate from a filtering standpoint, hum reduction is further accomplished by the utilization of decoupling networks between the power supply and the appropriate circuits.

Motor Speed Control Circuits

An entirely new problem presented by the color television unit is that of motor speed control. Color presentation is accomplished by means of a rotating filter disk similar to that used in the camera which is positioned before the face of the picture tube. This disk carries six filter segments, two in each of the three primary colors, red, blue and green. The disk rotates at 1,440 rpm and is synchronized with the 144-cycle field scanning rate of the receiver. The image formed on the screen of the picture tube is in white light and this light is passing through the colored filters, takes on successively the three primary colors. The system thus comprises two filter disks rotating in rigid synchronism, so positioned that the filters before the camera and the picture tube always have the same color at any instant. To synchronize the position of the receiver filter disk, the speed must be kept at 1,440 rpm and the phase must be automatically adjusted by means of synchronizing impulses so that the red light is produced by the receiver only when the red filter is positioned before the camera tube at the transmitter and similarly for the other two colors.

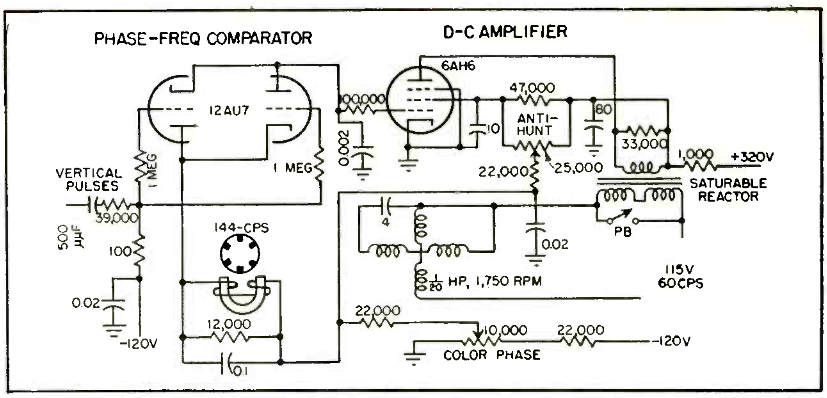

FIG. 6—Automatic phase and frequency comparison circuit used for motor control

Speed control is accomplished by means of an automatic phase and frequency control circuit, Fig. 6. The driving motor is a 1/20 hp split-phase induction motor, belt coupled to the color wheel and direct coupled to a six-pole alternator which, when running at 1,440 rpm, delivers a sine-wave voltage output at a frequency of 144 cps. The frequency is directly proportional to the motor speed. A balanced phase and frequency comparator consisting of a 12AU7 compares the sine-wave output from the alternator to vertical pulses at the 144-cycle field rate. The control voltage generated is applied to the grid of a high-g_m d-c coupled current amplifier which utilizes a 6AH6 tube. The plate current of this amplifier flows through the primary of the saturable reactor which saturates the iron core and so varies the inductance of the secondary winding in a manner which is to a first approximation inversely proportional to the primary current.

As shown in Fig. 6, the secondary inductance of the reactor is in series with the induction motor across the line voltage. A variation of secondary inductance will vary the 60-cycle voltage fed to the motor and thus control its speed. A color-phasing potentiometer controls the d-c bias at the grid of the 6AH6 control amplifier tube. An antihunt potentiometer controls the amount of feedback from the screen of the control tube back to the input circuit.

The gain and accuracy of the control system must be high enough so that the amount of phase deviation or instability caused by normal line voltage variation or heating effects will not be large enough to permit any trace of the preceding or following color field to be visible.

As mentioned before, proper color phasing is obtained only when the color of the filter at the receiver is identical to the one at the camera at any moment. The speed control circuit does not utilize any information which permits it to recognize the various color fields. It is therefore possible to be initially synchronized on any one of the three color fields when the set is turned on. The ambiguity is corrected by means of a front-control push-button which momentarily shorts out the secondary of the saturable reactor thus permitting the color disk to slip free for a short period and lock itself to a new color frame.

The converter chassis, cabinet, and shafts are insulated to avoid shock hazard when used with a black-and-white receiver of the hot-chassis type in which one side of the power line is connected to the chassis.

Overall Performance

The slave color converter unit provides good color pictures on transmissions using the CBS field-sequential system. A unit of this type has been demonstrated at the CBS color show at the Tiffany Bldg. in New York and found completely satisfactory.

The authors wish to credit the Engineering Staff of the Columbia Broadcasting System for their assistance and guidance, without which the work described herein would not have been possible.

Economical 5-KW A-M Transmitter

Phase-to-amplitude modulation provides high-quality signals with 1.5-percent rms distortion at low and medium audio frequencies and 2.8 at 7,500 cps. Total power input to transmitter is 13.5 kw for full output

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NEED AROSE at station KOH in Reno, Nevada, for a 5-kw a-m transmitter that would fit into an existing building that was originally designed to house a 1-kw transmitter.

It was decided that a phase-to-amplitude modulated transmitter would be used. The 5-kw design finally adopted resembles, to a certain extent, the 50-kw version used at KFBK in Sacramento, California, with the exception of a few simplifications. These modifications include the elimination of negative feedback circuits, the use of a simple phase modulator and triplers instead of cascaded phase modulators, and the elimination of complex tuning mechanisms. Several years of operating experience with the KFBK transmitter prove the feasibility of screwdriver tuning adjustments. The system used differs from the original one described by Chireix in the 1935 *Proceedings of the IRE* in that more straightforward phase modulators are employed, by the use of quarter-wave final-amplifier plate-tank networks and by use of a simple predistorting circuit to overcome the inherent distortion of the system, this inherent distortion being approximately five percent.

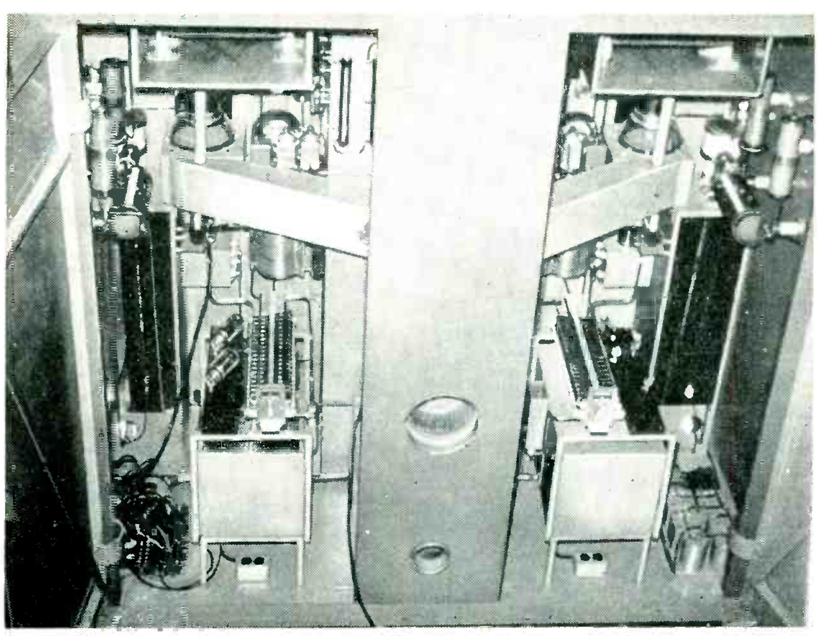
Brief Theory of Operation

The transmitter consists of a crystal oscillator, a buffer amplifier branching into two channels, two phase shifters, two frequency triplers, two sets of cascaded class C r-f power amplifiers and output circuits wherein the currents from the two phase-modulated channels are brought together resulting in the production of amplitude-modulated waves.

The output of the buffer amplifier divides into two components of equal amplitude and opposite phase. Each of these two components passes through a manually-operated phase shifter and excites a single constant-amplitude phase-shift modulator. Each modulator drives a separate tripler and a chain of power amplifiers which are common to each other only at the output of the final amplifier and at the grid circuit of the final amplifier where a compensating resistor for linearity adjustment is connected between the two grids.

The system operation is such that for a modulation trough the two r-f channels are fed into the common load in phase opposition so that no output results. Over the remainder of the modulation cycle the two channels are made to be more in phase in such a manner that their power outputs combine in the common load according to the modulation.

The grid or plate voltages of the two r-f channels will normally operate at a phase angle of 135 degrees. For conditions of 100-percent modulation, the phase of one channel is advanced 22½ degrees and the other is retarded 22½ degrees. At this



Five-kilowatt a-m transmitter is housed in 7 x 7 x 3 foot cabinet shown. Power supply is external instant the phase difference between channels could be 180 or 90 degrees depending on which channel initially leads or lags the other.

When the two channels are 180 degrees out of phase no voltage will appear across R_L as illustrated in Fig. 1A. This condition constitutes in effect a short circuit of the sink ends of both quarter-wave networks shown in Fig. 1A. Then due to the impedance-inverting qualities of the quarter-wave networks, the source ends of these networks will appear as very high impedances and little energy will be supplied from the power tubes.

When the phasing conditions are reversed, 100-percent positive peak modulation is obtained. Each channel then supplies energy to the load R_L. Due to the effect of the two sources of r-f power feeding R_L the resistance seen by each channel at the sink end of the quarter-wave network varies from zero to four times the load resistance required to obtain the correct carrier power. Then again due to the impedance inverting qualities of the quarter-wave networks, the power amplifiers themselves look into a load resistance which varies from an extremely high value to approximately one quarter that encountered at the 135-degree carrier condition.

Vector Diagrams

Figure 1B is a voltage diagram showing the phase relations of the final plate voltages of the two channels at carrier (solid vectors), at modulation peak (dashed vectors) and at a modulation trough (dotted vectors). Inasmuch as the two channels are connected to R_L in shunt rather than in series, the power relations at the load itself can best be understood by reference to the current diagram of Fig. 1C.

It is seen that the current I_L, flowing through the load is the vector sum of the two channel currents I_1 and I_2. When the relative phase between channels θ is 135 degrees the load current is at its carrier value. When θ is 180 degrees the load current (and consequently the load voltage) is 0, and with $\theta = 90$ degrees, I_L has it maximum value corresponding to a peak of modulation.

Here it also becomes evident that inasmuch as each final tube delivers varying amounts of power at a substantially constant r-f voltage, the phase-to-amplitude system is in reality one of load-impedance modulation. The load presented to the output terminals of the coupling network of channel 1 is

$$Z_{L1} = \frac{E_L}{I_1} = \frac{I_L R_L}{I_1}$$

An examination of Fig. 1C will show that

$$I_L = 2 I_1 \cos \frac{\theta}{2}$$

Thus

$$|Z_L| = \left(2 \cos \frac{\theta}{2}\right) R_L$$

and varies from a short circuit at $\theta = 180$ degrees to $\sqrt{2}\, R_L$ at $\theta = 90$ degrees.

This gives the absolute value of the complex impedance. Further study of Fig. 1 will show that the phase angle, of the impedance, or the power factor angle, is $\theta/2$. This makes the complete expression for the load impedance as seen by each channel

$$Z_L = \left(2 \cos \frac{\theta}{2}\right) R_L \underline{|\theta/2}$$

or in rectangular form

$$Z_L = \left(2 \cos^2 \frac{\theta}{2}\right) R_L + j\left(2 \sin \frac{\theta}{2} \cos \frac{\theta}{2}\right)$$

$$R_L = 2 R_L \cos^2 \frac{\theta}{2} + j\, R_L \sin \theta$$

This shows that in addition to the desired resistance variation $2R_L \cos^2 \theta/2$ there is also introduced

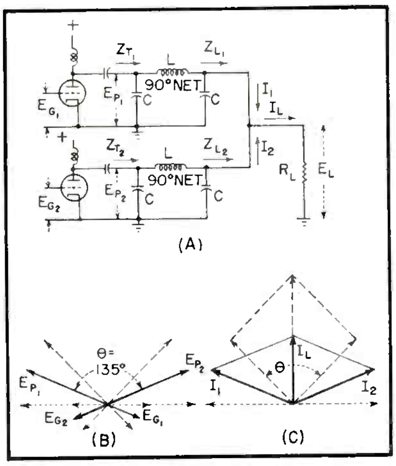


FIG. 1—Basic output schematic and vector diagrams show phase-to-amplitude principle

a reactive component, caused by the circulating current common to the two tank circuits. The reactance will be inductive for one channel and capacitive by an equal amount for the other channel.

Unfortunately these reactive components vary with the operating angle θ making it impossible to balance them out completely over the entire modulation cycle by introducing fixed reactances. However, it is evident that if enough fixed reactance of the proper sign is added to each channel to make the power factor unity at, or slightly below, the operating angle chosen for the proper carrier power, the power factor over the remainder of the modulation cycle will remain good except near the amplitude-modulation troughs where low efficiency is of little consequence.

Final Amplifier

If we assume that each final tube operates as a constant voltage generator, the power drawn from either tube varies inversely as the square of cos $\theta/2$. When the operating angle is chosen so that $\theta/2$ varies over the near-linear portion of the cosine curve, the load impedance and power output vary as the square of the angle of phase separation, which is the desired result.

It is also of interest that in actual practice the loaded Q of the 90-degree final amplifier plate-tank networks may vary from 20 at carrier to 5 for a positive crest of modulation and from 20 to 600 or so depending on the inherent Q of the output networks for a negative trough of modulation. For good fidelity, means must be provided to prevent the loaded Q of the tank, and consequently the r-f plate voltage, from rising above a predetermined value during part of a modulation cycle. This is accomplished at KOH by biasing the final amplifier grids so that plate current flows during a large portion of the positive r-f grid driving half cycles, thus keeping the output tanks loaded by the plate circuits of the output tubes. Such procedure reduces the plate efficiency to approximately 70 percent at carrier level.

A further improvement in r-f voltage regulation is effected by the

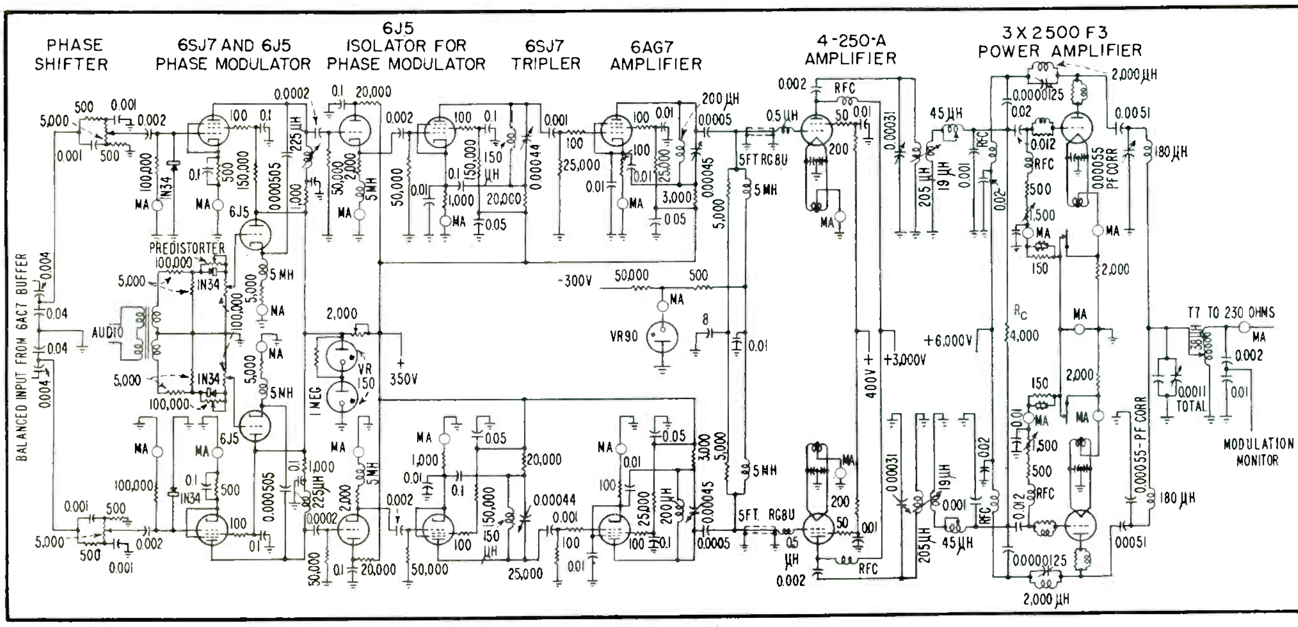


FIG. 2—Schematic of 5-kw phase-to-amplitude modulation transmitter. Two 6AC7's are used as crystal oscillator and buffer

use of a compensating load resistor R_c connected between the grids of the final amplifier tubes. When conditions of phasing between the two channels of the transmitter are momentarily more in phase less r-f power is dissipated in R_c. This results in an increase of final amplifier grid driving power at the times it is needed or during positive excursions of modulation.

During negative troughs the resistor serves to reduce the driving power and the final amplifier grid bias voltage. This in turn reduces the tendency for the final amplifier r-f plate voltage to rise during the portion of a modulation cycle when the final amplifier plate circuits are practically unloaded. The current through R_c varies approximately as $(2 \sin \theta/2)E_p/R_c$ where E_p is the rms r-f plate voltage of one driver tube. A rather complex vacuum tube r-f voltage regulator is used on the KFBK 50-kilowatt transmitter for the purpose of maintaining a constant r-f voltage at the plates of the final amplifier tubes.

Overmodulation

A very attractive feature of this transmitter not obtainable in other transmitters is that it may be heavily overmodulated without attendant side band interference, since the two phase-modulated channels can never in practice be exactly identical in power output. The carrier, therefore, will not cut off during accidental overmodulation. The positive peaks will continue to rise until the two phase-modulated channels are in phase or until the final amplifier tubes are saturated. Measurements on the KOH transmitter show 10 percent rms distortion at 110 percent positive peak modulation. At double the audio input level required for 100 percent modulation the second harmonic distortion is about 100 percent.

This may be understood from an inspection of Fig. 1C. Here 22.5-degree phase excursions in the two channels will cause a 180-degree out-of-phase condition and a negative trough of amplitude modulation. Any further phase changes in the same direction will cause the carrier to commence increasing in power. This is a condition that would change an over-all negative feedback circuit momentarily to one of positive feedback with resultant oscillation over a portion of the input audio cycle.

This difficulty was minimized on the KFBK 50-kilowatt transmitter by inserting a properly-phased carrier voltage into the negative feedback r-f rectifier. With the amount of carrier insertion used at KFBK, oscillation will not take place until positive peaks of modulation of approximately 130 percent are exceeded. The most straightforward manner of eliminating this complexity is to eliminate the necessity for the negative feedback as was done in the KOH transmitter.

Designed to operate without negative feedback, this transmitter has a noise level of −59 db below the 100-percent modulation level, an rms distortion at 100-percent modulation of 1.5 percent at low and medium audio frequencies and 2.8 percent at 7,500 cps. The distortion is predominantly of the second-harmonic variety, which is difficult to detect even with a trained ear.

Conclusion

A year of operation of this transmitter proves it to be stable, reliable and economical of tubes. The total power drain of the transmitter averages 13.5 kilowatts during operation. Although it is more critical of original adjustment than high-level-modulated transmitters, its economy of space, power and tubes and its excellent audio fidelity and its ability for heavy modulation recommend this type of transmitter to those stations having circuit-minded chief engineers and a flair for economy.

The author wishes to thank F. E. Terman and Oswald G. Villard, Jr. of Stanford University and William E. Evans, Jr. for their invaluable assistance in the development of the phase-to-amplitude modulated transmitters discussed in this paper.

Exterior of the Climax Observatory, where a prototype of the system described is in use

SERVO GUIDER for

Photoelectric devices keep telescope free from aiming errors in both hour angle and declination. Threshold control is incorporated to aid guiding during cloudy periods. Most changes in atmospheric transmission do not introduce false error signals

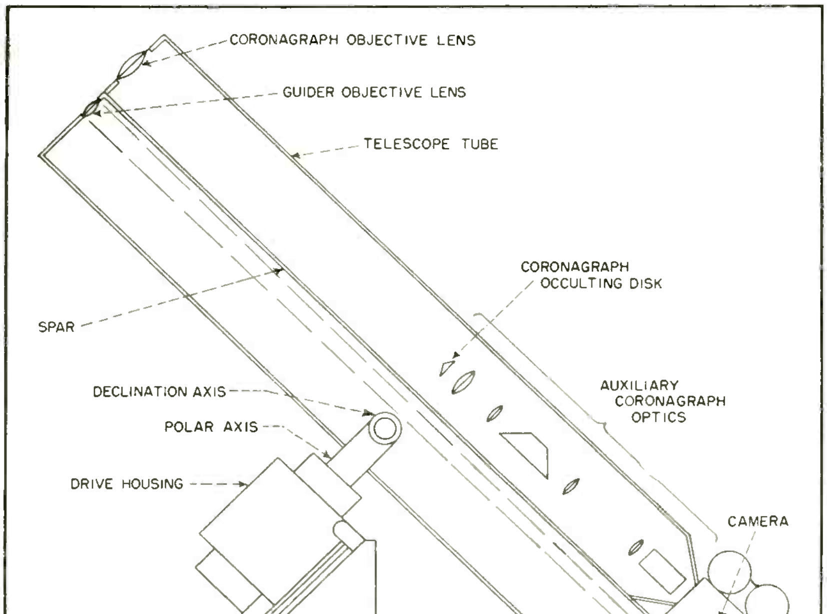
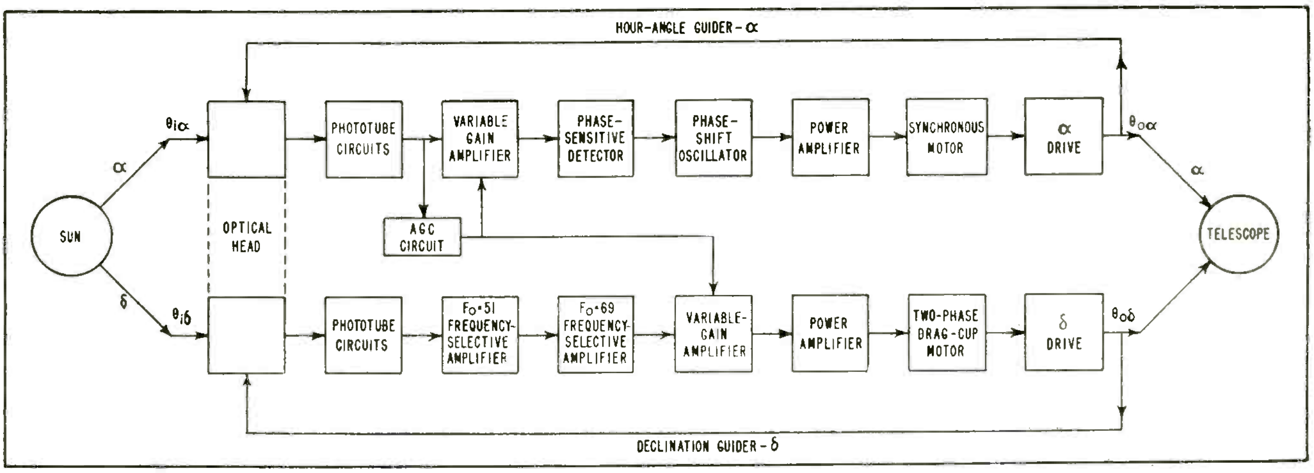


FIG. 1—Arrangement of components in the coronagraph and guider telescope

THE CORONAGRAPH is a special form of refracting telescope that makes it possible for the observer to look at the edge of the sun artificially eclipsed behind a disk within the telescope so that the faint features above the limb of the sun are visible.

To maintain the artificial eclipse and so prevent the intense light from the disk of the sun from obscuring the phenomena to be observed, the telescope must be pointed toward the sun with an accuracy of about one second of arc.

For several years the Harvard College Observatory coronagraph at Climax, Colorado, was pointed satisfactorily by off-on type servo guiders.[1] The continuous-control servo guiders described in this article were designed to control a new improved coronagraph. The first of these new coronagraphs is now in operation at Sacramento Peak, New Mexico, and a similar installation will soon be made at Climax. A prototype of the servo system to be described has been in operation for the past two years on the original



Block diagram of hour-angle and declination guiders

SOLAR TELESCOPES

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Climax coronagraph installation.

Since the apparent movement of the sun is naturally resolved into two components, two guiders or servomechanisms are used to point the telescope. The hour-angle motion is the apparent east-west movement of the sun caused by the rotation of the earth on its polar axis. The declination motion of the sun consists of small, random movements plus systematic movements north or south of the normal east-west movement.

The hour-angle and declination guiders correct the aiming errors which would otherwise arise from such factors as refraction effects in the atmosphere, lack of precision in the telescope drive mechanism, mounting alignment error, and flexure of the telescope tube. Thus, the sun is kept accurately in the telescope sights for long periods of time without manual corrections by the observer.

Hour-Angle Guider

The hour-angle guider may be considered as a system having a constant-velocity input with more or less random positive and negative displacements added to it. The telescope must follow the constant-velocity input without lag and also follow the random deviations as well as possible. The problems encountered in the design of such a system were solved largely by departing from conventional servo practice to the extent of employing a synchronous motor to supply the driving power.

In the absence of any error in pointing of the telescope, this motor is driven with a fixed frequency. This solar-rate frequency causes the telescope to follow the constant-velocity component without calling in the servo feedback loop. Zero error signal is required to run the telescope at the mean apparent velocity of the sun.

The servo loop acts to vary the frequency of the drive power and thus the speed of the motor only when the input deviates from this fixed velocity. This enables the use of a simple position servo rather than a velocity servo and also eliminates the need for the differentially geared correction motor used in conjunction with the constant-speed motor in conventional astronomical telescope drives.

Low inherent time lag is made possible by keeping the motor in synchronization during all speed variations. The guiding accuracy is limited by the random "seeing" variations caused by variable differential refractive indices of adjacent atmospheric media, even with the system gain well below the threshold of instability. Therefore, antihunt stabilization is unnecessary.

Declination Guider

The basic difference between this guider and the hour-angle guider results from the absence of a constant-velocity component in the declination movement. The input to this guider is merely a set of partially random displacements or drifts in a north-south direction.

The declination guider is similar to the hour-angle guider in that the servo loop operates in response to displacements between the sun and

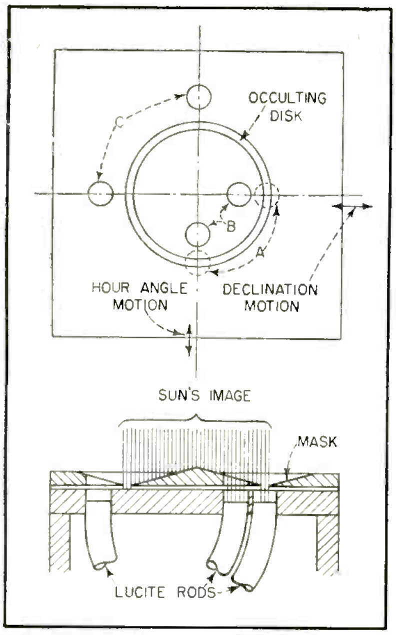


FIG. 2—The occulting disk assembly contains guider apertures *A*, reference apertures *B* and apertures used to extend range of return *C*

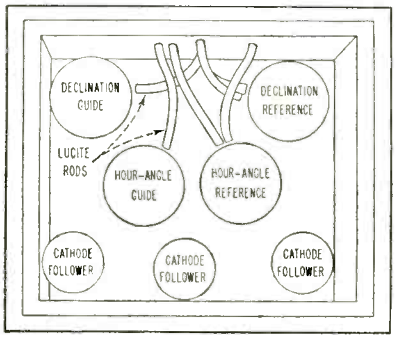
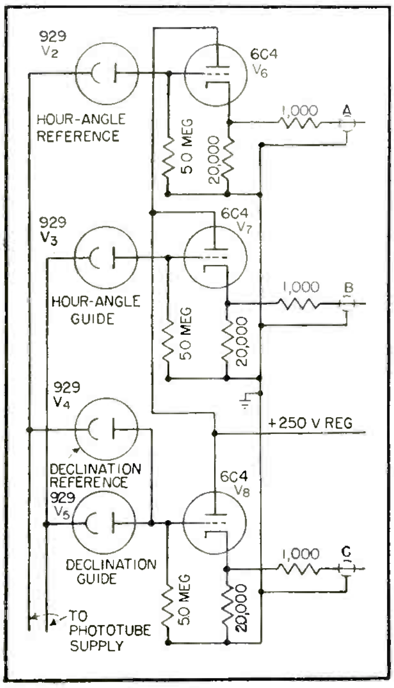


FIG. 3—Placement of lucite rods and phototubes in optical head



telescope. The servomechanism is at once an ordinary position servo and, as is customary with such systems, the driving power is supplied by a small two-phase low-inertia induction motor.

Guider Optical System

The optical system functions as the error detector for the two servomechanisms. Any differential angular displacement between telescope and sun produces variations in light flux proportional to this displacement. These variations are converted by phototubes into electric currents that vary with the error.

The optical system consists of a simple telescope mounted directly on the equatorial table of the coronagraph. The guider lens produces an image of the sun on an occulting disk of special design. Location of coronagraph and guider telescope components is shown in Fig. 1.

The guider lens produces an image of the sun slightly larger than the special occulting disk. The configuration of the disk is shown in Fig. 2. The apertures located parallel to an east-west line on the image are used to detect hour-angle errors; the apertures located parallel to a north-south line on the image are used to detect declination errors. Two beams of light are required for each coordinate.

The reference beams for each coordinate are taken from the photosphere or disk of the sun and pass through the apertures located between the edge and center of the disk. The guide beams for each coordinate are formed from a portion of the edge of the image that protrudes beyond the occulting disk. Under conditions of zero error, the sun's image is, in general, concentric with the occulting disk and nearly equal amounts of light flux emerge from the apertures near the center and at the edge of the disk.

As the error increases from zero, the reference beam area remains constant while the guide beam varies in area roughly in proportion to the deviation. The difference in intensity between the reference and guide beams is the measure of the error angle of the telescope. Thus, the magnitude of the difference of the two beams is proportional to the magnitude of the error, within limits, and the sign of the difference is indicative of the direction of the error. It should be noted that the guider cannot correct for the apparent vertical contraction of the sun caused by differential atmospheric refraction as the sun departs from the zenith.

Since small variable inhomogeneities in the photosphere (sunspots, faculae, filaments, flares) might change the reference beam intensity and thus introduce errors in telescope pointing, the area of the reference beam is made large and a light reducing filter is used to equalize the light flux to that of the edge beam at zero error. Lucite rods are used to direct the light from the apertures to the phototubes.

The phototubes and following portions of the system convert the light signal into an error-proportional direction-sensitive electrical signal. Since the error signal is a function of the difference between the two light beams, uniform variations in atmospheric transmission will not introduce false error signals. The sensitivity of the error detector varies with the overall light level but this sensitivity variation is compensated for by simultaneously applying inverse variations in gain to an amplifier stage later in the system.

A third aperture for each coordinate, designated *C* in Fig. 2, is located a short distance away from the occulting disk on the side opposite the other two apertures. No sunlight passes through this aperture under normal guiding conditions. However, in event of a prolonged cloudy period resulting in an error which would displace the image beyond the normal reference apertures, the *C* apertures take over the function of reference apertures. In this way the range of return is greatly increased.

The placement of the Lucite rods and phototubes in the optical head

FIG. 4—Optical head circuit. Leads *A* and *B* connect to the grid of the controlled amplifier stage, V_9, of the hour-angle circuit and also to amplifier V_{13} of that circuit. Terminal C connects to the input grid of the cascaded parallel-T feedback stages of declination circuit

is shown in Fig. 3. The cathode-followers provide low-impedance outputs for the signals from the telescope to the cabinet housing the remainder of the circuits.

Electrical Circuits

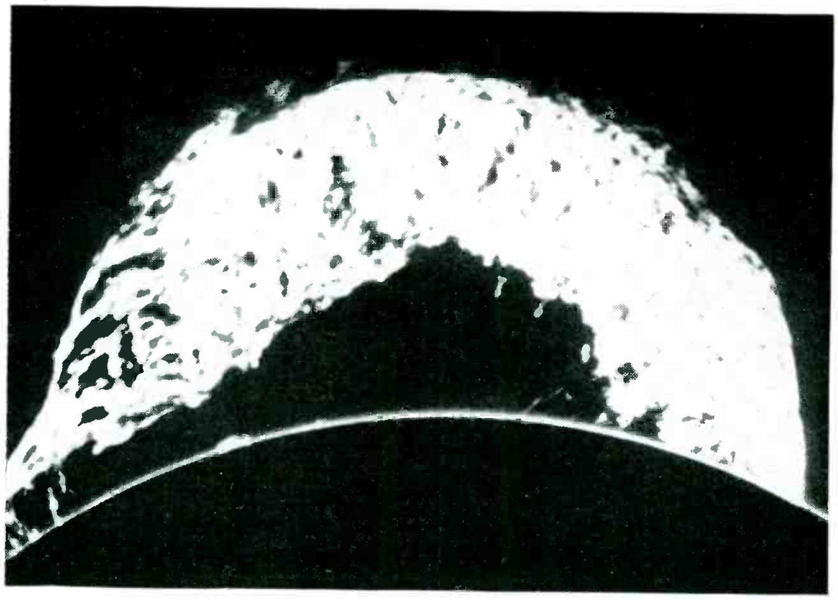
The electrical circuits of the two servomechanisms are shown in Fig. 4, 5 and 6. The reference and guide phototubes are made operative on alternate half cycles of the power line voltage by the action of V_1 in Fig. 6. The output of the phototubes are fed to cathode-followers V_6, V_7 and V_8. The amplitudes of the output pulses from the cathode followers will be dependent upon the illumination of the respective phototube cathodes.

As previously explained, the light flux reaching the reference phototubes is not subject to variation with guiding error, but changes only with variations in the ambient light level. The light flux reaching the guide photocells is a function of the error angle. Therefore, the difference in pulse amplitudes becomes the indication of the magnitude of the error angle. The direction of the error is indicated by the relative amplitude of the guide pulse with respect to the reference pulse.

The hour-angle reference and guide pulses appear at the grid of the controlled amplifier stage V_9. The pulses are amplified and coupled through cathode follower V_{10} to the input of the phase-sensitive detector V_{11} and V_{12}. The cathode follower provides a low-impedance output for the operation of a remotely located oscilloscope used to monitor guiding during photographic operations.

The reference pulse is also applied to amplifier V_{13}, rectified by V_{14} and used to make the gain of V_9 of the hour-angle system and V_{15} of the declination system inversely proportional to the ambient light level. Thus, V_9 and V_{15} compensate for the variations in sensitivity with ambient light of the error detector.

The amplified output of the hour-angle reference and guide phototubes is converted into a direct voltage by the phase-sensitive detector. This direct voltage is thus an almost exact replica of the error



Solar prominence photograph taken with coronagraph telescope

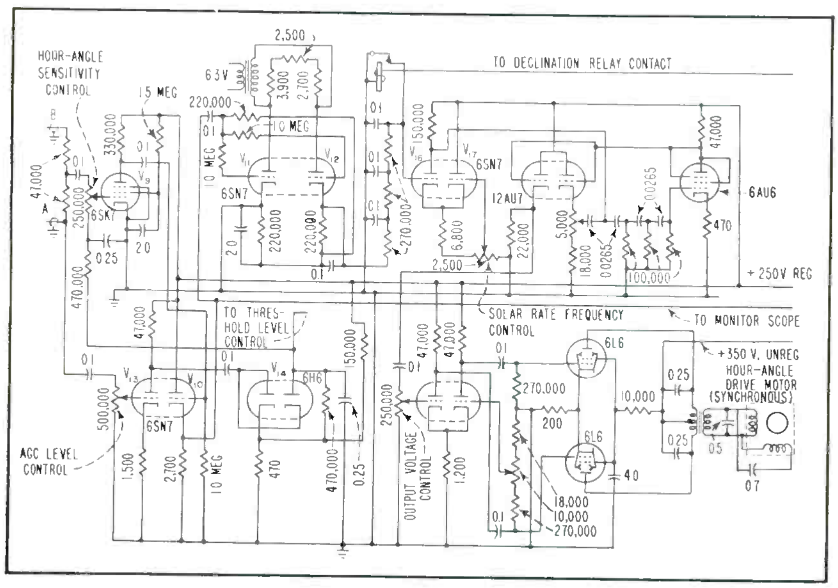


FIG. 5—Hour-angle circuit. Lead *A* connects to the cathode follower fed by the hour-angle reference phototube and *B* connects to the hour-angle guide phototube circuit

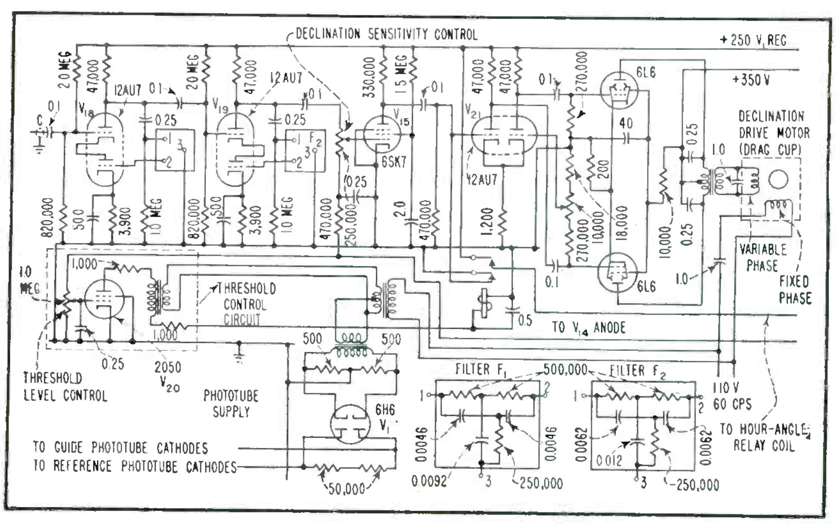


FIG. 6—Declination circuit. *C* connects to the cathode follower fed by the declination reference and guide phototubes

as a function of time.

Since the telescope is being driven by a synchronous motor, its angular velocity is exactly proportional to the frequency of the alternating voltage applied.

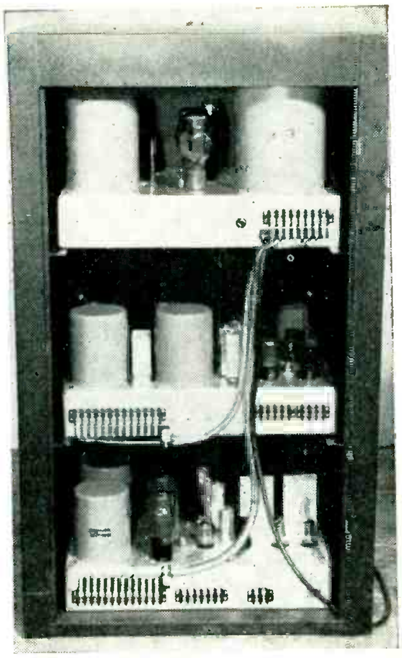
Speed Control

The required speed control is realized by driving the motor with the amplified output of a frequency-modulated phase-shift oscillator.[2] The frequency of the oscillator is dependent upon the d-c grid-cathode voltage of V_{16} which functions as one of the resistive elements in the R-C phase-shift network of the oscillator. The grid voltage of V_{16} is the d-c output of the phase-sensitive detector so that the frequency of the oscillator and therefore the speed of the motor is a function of the magnitude of the error angle between telescope and sun.

The constant-velocity component of motion for zero detector output is obtained by a cathode biasing system. An adjustable voltage of sufficient stability is produced by V_{17}. This voltage normally produces an oscillator frequency of approximately 60 cycles. The drive mechanism is designed to give the telescope a velocity equal to the apparent velocity of the sun at this frequency so that in event of guider failure the motor may be operated from the 60-cycle power line and the telescope corrected manually.

The simple f-m system used produces an increase in oscillator output voltage with an increase in oscillator frequency.[3] This characteristic tends to keep the power input to the motor constant with respect to frequency variation so that the motor operation is synchronous at all times.

The telescope declination motion is imparted by a two-phase drag-cup motor. The motor is driven by the amplified output of the declination phototubes. If the reference and guide pulses are of equal amplitude, the condition of zero error, the lowest frequency component in the phototube output will be 120 cycles. This signal will be attenuated by the frequency-selective characteristics of the declination amplifier and applied to the motor. The fixed phase excitation is from the 60-cycle power line; therefore,



Rear view of cabinet housing guiders

this null signal will not cause rotation of the motor shaft.

An error in guiding will produce a displacement in pulse amplitudes thereby introducing a directional-sensitive 60-cycle component into the output of the phototubes. This signal, applied to the motor through the amplifier, will cause the motor to drive the telescope in such a direction as to reduce the error to zero. By keeping the time constants small, the maximum sensitivity is again limited by "seeing," rather than system instability. In an earlier model of the guider, anti-hunt provisions were incorporated but operational experience has proved these unnecessary in the present system.

Frequency-Selective Characteristics

The frequency-selective characteristics of the declination amplifier are obtained by using V_{18} and V_{19} in cascaded, parallel-T feedback stages.[4] These amplifiers are tuned to frequencies of 51 and 68 cycles to provide a constant phase shift with frequency around 60 cycles. This is done to maintain the proper phase relation between the fixed and variable phase voltages during expected power line frequency variations at the Sacramento Peak installation. The remainder of the declination circuit is conventional in every respect.

To facilitate guiding during cloudy periods, a threshold control has been incorporated in the guider. When clouds obscure the sun, the hour-angle reference phototube output decreases with a resulting decrease in agc voltage. When the agc voltage drops below a predetermined level, thyratron V_{20} is allowed to conduct thus closing the relay shown in its plate circuit. The relay grounds the declination signal at the input to V_{21} so that no declination corrections are made.

An auxiliary set of contacts on the declination relay cause a relay located on the hour-angle chassis to return the grid of V_{16}, the frequency control tube, to ground. The hour-angle system then operates at the solar-rate frequency during the cloudy period. When the clouds disappear, the agc voltage rises and the guider resumes automatic operation without any attention from the observer.

In the guider, the power supply is placed on the top rack of the cabinet, the hour-angle chassis is on the middle rack, and the declination chassis is placed on the bottom of the cabinet. The only control on the front panel of the guider is the off-on switch.

The guider is the result of the efforts of Walter O. Roberts, Superintendent of the High Altitude Observatory, John W. Evans, Assistant Superintendent, R. H. Lee, J. C. Palmer, and the writers. Preliminary development was carried on at the firm of W. D. Pratt, consulting engineer. The work was done under a research and development contract administered by the Air Force Cambridge Research Laboratory.

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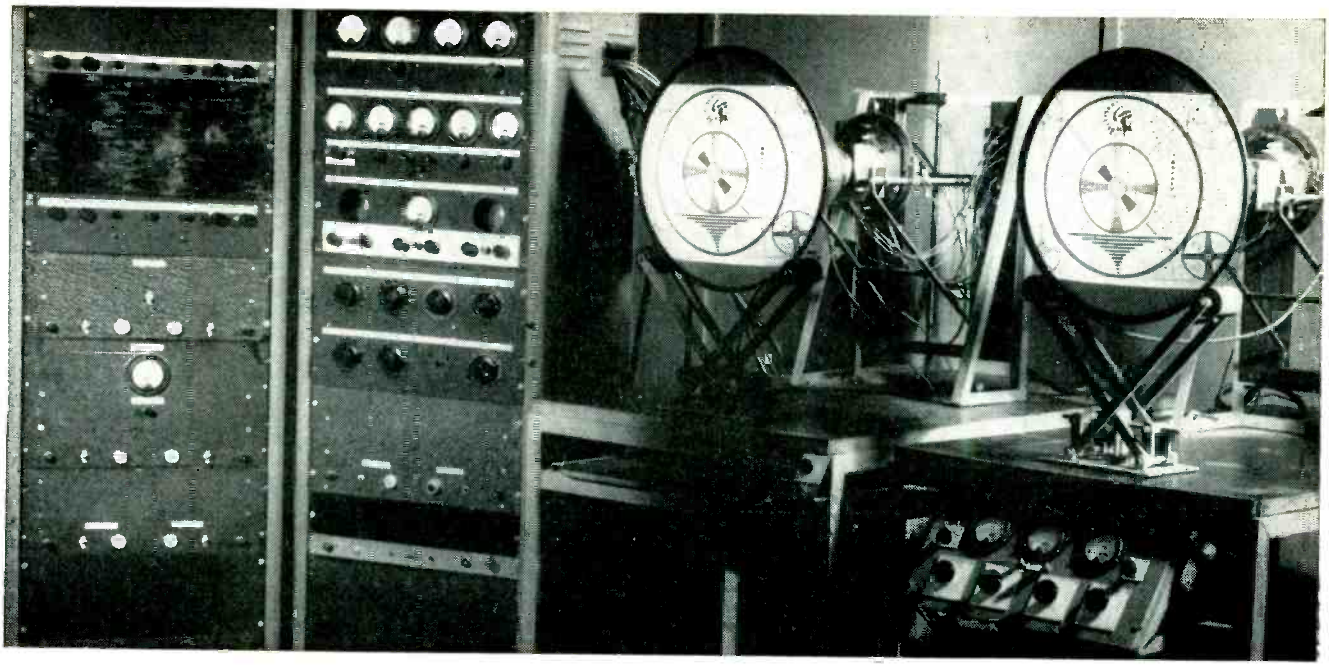

Dual magnetic-deflection test setup for side-by-side comparison of picture-tube resolution

Picture-Tube Performance

How to determine focusing strength performance and resolution characteristics for tv picture tubes. Equations are given for both magnetic-focus types and new electrostatic-focus tubes designed to conserve critical materials

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EXTENSIVE application of television picture tubes utilizing magnetic focus and deflection somewhat complicated the problem of tube design because of the influence of the focus and deflection devices on tube performance.

Since in many instances the tube designer has not been responsible for the design of components, it is desirable to study the magnetic-type cathode-ray tube in a basic manner with emphasis on those performance characteristics which can be modified by external accessories.

The first problem to be considered is the determination and specification of focusing strength. Tube manufacturers' specifications define the focusing strength as current in a standard focus coil at specified conditions of pattern size, anode voltage and brightness. The location of the focus-coil air gap is specified with respect to the yoke or neck reference line. The focusing current value is given as approximate, or with a wide tolerance such as ± 20 percent. However, focusing devices are in use which cannot achieve the range required by tube specifications.

The simplest approach to the problem of focus-strength determination is to consider the magnetic focus lens as represented by an ideal thin lens of an analogous optical system, assuming that a plane through the center of the air gap represents the Gaussian plane of the lens. Also, it may be assumed that the object of the optical system is a small point in the vicinity of the control-grid aperture and that the image lies at the tube screen. Treating the lens as a path-changing device, it is obvious that to achieve focus at the image, lens strength must change as the angle through which a given ray from the object is changed.

Figure 1 illustrates the geometry of the ideal case. The height from the axis of the intercept of an object ray and an image ray is taken as a constant and is represented by R. The object distance is d and the image distance is d'. The sum of the angles α and β, which the object and image rays make with the optical axis, is assumed to be a factor proportional to lens strength and is represented by S. The following relationships may be derived

$$S = \alpha + \beta = \tan^{-1}\frac{R}{d} + \tan^{-1}\frac{R}{d'}$$

$$= \frac{R}{d} + \frac{R}{d'} = \frac{R\,(d' + d)}{dd'},$$

since $R << d$ or d'

$$\frac{S}{R} = \frac{d' + d}{dd'} = \frac{1}{f}$$

In essence, this derivation is the familiar thin-lens relationship $1/f = 1/u + 1/v$, if S/R is set equal to $1/f$. Since an expression is available for the focal length of a thin magnetic lens in terms of the magnetic field distribution and the accelerating voltage, it is apparent that the focal length for a given case may be taken as inversely proportional to the square of current in the electromagnetic lens. In the idealized case the focus current may be expected to vary as the square root of the sum over the product of the object and image distances.

For electromagnetic lenses[1]

$$\frac{1}{f} = \frac{1}{8}\frac{e}{m}\frac{1}{V}\int_{-\infty}^{+\infty} H_z^2 dz$$

$$= k I^2$$

$$I = K\sqrt{\frac{d' + d}{dd'}}$$

The resulting relationships which are the most useful in applying the thin-lens law are as follows:

$$I_1 = K\sqrt{\frac{d_1 + d_1'}{d_1 d_1'}}$$

$$I_2 = K\sqrt{\frac{d_2 + d_2'}{d_2 d_2'}}$$

$$\frac{I_1}{I_2} = \sqrt{\frac{(d_1 + d_1')\, d_2 d_2'}{(d_2 + d_2')\, d_1 d_1'}} \qquad (1)$$

When $d_1 + d_1' = d_2 + d_2'$

$$\frac{I_1}{I_2} = \sqrt{\frac{d_2 d_2'}{d_1 d_1'}} \qquad (2)$$

When $d_1 = d_2$

$$\frac{I_1}{I_2} = \sqrt{\frac{(d_1 + d_1')\, d_2'}{(d_2 + d_2')\, d_1'}} \qquad (3)$$

Equation 1 gives the ratio of currents required for focus in the general case of two different sets of object and image distances. Equation 2 considers the special case where the length of the optical system is a constant. This equation is useful in predicting the change in focus current required when the focus coil is located at different positions on the neck of a given tube type. Equation 3 is the case analogous to comparing tubes with the same gun to focus coil distance but of different screen size or deflecting angle.

Test Results

To test the validity of the equations, a number of measurements were made on cathode-ray tubes ranging in size from 5 to 19 inches in outside diameter. The tubes tested utilized the same type electron gun.

Figure 2 shows the experimental results on a 19-in. tube as compared to a 5-in. tube. The lower solid line curve represents the measured data for the 19-in. tube, and the circles indicate the theoretical points using Eq. 2 and setting $I_1 = I_2$ at a distance from G_1 to focus-coil gap of 2.2 inches.

The upper solid line of Fig. 2 represents measured data on the 5-in. tube, while the points indicated by squares were computed using Eq. 3 and the measured 19-in. data.

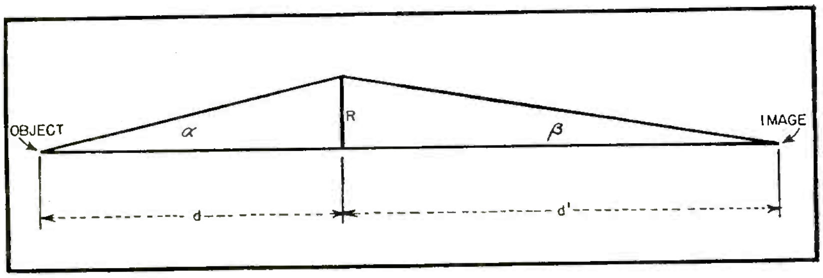

FIG. 1—Geometry of thin-lens setup for evaluating picture-tube focus strength

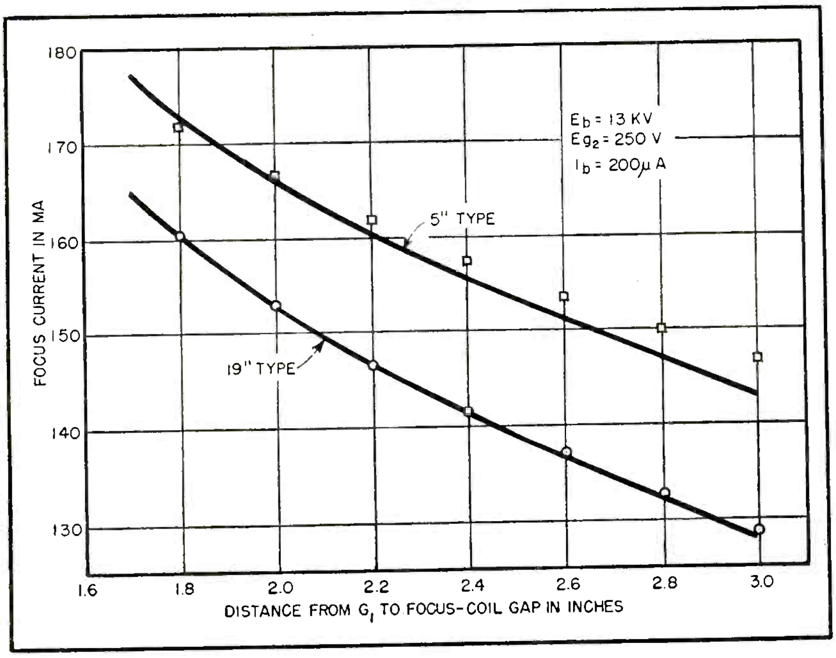

FIG. 2—Focus-current variation with tube size as determined by Eq. 2 and 3

Electrostatic Focus

Using essentially the same approach as for the magnetic focus case, it is possible to derive similar equations for electrostatically focused tubes.

In view of material shortages it has been proposed to eliminate the need for external focusing components by the use of an electrostatic lens of the Einzel type. This lens[2] utilizes a focusing electrode in the form of a ring or disk located between electrodes maintained at final anode potential.

Strength of a given lens of this type is a function of the focusing electrode voltage V_f and the anode voltage V_a. Setting $1/f$ equal to $k\,(V_a - V_f)/V_f$, the general equation for variations in focus voltage with variations in tube and gun dimensions becomes

$$\frac{\phi_1}{\phi_2} = \frac{(d_1' + d_1)\, d_2 d_2'}{(d_2' + d_2)\, d_1 d_1'}$$

where ϕ_1 equals $V_{a1}/V_{f1} - 1$ and ϕ_2 equals $V_{a2}/V_{f2} - 1$. The other relationships analogous to the magnetic focus case may be derived from the preceding equations.

On the larger sizes of direct-view tubes, from 12 inches up, focusing strength required for a given anode voltage varies only slightly with distance to the screen and in a direction such as to decrease as the tube size becomes larger.

The greatest variation in focus strength on existing types occurs with variations in location of the focusing device with respect to the electron gun. To minimize the range of adjustment required for such devices, it is desirable to locate with respect to the electron gun rather than to a reference point on the tube neck or bulb body.

Resolution Capability

The second problem of major importance is the resolution capability of a given picture-tube type and the influence of external component designs on this characteristic. A method of vertical resolution determination has been used which is an adaptation of the merging-pattern type of line-width measurement used extensively for industrial and military instrument and indicator tubes.

In applying this method to television picture tubes, 525-line interlaced scanning is used with the horizontal width adjusted to normal picture size. The tube is operated without video modulation, but by means of a grid-gating circuit, a square-wave blanking signal is used to remove the interlaced scan. Elimination of the interlace results in a highly stable pattern which is necessary for determination of the vertical amplitude at which the individual scanning lines appear to merge and are no longer discernible as individual lines.

Figure 3 illustrates the appearance of a test pattern at a near-merged (left side), merged (center) and over-merged condition (right). This result was obtained by slight defocusing of the pattern to show all three conditions at the same time. On all of the types tested, the merged condition was readily discernible and the reproducibility of observed data was good.

Vertical resolution may be determined by the formula $R = N_s V / 2h$, where R is the apparent vertical resolution in number of lines, V is the maximum vertical dimension of picture scan, h is the measured height of the merged pattern and N_s is the total number of scanning lines.

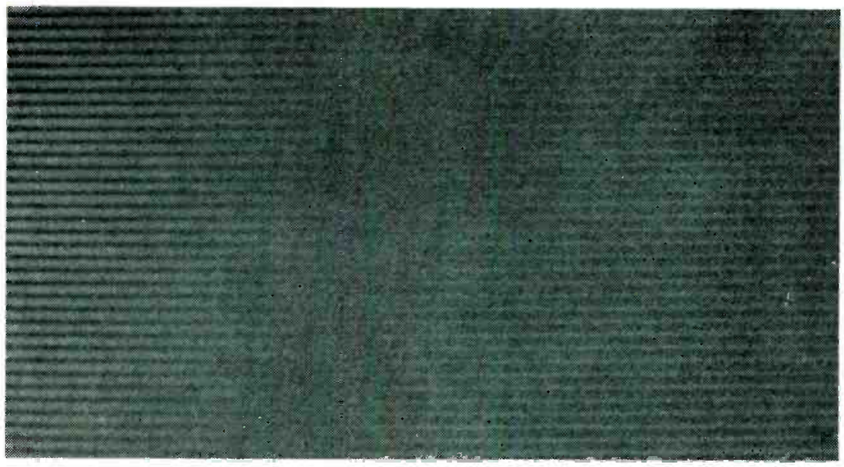

FIG. 3—Test pattern appearance at near-merged (left), merged (center) and over-merged (right) conditions. Result was obtained by slight defocusing of pattern

Figure 4 shows the results of measurements made on a 19-in. type picture tube. In this case, the resolution was measured as a function of location of the focusing component with respect to the control-grid aperture.

A change in distance of 1 inch causes a change in resolution of from 435 to 720 lines and resolution changes approximately inversely with focus current in the electromagnetic coil.

With the size and current distribution of the object fixed, the tube designer can change resolution by changing the location of the electron gun with respect to the focus device or by introducing varying degrees of electrostatic prefocusing between the object and the focus lens. The ultimate result of either method is to produce a larger beam diameter at the focus and deflection region if the center resolution is increased, or a smaller beam diameter if the resolution is decreased.

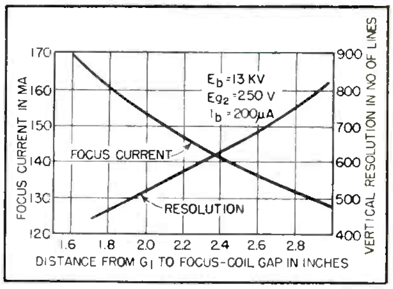

FIG. 4—Focus current and vertical resolution as a function of distance from control grid to focus-coil gap for a 19-in. magnetic-type picture tube

A low-center resolution cathode-ray tube has less deflection distortion and gives the viewer the impression that the focus is uniform over the entire picture area. The viewer may find this more pleasing than added detail sharpness in the central-picture zone achieved at the expense of focus uniformity.

To resolve this problem, side-by-side comparison tests were made on a number of tubes with known vertical resolution characteristics. It was found, considering the central picture area alone, that a definite preference existed for tubes with resolution figures in excess of 500 lines, because of increased detail contrast.

When the same tests were made considering the entire scanning area, those tubes with very high resolution were found objectionable because of the lack of focus uniformity from the center to the picture edges. On tubes of low resolution, below 400 lines, the lack of detail sharpness was found objectionable despite excellent uniformity of focus.

On the basis of such subjective tests, a vertical resolution range of from 450 to 550 lines was chosen as optimum with a preference for the higher side of the range in view of the increased availability of low-distortion deflection yokes.

References

(1) I. G. Maloff and D. W. Epstein, "Electron Optics in Television," McGraw-Hill Book Co., Inc., New York, 1938.

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Automatic Calibration of Radiosonde Baroswitches

Production-line calibrator turns out individual 150-point calibration charts for 16 pressure switches simultaneously in 8 minutes without human-element errors. Servo motor moves phototube to follow top of mercury column in automatic barometer, and synchro generator transmits column position to chart-printing recorders

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CALIBRATION of the precision multipoint pressure switches of meteorological radiosondes involves determining the exact pressure required to make each of 150 successive electrical contacts. Before the development of the automatic calibrator for these baroswitches, an operator working with her individual bell jar, test barometer and audio oscillator would observe the exact pressure value corresponding to each 5th contact.

About 6 years ago a simple automatic calibrator was developed consisting essentially of a mercury J tube, with one end connected to the test chamber and the other end open to the atmosphere. A float switch arrangement followed the top of the mercury in the open end and controlled 10 recorders, each of which recorded the data from a switch in the test chamber. While relatively crude in the light of modern instrument development, this equipment was effective and has successfully calibrated approximately 750,000 baroswitches.

Recent design modifications in the baroswitch, plus greatly increased accuracy requirements, necessitated modernization of the calibration procedure. A photoelectric follower was developed to replace the float switch, and chart scale length was increased from $11\frac{3}{4}$ inches to about 30 inches for the full 30-inch range of atmospheric pressure. This made each millibar division approximately $\frac{1}{32}$ inch, the millibar being roughly 0.001 atmosphere. The individual test points were printed on this scale by a recording mechanism, with sufficient test points numbered to identify any test point at a glance. To handle such a scale it was decided to use the rather unusual method of feeding the paper through the recorder in proportion to the changes in the test chamber pressure, rather than in proportion to time as is used in many conventional recorders.

The complete calibration equipment as finally designed results in an extremely simple procedure for the operator. He merely loads 16 baroswitches into the test chamber, closes the door, pushes a start button and 8 minutes later, removes the 16 baroswitches from the chamber and 16 corresponding cali-

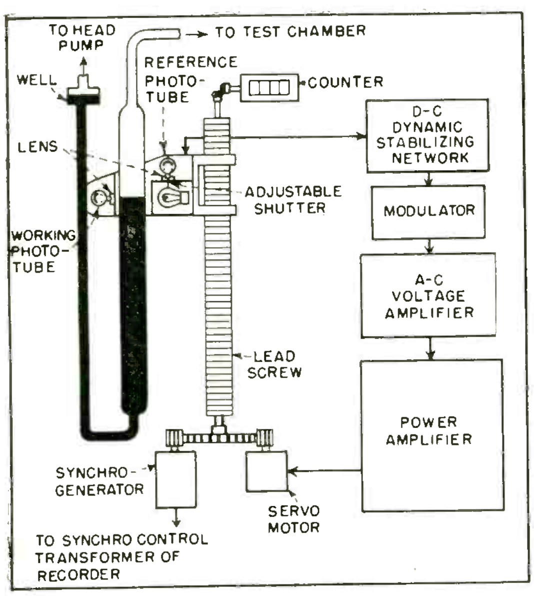


FIG. 1—Arrangement of automatic barometer that measures pressure in test chamber

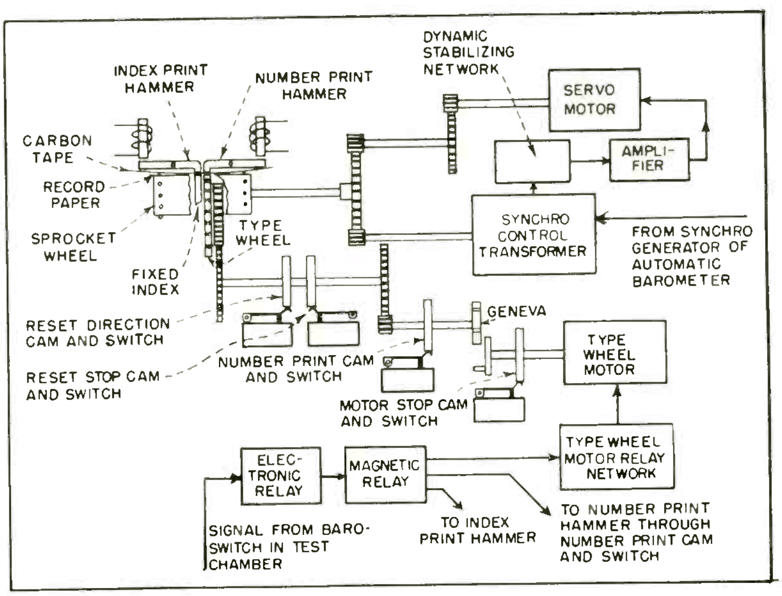
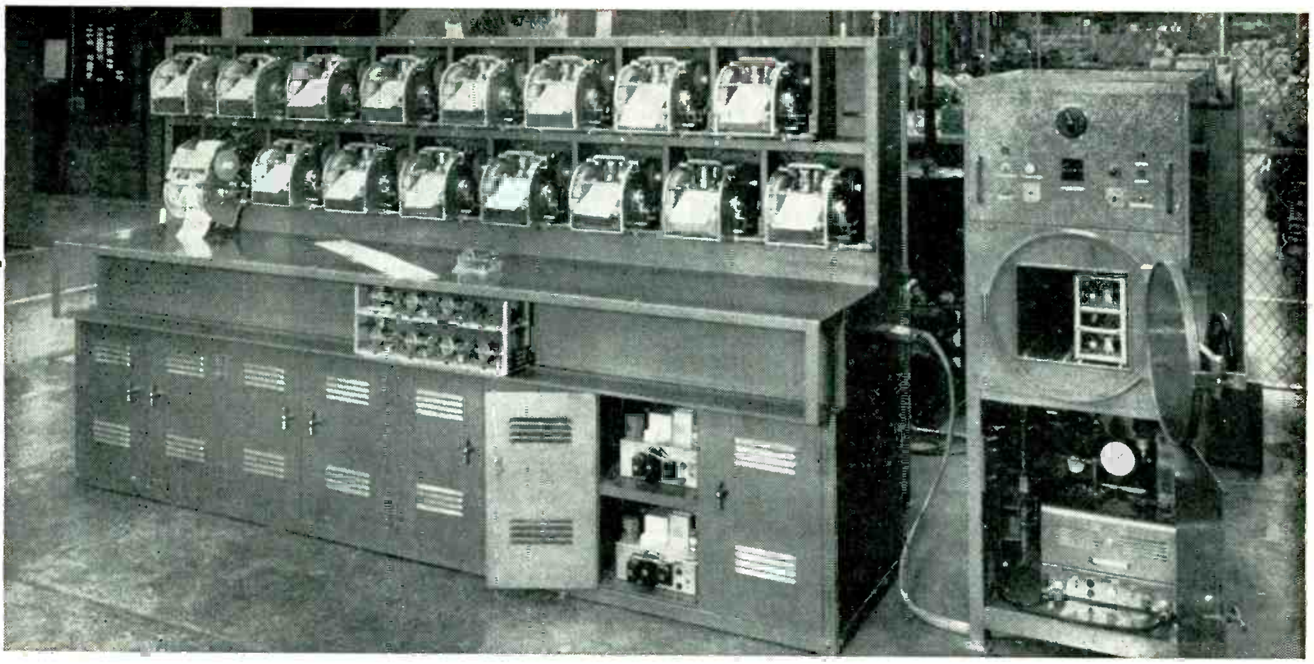


FIG. 2—Method of driving chart paper in recorder as function of changing pressure in test chamber



Test chamber for holding baroswitches is at right, with vacuum pump underneath for varying pressure in chamber from atmospheric to vacuum. Servo amplifier is in front of pump in lower compartment, and chart-printing recorders are on bench

bration charts from the 16 recorders incorporated in the equipment.

Automatic Barometer

The basic measuring element is a mercury column, chosen because of the high accuracy obtainable together with freedom from drift and hysteresis problems. An accuracy in the order of 0.02 percent of full range is obtainable from the measuring system, and the over-all accuracy including the recorder is 0.05 percent.

The biggest and most variable error encountered in an ordinary mercury column is due to temperature variations, and is corrected by placing the column in a constant-temperature cabinet. Using a continuously operating vacuum pump to maintain a high order of vacuum at the top of the mercury column eliminates the next most troublesome feature of the ordinary barometer, uncertainty as to the order of vacuum above the column. Scale linearity is assured by the use of machined parts and precision bore glass tubing.

A rectangular metal housing surrounding the mercury column near the top contains a light source and phototube system used to detect the location of the top of the mercury column. This housing is moved up and down the tube, to follow the mercury column, by a precision lead screw located behind the mercury column. In the phototube assembly, the use of an optical condensing system was avoided to simplify adjustment and maintenance. A system of slits collimates the light between the lamp and the phototube. A plastic concave cylindrical lens is used to spread this narrow beam of light evenly over the area of the phototube cathode. A second phototube illuminated by the same lamp through another slit, having an adjustable shutter, compensates for variations in intensity of the light source.

A 2-phase 5-watt a-c motor geared to the lower end of the screw acts as the servo motor in a precision servo system controlled by the phototube. One phase is fed directly from the 115-volt, 60-cycle supply. The other phase is driven from an amplifier fed by the phototube. This motor, working from the amplifier signal, drives the lead screw in a direction to bring the phototube toward the location of the top of the mercury column. A conventional counter driven by the top end of the lead screw shows pressure in millibars directly. A synchro generator, also driven by the lead screw gear, transmits mercury column position information to the recorders in the system.

Figure 1 shows the basic action of the phototube amplifier circuit, which is essentially a conventional electronic servo system. The amplifier receives a signal from the phototube which is proportional to the error in location of the phototube relative to the location of the mercury column top. This is d-c voltage proportional in value to the amplitude of the error, reversing in polarity when the sign of the error reverses. This signal is fed into an R-C network which modifies it in such a manner as to produce dynamic stability of the entire system, principally counteracting the inertia effects of the servo motor rotor and attached rotating parts.

The synchronous vibrator-type modulator converts this d-c voltage into a 60-cycle a-c voltage with amplitude proportional to error and a phase shift of 180 deg with change in sign of the error. This signal is fed through one stage of voltage amplification and a power amplifier stage to the control phase of the servo motor. The closed loop of the conventional servo system is completed through the mechanical lead screw back to the phototube carriers.

Chart Printer

The sprocket wheel driving the paper chart of the recorder is located below the hold-down fingers at either edge of the chart. This sprocket is driven by another precision servo motor system receiving its control signal from the automatic barometer. With this arrangement the paper position becomes a precise function of the mercury column position in the automatic barometer. For this to be true, precision printing and punching of the perforated charts is necessary, as the principal source of error is in maintaining good registration between sprocket holes and chart printing. Such charts have been obtained after some effort and are in the form of a continuous strip several thousand charts long with perforations between each chart for easy separation.

Two printing hammers with their associated electromagnetic drives are at the top of the recorder. The lefthand hammer prints the index marks for successive test points. The right-hand hammer prints the test point numbers, printing every 5th number only. Directly below the hammers and under the paper is located a fixed index point below the left hammer and a number type wheel below the right hammer. This type wheel moves after every index printing but requires five such moves to travel from one type position on its circumference to the next. A carbon paper ribbon is located between hammers and chart.

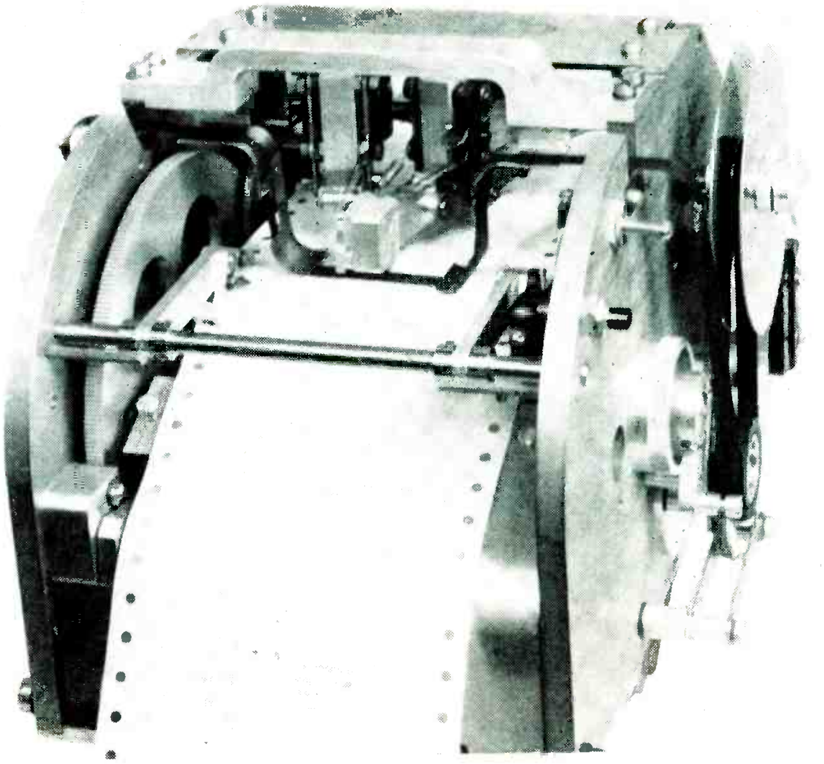


Chart-printing recorder. Lines and numerals at right of printed scale are put on by the recorder automatically by hammer-actuated type wheels, giving over-all chart accuracy of 0.05 percent

The recorder mechanism is shown in Fig. 2. The paper drive sprocket wheel is gear-driven by a 2-watt, 2-phase, 60-cycle, low-inertia servo motor. The sprocket wheel gear in turn drives a synchro control transformer which has a gear ratio corresponding to 36 millibars on the chart per revolution of the control transformer. Since synchro control transformers of this type are accurate to well under 1 deg of rotation, this gear ratio produces a basic accuracy of 0.1 millibar or 0.01 percent of full range.

The type wheel motor in Fig. 2 is a geared motor producing 60-rpm shaft speed and driving the motor stop cam and the input member of a Geneva stepping drive. The motor stop cam serves to stop the motor after one revolution of its shaft. The Geneva drive has a reduction of 5 to 1 and drives the number cam, also the type wheel countershaft through a 30-to-1 gear reduction. The countershaft carries the reset direction cam and reset stop cam.

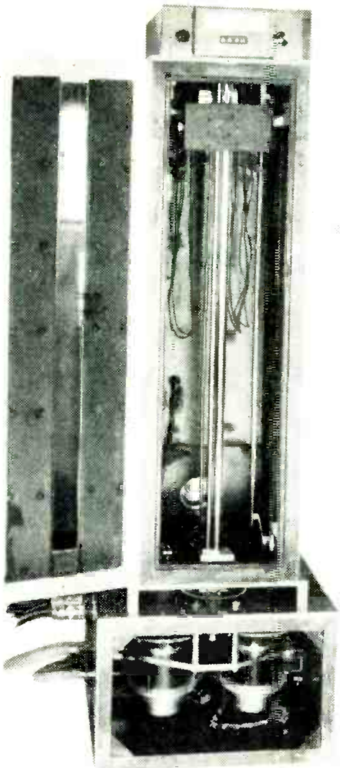
At the end of a recording cycle, the print wheel is reset by continuously driving the type wheel motor in a direction to move the type wheel back to its starting position by the shortest path. The reset direction cam controls the direction of motor rotation to produce this effect, while the stop cam stops the motor when the starting position is reached. This countershaft also drives the type wheel through a 1-to-1 gear ratio. A ribbon drive, not shown in the diagram for simplicity, is driven by the type wheel motor through a ratchet mechanism which prevents backing up of the ribbon when the motor is run backwards during a reset operation.

Chart Drive

The signal coming from the automatic barometer via a program control, showing the mercury column position, is fed to the synchro control transformer in the recorder. This is a typical 3-phase, 60-cycle synchro secondary signal. The control transformer compares the sprocket wheel position with the signal from the barometer, and produces a single-phase 60-cycle signal proportional in amplitude to the position error and having a 180-deg phase shift with a change in sign of the error. This signal is fed into a stabilizing network similar in purpose to that in the barometer.

After passing through two stages of amplification, the signal is fed into the servo motor control winding. The servo motor then drives the sprocket wheel in a direction to reduce the error shown by the control transformer. The sprocket wheel gearing acts to close the servo loop back to the control transformer. Since the speed of this servo is considerably faster than that of the barometer, no difficulty is encountered from failure in synchronization between the barometer and recorder so long as operation is uninterrupted.

With each make of the baroswitch contacts in the test chamber, a signal is fed to an electronic relay in the printing system. The electronic relay reduces the load on the delicate baroswitch contacts. The output of the relay is a pulse which closes a magnetic relay momen-



Automatic barometer with cover open, showing mercury column, phototube follower at top, and synchros below

tarily, producing a power pulse to operate the printing hammers. This pulse is fed directly to the index hammer mechanism, but the pulse to the number hammer passes through the cam-actuated number switch that is only closed for one out of five pulses, allowing printing of 5th contacts only.

The magnetic relay pulse is also fed into the type wheel motor relay network, which acts to drive the motor until a signal is received from the motor stop switch after one shaft revolution.

Operating Sequence

The program control controls the operation of the barometer and recorders in proper sequence. It includes necessary auxiliary functions, consisting of a pressurizing mechanism, an evacuating mechanism, a venting mechanism and a test circuit used in testing operation of the equipment and calibrating the calibrator. The baroswitches to be calibrated snap into two trays, each carrying eight switches. These trays slide into the test chamber and automatically plug into the electrical circuit by means of a plug system located at the rear of the test chamber. A quick-acting door clamp seals the chamber door.

The vacuum rate-sensing mechanism consists of a metal sylphon connected to the test chamber system and balanced by a heavy helical spring. The extension of this spring is controlled by a motor-driven cam on which the desired pressure-time cycle has been cut. In operation, revolution of the cam produces varying tension in the spring which, if not balanced by pressure changes in the sylphon, moves the core of a small differential transformer located between the spring and bellows. The a-c signal from this transformer, fed through the amplifier, drives the motor of the control valve in a direction to change the pressure so as to reduce the error thus indicated.

The sequence of operation begins with the closing of the start switch by the operator. This energizes the pressure relay network, which in turn opens the pressure solenoid valve and starts the air compressor. Pressure builds up in the test chamber until the high-pressure contact on the servo pressure switch on the control chassis closes at a pressure of 1,070 millibars. This closure acts on a relay network to close the pressure solenoid and shut off the air compressor. Simultaneously the recorder paper feed servos, the recorder printing circuit and the evacuation rate mechanism motor are activated.

The chamber is evacuated at a rate predetermined by the contour of the pressure rate cam, while the 16 recorders simultaneously record the switch closures of their respective baroswitches. This action continues until evacuation is carried to a pressure of somewhat less than 5 millibars, at which point the low-pressure contact of the servo pressure switch is closed. This, acting on the relay network, shuts off the recorder servos and printing circuits. The recorder reset circuit is simultaneously energized, which activates the evacuation rate control reset, the recorder reset mechanisms and the vent solenoid on the test chamber.

As soon as the test chamber pressure has reached atmospheric pressure, the operator may open the chamber and remove the 16 baroswitches. The recorder servos and printing circuits are deenergized during the return of the test chamber pressure to atmospheric to prevent feeding the chart back into the recorder and to avoid extraneous printing by baroswitch contact action during the switch closures resulting from the increasing pressure.

Before starting another calibration cycle, the operator feeds the finished chart out of the recorder and sets the next chart at approximately the pressure at which the high-pressure contact of the servo pressure switch closes. When this contact closes during the next calibration cycle, the chart is automatically synchronized with the barometer by the recorder servo system.

At mercury column speeds above 10 millibars per second, up to the maximum of about 15 millibars per second, the servo system tends to lag behind the mercury column excessively. To avoid danger of inaccurate readings due to excessive speed, a neon bulb connected across the control phase of the servo motor lights at about 10 millibars per second as a warning to the operator. Since control phase voltage is a criterion of phototube position error relative to the mercury column, lags due to excessive mechanical friction will also be indicated. The formation of dirt deposits on the glass tube has not proved to be a problem in connection with the use of a phototube pickup, provided a clean system is maintained.

Other Applications

The equipment described may be used as a general laboratory precision barometer. Elimination of corrections and the ease of reading to high accuracies without optical magnification or parallax is of great value where much pressure observation is required. Other uses include remote indication of barometric pressure by synchro repeaters, automatic pressure recording of other phenomena adaptable to electric switching technique and the development of programming equipment suitable for adapting the barometer-recorder combination to other products.

Simplified Q Multiplier

Portion of cathode-follower output is stepped up by passive components and fed back to grid of tube to give extremely high selectivity with absolute stability. Extra parts needed are one tube, one capacitor and two resistors

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WITH THE RISE of radio navigation, c-w radar, and other systems requiring maximum signal-to-noise ratio, there have grown up in recent years a large number of applications for amplifying systems of very narrow bandwidth. Since the basic limitation on the narrowness of bandwidth which can be obtained in an ordinary tuned amplifier is the resistance associated with the tuned circuit it uses, it seems logical that one solution to the problem would be the use of an active network to supply energy to the system according to exactly the same laws by which the resistance dissipates it, so that some of the effect would be cancelled out.

The use of such active networks, known, for obvious reasons, as negative resistances, turns out to be an entirely practical method of raising the Q of a tuned circuit. Ohm's law holds exactly for a negative resistance element, except for sign change, so it is possible to treat it exactly as any other circuit component, even to the extent of combining it with the positive resistances in the circuit.

Consider, for instance, a tuned circuit having an equivalent parallel resistance R. The initial value for Q would be

$$Q_0 = \frac{R}{\omega L} \qquad (1)$$

and suppose there is put in parallel with this tuned circuit an active network having a negative resistance characteristic. The negative resistance can be combined with the positive resistance of the circuit by the usual laws of combination of parallel resistances to give the following relationship for R_{eff}:

$$R_{eff} = \frac{(-R_n)\,R}{(-R_n)+R} = \frac{R\,R_n}{R_n - R} \qquad (2)$$

which is obviously greater than the original R, corresponding to a multiplication of the original Q by a factor equal to the ratio of the two resistances. In other words

$$\frac{Q_{eff}}{Q_0} = \frac{R_n}{R_n - R} \qquad (3)$$

This Q multiplication can be made arbitrarily large by simply letting R_n approach R.

Practical Systems

A number of systems have been used to secure this negative resistance characteristic, such as secondary emission in a tetrode (dynatron)[1] or the formation of a virtual cathode between screen and suppressor (transitron)[2]. By far the most satisfactory method to date, however, has been the use of positive feedback around a vacuum-tube amplifier.[3,4] This basic method is used in the new circuit proposed here.

Consider an amplifier of gain A and internal resistance R_i such as is represented schematically in Fig. 1A, and assume that positive feedback is introduced through the resistor R_f.

Under the assumption that the input resistance of the amplifier is so high compared to the other circuit resistances that it may be neglected—a condition easily realizable in practice—Kirchhoff's voltage law can be applied to yield the following equation

$$e_1 = i_1 R_f + i_1 R_i + A e_1 \qquad (4)$$

which can be rearranged to yield

$$Z_1 = \frac{e_1}{i_1} = -\frac{R_f}{A-1} - \frac{R_i}{A-1} \qquad (5)$$

where Z_1 is simply the effective input impedance of the circuit.

This effect is the basis for the increased selectivity of the ordinary regenerative amplifier or detector. Such a regenerative circuit, however, lacks the important characteristic of stability. Referring to Eq. 3 it is seen that appreciable multiplication of the Q is to be had only when R_n is very nearly equal to R.

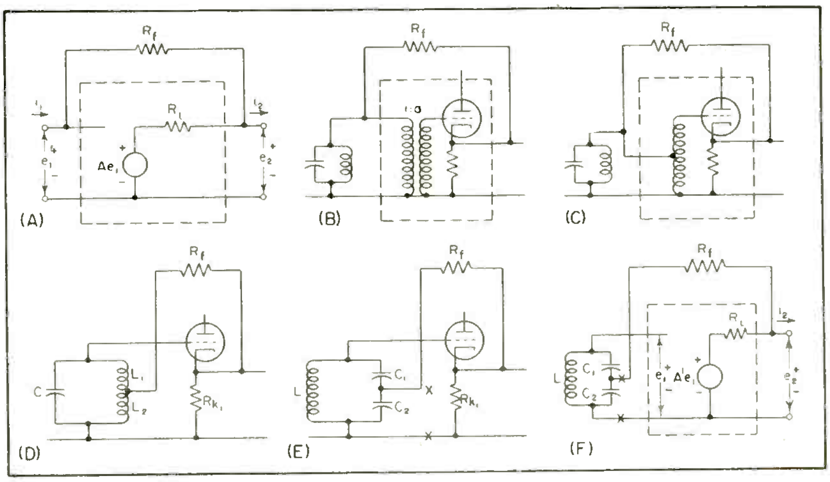

FIG. 1—Simplified circuits showing evolution of single-tube Q multiplier

The author is now with Magnetic Device Section, Control Divisions, General Electric Co., Schenectady, New York. Work described was done at MIT Research Laboratory of Electronics under U. S. Navy Bureau of Ordnance contract Nord-9661.

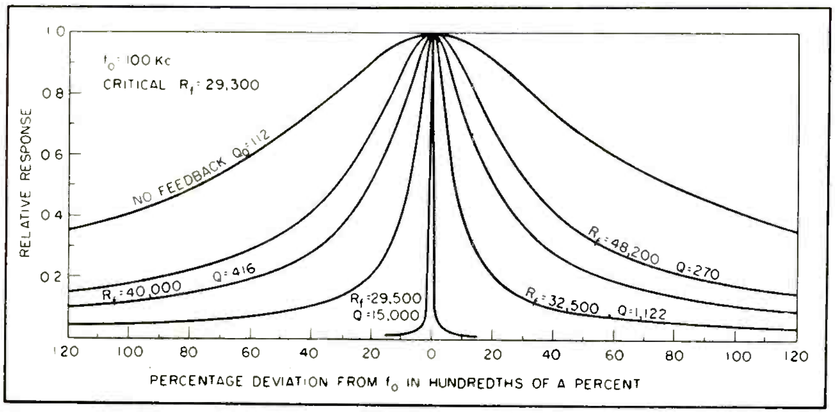

FIG. 2—Curves show selectivity obtainable with Q multiplier. Higher Q values were not tested because of measurement equipment limitations

Therefore it takes only a very slight percentage change in R_n, such as would be caused by variations in plate supply voltage, to cause the two resistances to become equal, the Q and impedance level to go to infinity, and oscillations to ensue.

One way to resolve this difficulty is to use a highly stabilized amplifier for the active element so that changes in electrode voltages and other random variations will have little effect upon the gain, and hence upon the negative resistance which is produced. Both Terman[3] and later Ginzton[4] have considered in some detail one such circuit utilizing a highly stabilized two-stage amplifier. It is the purpose of the present paper to describe a much simpler circuit which achieves essentially the same results with only a single stage. The basis of this circuit is the cathode follower. It has power gain, correct phase relation, and it has very high stability. But, it has less than unity gain. Fig. 1B shows that this drawback can be eliminated by a passive gain element, a transformer. The evolution from this circuit to the practical ones is shown in Fig. 1.

Stability Considerations

The most serious factor limiting the applicability of any positive feedback circuit is the stability. Ginzton[4] described a two-tube circuit; a more general derivation follows:

Consider the circuit shown in Fig. 1F in schematic form. Note that in the special case where $C_1 = \infty$ and $A' > 1$, this circuit reduces to the type of system considered by Gizton, while when $C_1 \neq \infty$, $A' < 1$, it represents the new circuit of Fig. 1E.

The gain of any feedback amplifier can be represented by the equation

$$A' = \frac{K}{1 - \beta K} \qquad (6)$$

In the present case, the gain of primary interest is not that of the tube itself, but rather that from points X-X (Fig. 1F) to the tube grid and through to the output at the cathode. This gain is the product of the active gain A' and what might be called the passive gain a, or gain contributed by the tapped tuned circuit

$$A = \frac{aK}{1 - \beta K} \qquad (7)$$

where

$$a = \frac{C_2 + C_1}{C_1} \qquad (8)$$

At this point the assumption is made that the output impedance of the amplifier is negligible with respect to the feedback resistor R_f. This is reasonable for an amplifier stabilized with a high degree of negative feedback. Equation 5 for the negative resistance developed across terminals X-X then reduces to

$$-R_n = -\frac{R_f}{A - 1} \qquad (9)$$

or, substituting from Eq. 7 for the actual gain of the circuit

$$-R_n = -\frac{R_f\,(1 - \beta K)}{a\,K - 1 + \beta\,K} \qquad (10)$$

Passing over the details of the derivation, it may be said that this equation is now differentiated partially with respect to the no-feedback gain K, simplified, and rearranged to yield an equation relating the fractional change in the negative resistance produced to the fractional change in the no-feedback gain. That is, an equation of the form

$$\frac{\delta R_n}{R_n} = \frac{1}{k}\;\frac{\delta K}{K} \qquad (11)$$

where the factor k might be called the stability coefficient of the system. In this case the stability coefficient is

$$k = \frac{(1 - \beta K)\,[(a + \beta)\,K - 1]}{a\,K} \qquad (12)$$

It is apparent that one would like to make the magnitude of this stability coefficient as large as possible. The maximum possible value is found by differentiating again with respect to a convenient parameter —in this case β—and setting the derivative equal to zero. The optimum value of β turns out to be

$$\beta_{opt} = -\left[\frac{a}{2} - \frac{1}{K}\right] \qquad (13)$$

The corresponding value of the stability coefficient is

$$k_{opt} = -\frac{a\,K}{4} \qquad (14)$$

It is now a simple matter to determine the optimum operating conditions for the circuit

$$\beta_{opt} = -1 \qquad (15)$$

$$k_{opt} = -K/2 \qquad (16)$$

The stability of the negative resistance is merely incidental to the matter of prime concern—the stability of the effective Q. The above results can be related to the Q stability by beginning with Eq. 3 and employing much the same process of differentiating (this time with respect to R_n) and simplifying as in Eq. 10. The result is

$$\frac{\delta Q_{eff}}{Q_{eff}} = -\left[\frac{Q_{eff}}{Q_0} - 1\right]\frac{\delta R_n}{R_n} \qquad (17)$$

Or, combining the two equations

$$\frac{\delta Q_{eff}}{Q_{eff}} = \left[\frac{Q_{eff}}{Q_0} - 1\right]\frac{2}{K}\;\frac{\delta K}{K} \qquad (18)$$

A number of interesting facts are apparent from this expression: (1) The stability is independent of the absolute value of initial Q. It is then just as easy to multiply Q from 100 to 1,000 as from 10 to 100. Thus it is important to begin with as high a Q as possible to gain maximum stability. (2) The stability is independent of the frequency, so that the circuit can be used to multiply Q anywhere in the spectrum where the stated assumptions can be met. (3) The higher the Q multiplication, the lower is the stability. For high multiplications this is approximately an inverse relation. (4) The stability increases in direct proportion to the no-feedback gain.

Another Stability Criterion

It seems logical to set up as an important design criterion of a narrow-band amplifier circuit, the amount of change in the no-feedback gain—that is, the change in the g_m with electrode voltage changes, aging, and other possible circuit variations—which can be tolerated without causing the system to break into oscillation.

As a starting point, consider again Eq. 3 for the Q multiplication, and solve this equation for R_n

$$R_n = R\,\frac{\dfrac{Q_{eff}}{Q_0}}{\dfrac{Q_{eff}}{Q_0} - 1} \qquad (19)$$

From Eq. 3 it is apparent that the point at which oscillations begin will be that point where R_n becomes equal to R. Therefore if R is subtracted from the above expression for R_n, the result will be the absolute value of the change in R_n which can be tolerated without causing oscillations. This can then be divided by R_n, to yield the fractional change in R_n which can be tolerated

$$\left(\frac{\Delta R_n}{R_n}\right)_{\text{tolerable}} = \frac{\dfrac{R}{\dfrac{Q_{eff}}{Q_0} - 1}}{R_n} \qquad (20)$$

or, making use of Eq. 19 again

$$\left(\frac{\Delta R_n}{R_n}\right)_{\text{tolerable}} = \frac{Q_0}{Q_{eff}} \qquad (21)$$

But here again the negative resistance is merely a derived characteristic of the circuit. What is really wanted is the permissible change in the no-feedback gain K. It is apparent from the optimum operating conditions which were derived, and from Eq. 10 that the negative resistance can be represented as

$$R_n = R_f\left(\frac{K+1}{K-1}\right) \qquad (22)$$

Then if R_{n1} represents the value of the negative resistance at some particular chosen operating point of the circuit and R_{nc} the critical value of negative resistance at which oscillations occur, Eq. 21 above can be rewritten

$$\left(\frac{\Delta R_n}{R_n}\right)_{\text{tolerable}} = \frac{R_{n1} - R_{nc}}{R_{n1}} = \frac{Q_0}{Q_{eff}} \qquad (23)$$

Substituting from Eq. 22 and simplifying, this becomes

$$\frac{R_{n1} - R_{nc}}{R_{n1}} = \frac{2\,(K_c - K_1)}{K_1 K_c - K_1 + K_c - 1} \qquad (24)$$

where K_1 is the no-feedback gain at the particular operating point chosen above, and K_c is the no-feedback gain at the critical point.

Now let $K_c = K_1 + \Delta K$. Then

$$\frac{R_{n1} - R_{nc}}{R_{n1}} = \frac{2\,\Delta K}{K_1^2 + K_1\,\Delta K + \Delta K - 1} \qquad (25)$$

which, by Eq. 21 is equal to $\dfrac{Q_0}{Q_{eff}}$. Equating and solving for ΔK gives:

$$\Delta K = \frac{K_1^2 - 1}{\dfrac{2\,Q_{eff}}{Q_0} - (K_1 + 1)} \qquad (26)$$

If this equation is now divided by K_1 the result is the fractional change in no-feedback gain K ($= g_m R_k$) which can be tolerated without oscillations

$$\left(\frac{\Delta K}{K}\right)_{tol} = \frac{1 - \dfrac{1}{K^2}}{\dfrac{1}{K}\left(2\,\dfrac{Q_{eff}}{Q_0} - 1\right) - 1} \qquad (27)$$

In practice, K is almost always kept much larger than 1, and the Q multiplication much larger than a half, so that a somewhat simpler working formula may be obtained:

$$\left(\frac{\Delta K}{K}\right)_{tol} \approx \frac{1}{\dfrac{\dfrac{Q_{eff}}{Q_0}}{\dfrac{K}{2}} - 1} \qquad (28)$$

This is a most interesting expression. For suppose that at some particular operating point a

$$\left.\frac{Q_{eff}}{Q_0}\right|_a = \left.\frac{K}{2}\right|_a \qquad (29)$$

The above equation then goes to infinity, signifying an infinite change in K necessary to cause oscillation. Further, suppose that

$$\left.\frac{Q_{eff}}{Q_0}\right|_a < \left.\frac{K}{2}\right|_a \qquad (30)$$

Then the fractional change in K necessary to cause oscillations is a negative number greater than 1. But this would require a negative gain, which, of course, is impossible in a vacuum-tube amplifier. It can be concluded, therefore, that if at any operating point, the condition

$$\left.\frac{Q_{eff}}{Q_0}\right|_a \lesseqgtr \left.\frac{K}{2}\right|_a \qquad (31)$$

is met, or, in other words if the circuit constants are adjusted so that the no-feedback gain K ($= g_m R_k$) is always greater than twice the degree of Q multiplication which is desired, there will be no chance of the circuit breaking into oscillation no matter how much the g_m of the tube may change with aging, changes in electrode voltages, shock and so on.

Here, then, is the fundamental contribution of this new circuit. Without any substantial increase in the complexity over the ordinary regenerative system, it has made possible attainment of arbitrarily high Q multiplications, while at the same time retaining the absolute stability of the ordinary amplifier.

Practical Circuit

It is not possible to set down any hard and fast rule as to the magnitude of the $g_m R_k$ product which may be obtained. Experience has shown, however, that with a 6AK5 and a supply voltage of 200 volts, values of about 100 are easily attainable. With higher supply voltages, correspondingly higher values of the $g_m R_k$ product may be realized.

Now suppose that a relatively modest degree of Q multiplication—say 10—is all that is wanted. (This still will allow Q's of the order of 2,000 to 3,000 if a good coil is used). The above equations then become

$$\left(\begin{matrix}\%\text{ change in}\\ Q_{eff}\end{matrix}\right) = \frac{1}{5.5}\left(\begin{matrix}\%\text{ change in}\\ g_m\end{matrix}\right) \qquad (32)$$

Oscillation impossible

In other words, the percentage change in the Q is only approximately a sixth of the percentage change in the g_m which caused it, and it will be impossible to cause the circuit to oscillate no matter how much the g_m may change with shifts in plate voltage and other circuit parameters.

Even for the relatively high Q multiplication of 100, which would

(Continued on p 134)


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(Continued from page 132)

correspond to possible Q's of the order of 30,000, stability is excellent.

$$(\% \text{ change in } Q_{eff}) = 2\,(\% \text{ change in } g_m) \quad (33)$$

$$100\% \text{ change in } g_m \text{ to cause oscillation}$$

This is still well within the practical range of operation, if a power supply of any reasonable regulation is used.

Experimental Results

The curves of Fig. 2 show the results obtainable from a typical circuit of this new type. These curves were taken by applying a variable-frequency, constant-voltage signal to the Q multiplier circuit through an isolating stage and measuring the output voltage as a function of the frequency. The no-feedback curve is a plot of output voltage versus frequency when the feedback circuit was opened, or when $R_f = \infty$ and the circuit was operating as an ordinary cathode follower. The other curves show the effect of reducing the feedback resistor closer and closer to the critical value of 29,300 ohms. The maximum Q value of 15,000 shown was by no means the limit obtainable with the circuit. There was simply no measuring equipment available precise enough to allow a reliable set of data to be taken for higher Q's.

Theory indicates that the shape of the response curve should be unaltered by the Q multiplication. This was checked by plotting data taken for several values of multiplication on the same graph as the universal resonance curve. In every case the results were identical. This means that these circuits may profitably be cascaded or staggered, using the identical means of calculation as for ordinary resonant circuits.

Experiments have verified the two stability relations. In both cases, the stability turned out to be slightly higher than predicted.

Practical Suggestions

For the convenience of the designer, it might be well here to summarize a few practical hints which have been discovered in the course of working with this circuit. First of all, for reference, the actual circuit used for the preceding experimental measurements is reproduced in Fig. 3A.

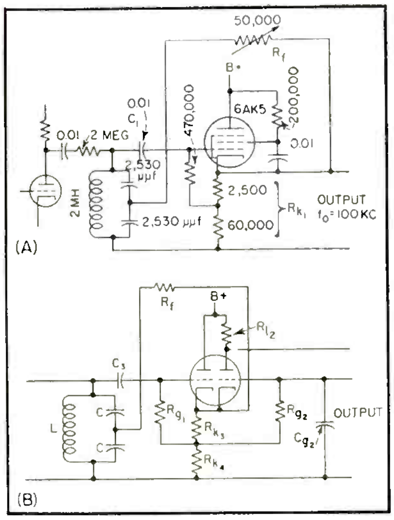

FIG. 3—Practical circuits of single-tube Q multiplier. In *B* the first triode section serves as the Q multiplier and the second as a grounded-grid amplifier

The exact critical value of the resistance R_f is easily found from Eq. 3. Remembering that the negative resistance is developed across only half of the tuned circuit in this system, Eq. 3 actually becomes:

$$\frac{Q_{eff}}{Q_0} = \frac{R_n}{R_n - R/4} \quad (34)$$

But R_n is given by Eq. 22. Substituting and regrouping gives

$$\frac{Q_{eff}}{Q_0} = \frac{1}{1 - \dfrac{R/4}{R_f}\,\dfrac{(K-1)}{(K+1)}} \quad (35)$$

from which it is apparent that the critical resistance is

$$R_f = \frac{R}{4}\;\frac{(K-1)}{(K+1)} \quad (36)$$

For design purposes this value can be taken simply as one-fourth of the tuned circuit impedance. If the circuit is operating properly, oscillations will ensue for all values of R_f less than this value. For $R_f = \infty$ the circuit operates as a cathode follower, and as R_f decreases toward the critical value, the Q multiplication increases without limit.

The actual R_k to be used in computing the $g_m R_k$ product is the cathode resistor R_{k1} in parallel with the series combination of R_f and one-fourth of the impedance of the tuned circuit—that is, approximately the cathode resistor in parallel with one-half the tuned circuit impedance in the multiplier.

The grid biasing connection shown in Fig. 3A is used for the purpose of increasing the $g_m R_k$ product, and hence the stability. Using this arrangement, a large cathode resistor can be used without increasing the grid bias excessively and thus reducing g_m.

Somewhat higher stabilities are obtained by using pentode as in Fig. 3A, instead of the triode discussed previously. The screen should be by-passed to the cathode. Otherwise the tube will operate as a triode. If only moderate multiplications are needed, however, the double triode circuit shown in Fig. 3B may be found useful. Here the first section is used as a Q multiplier, and the second as a grounded-grid amplifier.

The source impedance should be kept high, either by the use of a series resistor as in Fig. 3A, or by designing the preceding stage for a high output impedance. If high Q multiplications are sought, the series resistor is preferable, in conjunction with a low output impedance for the previous stage.

The phase shift must be kept to a minimum to avoid frequency shift as the Q multiplication is changed.

When the split inductor variation of Fig. 1D is used, the cathode resistor R_{k1} may be omitted. This allows about a 2-to-1 increase in stability.

The signal input should be kept relatively low for best results. Experience with the type 6AK5 has shown that inputs much more than a volt or two result in reduced effective Q multiplication due to curvature of the tube characteristic.

It is possible to raise the Q of a coil alone by use of the circuit in Fig. 1D with the capacitor omitted. Use in such a manner suggests a number of additional applications for the circuit.

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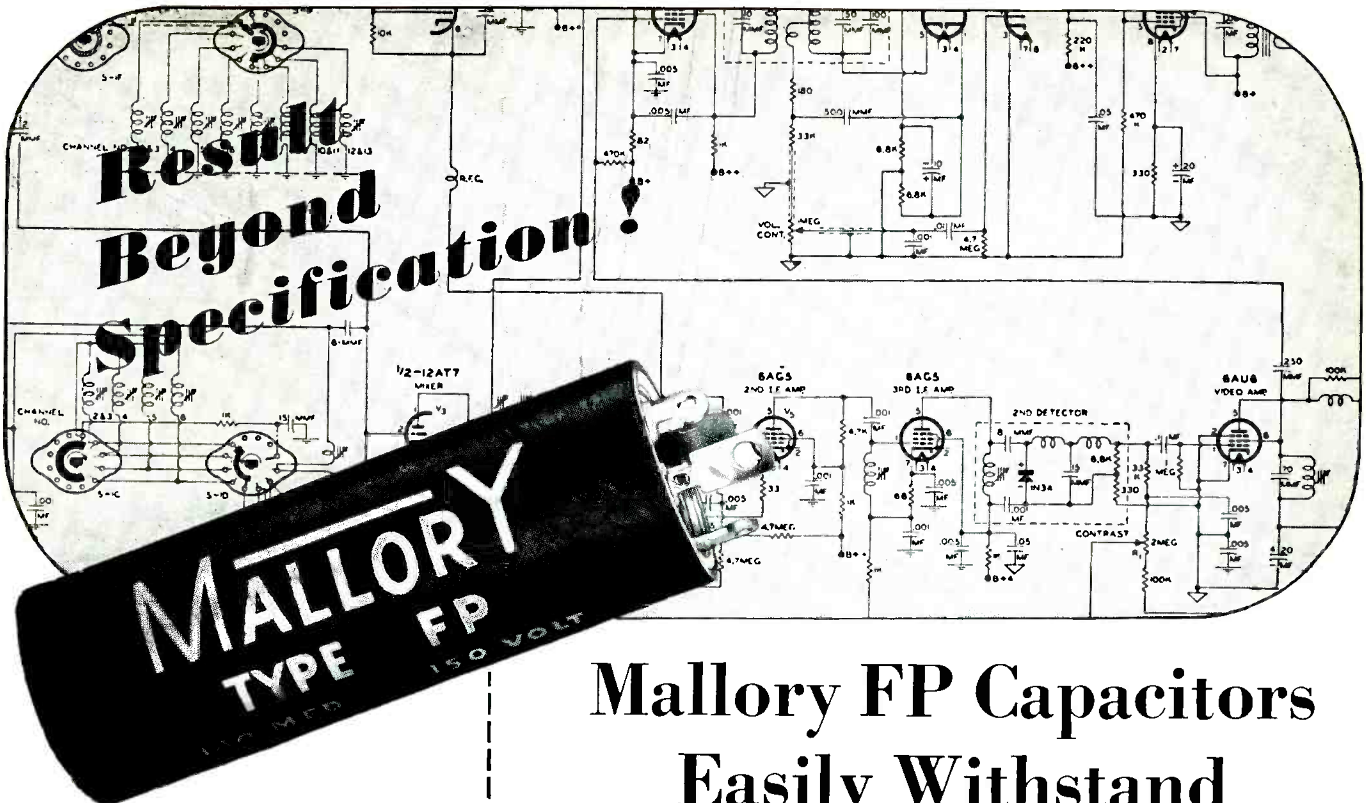

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TUBES AT WORK

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Synchronized Electronic Switch 136
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Synchronized Electronic Switch

BY JOSEPH F. DUNDOVIC
Aeronautical Division
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Physical Research Department
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St. Paul, Minn.

THE electronic switch is a convenient device for allowing the simultaneous viewing of two waveforms or signal inputs on one oscilloscope face. Relative phase, frequency, and amplitude comparisons may be quickly made.

Basically, an electronic switch consists of two input tubes whose plates are connected to a common load resistance. A square-wave switching voltage is applied alternately to a control grid of the tubes. On alternate half cycles of the square wave the input tubes are either biased to cutoff or allowed to function normally, one tube conducting while the other is cut off.

The switching voltage is usually obtained from an adjustable frequency, free-running multivibrator. The random switching rate sometimes results in switching transients appearing on the face of the oscilloscope tube, particularly at the higher sweep frequencies.

The synchronized electronic switch employs a square-wave generator the frequency of which is exactly one-half that of the sweep frequency of the oscilloscope. In this manner the waveforms of the two input signals appear on alternate traces of the beam across the face of the cathode ray tube. All switching occurs during the retrace and is not normally visible on oscilloscopes using retrace blanking. A connection is made to the horizontal amplifier of the oscilloscope to obtain the sweep frequency synchronizing voltage.

Figure 1 is a simplified block diagram of the synchronized switch. An Eccles-Jordan flip-flop circuit is used as the square-wave generator in place of the multivibrator. If triggering occurs once every cycle of the sweep frequency the output is a square wave of one-half the frequency of the sweep.

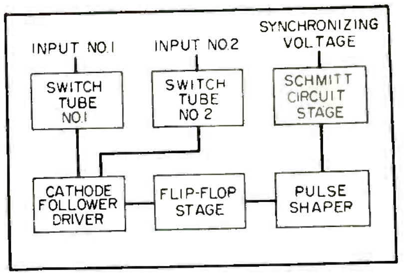

FIG. 1—Simplified block diagram of the synchronized electronic switch

Theoretically, the sawtooth waveform of the sweep voltage may be differentiated, amplified and used to trigger the flip-flop. The flip-flop circuit, however, requires a trigger pulse with a steep wavefront and the amplitude of the pulse must be maintained within rather narrow limits. The sweep flyback time is not independent of frequency, consequently at the lower sweep frequencies it is difficult to retain the proper trigger pulse characteristics.

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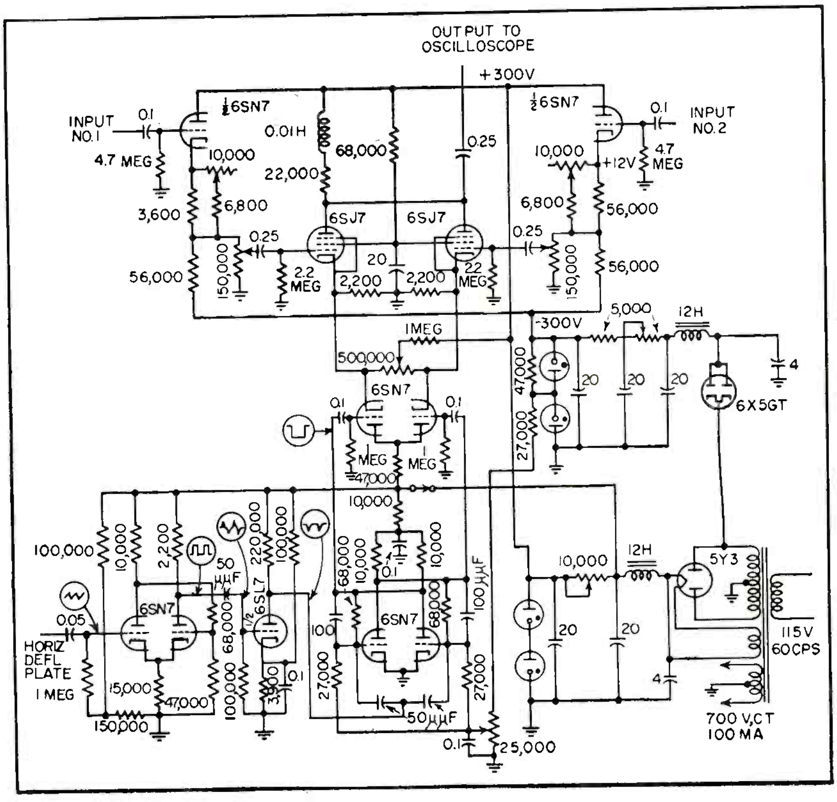
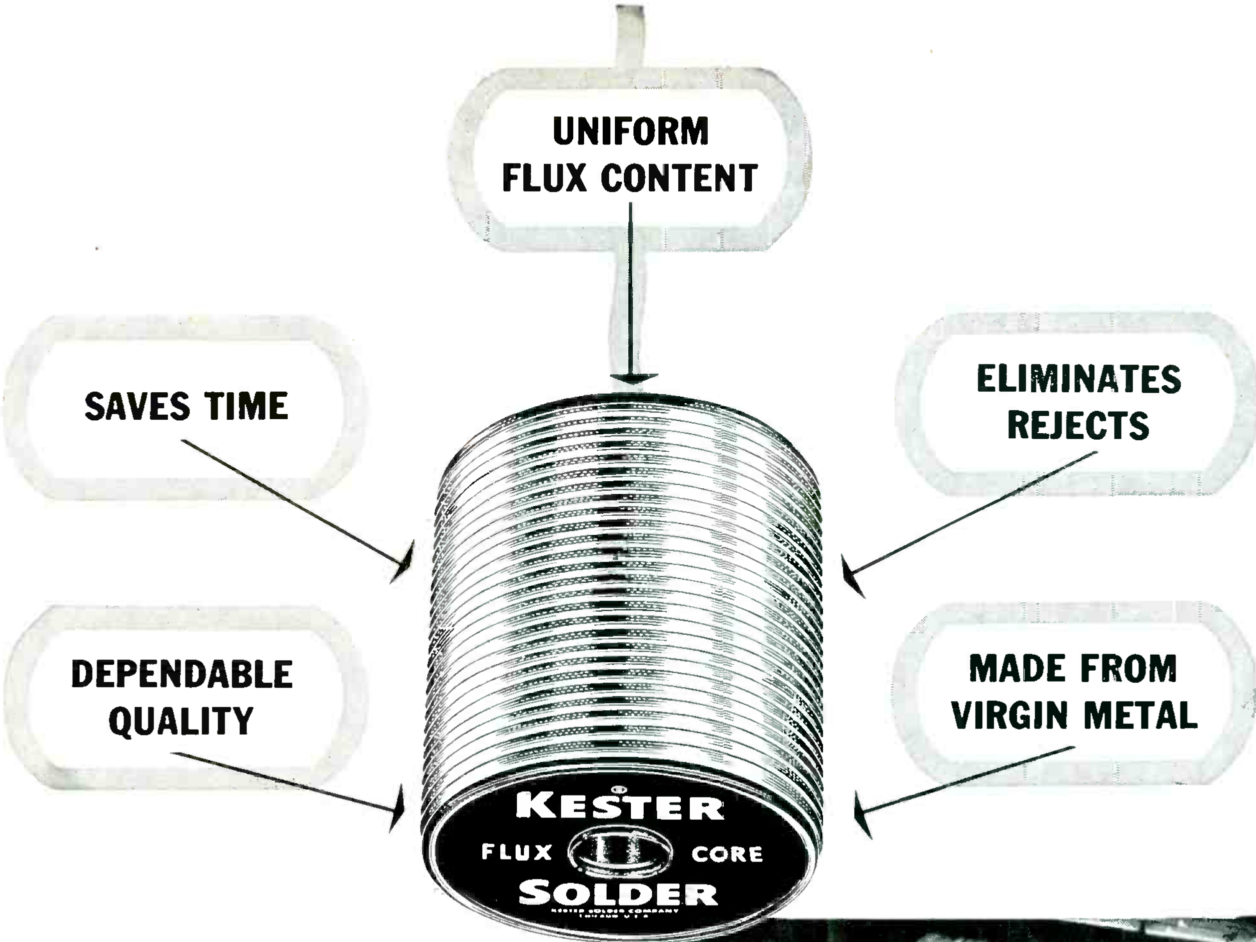


Schematic diagram of the synchronized electronic switch



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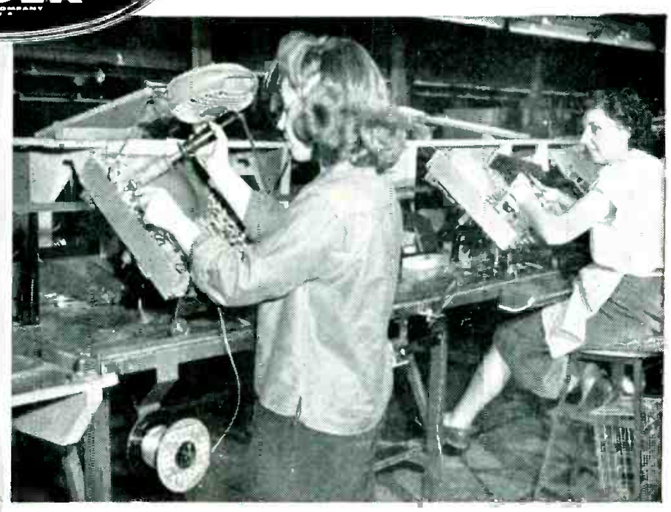

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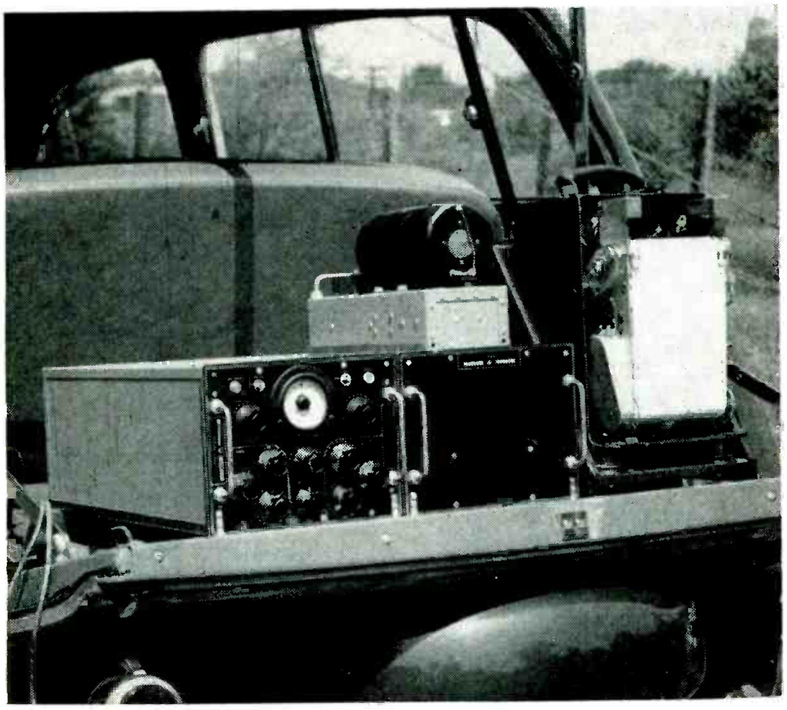

EDDY-CURRENT DISTURBANCE induced in the vertical stabilizer of a P2V aircraft is being measured at Airborne Instruments Laboratory with the experimental setup shown in the cover picture. The magnetically sensitive element mounted on the crosspiece of the gallows suspending the stabilizer is connected to the recording equipment located in the station wagon, as shown in the accompanying photograph. As the stabilizer is swung back and forth in a pendulum fashion, the resulting disturbances in the magnetic field at the instrument are recorded.

From the magnetic-field disturbance measurements, it is possible to determine the positions in the aircraft best suited for the magnetometer. The same measurements are used in the design of equipment for cancelling the remaining disturbing fields which exist at the chosen locations.

circuit[1] it is possible to obtain sharp trigger pulses of constant amplitude throughout the entire frequency range of the sweep oscillator. This circuit utilizes a pair of triodes direct-coupled in such a manner as to have two definite stable operation states depending upon the voltage on the input control grid. Transition between the two states of operation is extremely rapid, with the result that when an alternating voltage is applied to the control grid the output is a square wave. The square-wave voltage is of the same frequency as the input signal and its amplitude is constant for all values of input above approximately 8 volts rms.

Transition time of the Schmitt circuit is independent of the frequency of the input voltage so that when the output wave is differentiated by an R-C differentiating circuit the resulting pulses are constant in both sharpness and amplitude.

In the circuit diagram shown, the sawtooth sweep voltage is obtained from one of the horizontal deflection plates of the oscilloscope crt and is fed to the control grid of the 6SN7 Schmitt circuit stage. The square-wave output is differentiated by the 50-$\mu\mu$f coupling capacitor and 100,000-ohm grid resistor of the 6SL7 triode pulse amplifier.

The 6SL7 is biased beyond cutoff so that the negative grid pulses are most ineffective and only negative plate pulses are supplied to trigger the flip-flop circuit which follows.

The negative trigger pulses are applied simultaneously to both grids of the 6SN7 flip-flop circuit, triggering the circuit back and forth. The resulting output from the flip-flop is the required square wave of one-half the frequency of the sweep oscillator. This voltage is applied to the grids of the 6SN7 cathode-follower stage whose cathodes are tied to the cathodes of the two 6SJ7 switching tubes.

When a positive half cycle is on the grid of one cathode follower, the plate current flowing through the cathode resistor produces enough voltage drop across the resistor to bias the 6SJ7 to cutoff. At the same time the other cathode follower is cut off by the negative grid voltage since the grids are 180 degrees out of phase. One switch tube is cut off while the other is functioning to pass its input signal during one sweep of the beam across the face of the cathode ray tube. During the next sweep the situation is reversed and the other signal input is passed.

The 500,000-ohm potentiometer connected between the cathodes of the switching tubes is used to select the amount of separation desired between the two traces. When the slider is off center, one switch tube will be biased more strongly than the other. The average plate voltages on the switch tubes while they are conducting will be different and this difference will be carried on through the oscilloscope amplifier as a trace separation.

A 25,000-ohm potentiometer in the grid circuit of the flip-flop stage sets the negative bias level for the grids. It may be an internal adjustment since it is set initially for optimum operation and then left unchanged.

The electronic switch has an input impedance of 4.7 megohms at the grids of the 6SN7 cathode-follower input tube. Signal voltages

(Continued on p 156)

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Accurate Instantaneous Frequency Comparison

BY RAYMOND M. WILMOTTE
Raymond M. Wilmotte Inc.
Washington, D. C.

THE USUAL METHOD of finding when the varying frequency of a signal passes through a predetermined frequency, is by means of an oscillator at this latter frequency, obtaining the beats between the signal and the oscillator and noting when the beat frequency passes through zero. That process is in general simple and satisfactory except in the case when the frequency of the signal varies rapidly. When there is a very rapid change, the beat frequency may not remain long enough at a low value for a circuit to be able to recognize it as a low frequency. The key characteristic in such a case is not that the beat frequency is zero at a particular instant, but that it changes sign. Unfortunately most circuits are unable to detect the difference between a positive and a negative beat frequency.

This problem came up in connection with special work on certain f-m systems and was disclosed some time ago to the Patent Office.

A simple circuit to distinguish between positive and negative beat frequencies makes use of the theory of the operation of limiters. It is known that when two f-m signals of different but nearly equal amplitude are passed through a limiter, the resulting output contains short periods during which the rate of change of phase is very large. These phase changes can be translated into voltages by means of a discriminator circuit designed to have a sufficiently wide frequency characteristic to be able to respond adequately to these large rates of change of phase.

The expressions for the value of the maximum and minimum output of a discriminator caused by two signals are simple and well known. If the frequencies of the two signals A and B are f_A and f_B respectively,

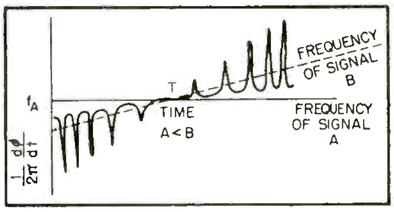


FIG. 1—Curve shows rate of change of phase of resultant as frequency B passes through frequency A

and the amplitude ratio of A to B is r then the maximum and minimum responses of the discriminator are respectively proportional to

$$f_A + q\left(\frac{r}{1+r}\right) \qquad (1)$$

and

$$f_A - q\left(\frac{r}{1-r}\right) \qquad (2)$$

where

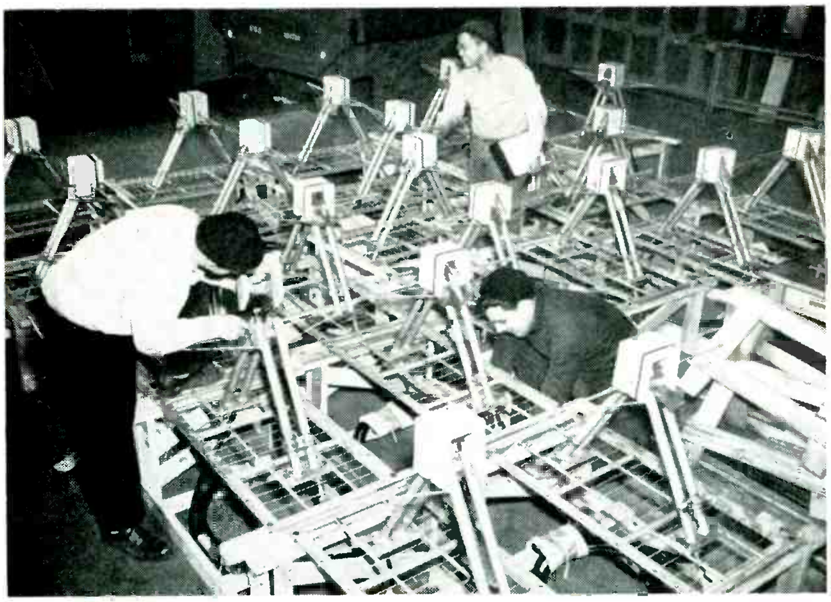
$$q = f_A - f_B \text{ and } r > 1$$

It is to be noted that when q is positive f_A is less than expression 1 and greater than expression 2, while when q is negative the reverse is true. It is also to be noted that in either case when r is nearly equal to unity, the maximum given by expression 2 differs very much more from the mean value f_A than the maximum given by expression 1.

The application of these results to the simple case of signal A of steady frequency and another signal B of frequency varying linearly is

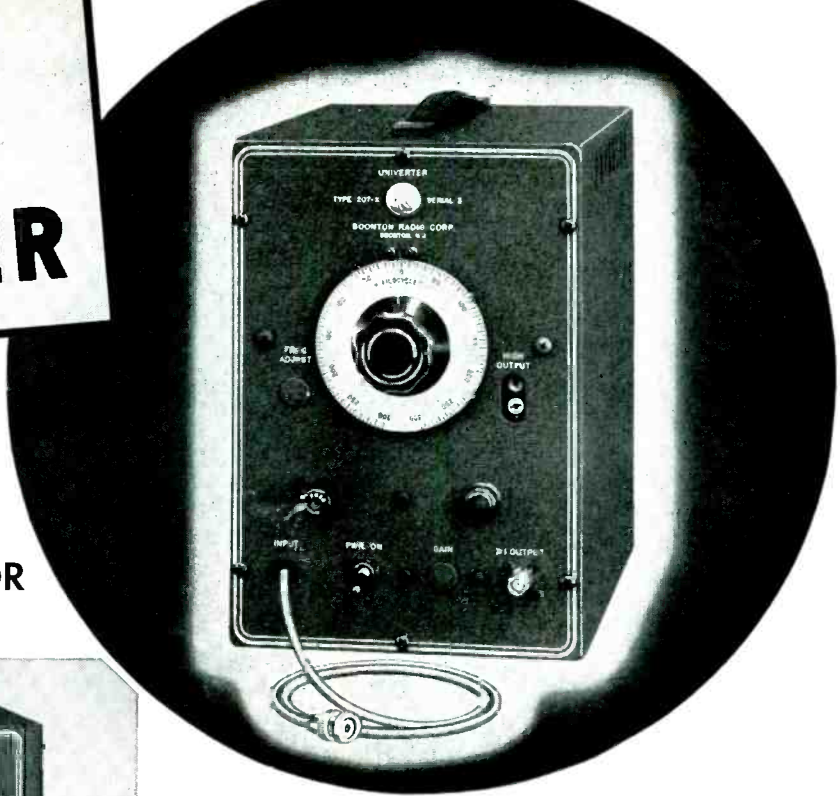
(continued on page 186)

WPIX ANTENNA READY FOR INSTALLATION



WPIX channel-11 super-gain antenna undergoes final crating for shipment from RCA Camden, N. J., plant for installation on Empire State tv totem pole in New York City. Operation from the new location is expected to begin August 1, 1951

Announcing a *NEW* UNIVERTER



Continuous Coverage 0.1 to 216 mc.

Accessory for the

FM-AM SIGNAL GENERATOR

TYPE 202-B

FM-AM SIGNAL GENERATOR

TYPE 202-B

This instrument has become the standard signal source for the FM and Television Industry.

The Type 207-A Univerter described at the right was developed to extend its useful frequency range down to 100 kc. without changing the signal level or modulation characteristics shown below.

SPECIFICATIONS:

RF RANGES: 54-108, 108-216 mc.
FREQUENCY DEVIATION: 0-24 kc., 0-80 kc., 0-240 kc.
FM DISTORTION: Less than 2% at 75 kc. deviation
AMPLITUDE MODULATION: Continuously variable 0-50%.
RF OUTPUT VOLTAGE: 0.1 microvolt to 0.2 volt.

UNIVERTER

TYPE 207-A

The Type 207-A Univerter fills the widespread need for an FM-AM source in the frequency range of from 0.1 to 55 mc. This instrument is a unity gain frequency converter which subtracts 150 mc. from a signal derived from the Type 202-B FM-AM Signal Generator to produce an output of from 100 kc. to 55 mc. This is accomplished without change of signal level or of modulation and with negligible spurious frequencies. Thus the Type 207-A Univerter when used with the Type 202-B Signal Generator shown at the left will provide complete FM-AM Signal Generator coverage from 100 kc. to 216 mc.

In addition to the unity gain output, the Type 207-A Univerter provides a high level output of about 7.5 times the input thus making about 1.5 volts available for high level tests

In order to facilitate band-width measurements, the Univerter is provided with an incremental frequency dial which is calibrated in 5 kc. increments over a range of ± 300 kc. This permits selectivity curves to be taken on even the most selective mobile receivers.

The power supply is well regulated to prevent change of gain or output frequency with line voltage variation from 95 to 130 volts.

Complete specifications, price, and delivery information will be furnished on request.

BOONTON RADIO *Corporation* BRC
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DESIGNERS AND MANUFACTURERS OF THE Q METER · QX CHECKER
FREQUENCY MODULATED SIGNAL GENERATOR · BEAT FREQUENCY
GENERATOR AND OTHER DIRECT READING INSTRUMENTS

NEW PRODUCTS

Edited by WILLIAM P. O'BRIEN

Civil Defense Receiver

GENERAL ELECTRIC CO., Syracuse, N. Y., has announced a new f-m receiver for civil defense applications wherever two-way radio systems exist—fire, police, taxi, electric service companies, key CD agencies and personnel. Messages can be broadcast to all groups at once or to separate groups individually, each receiver being inactive until turned on by headquarters. Type ER-18-A is for use in the 152 to 174-mc band; type ER-19-A, for the

30 to 50-mc band. Designed to operate on 117-volt a-c power, they are easily adaptable to 6-volt d-c operation by use of a low power inverter and a storage battery. Called the Civil Defender, it can be used to automatically start and stop air raid sirens and other warning devices upon reception of a special tone from headquarters.

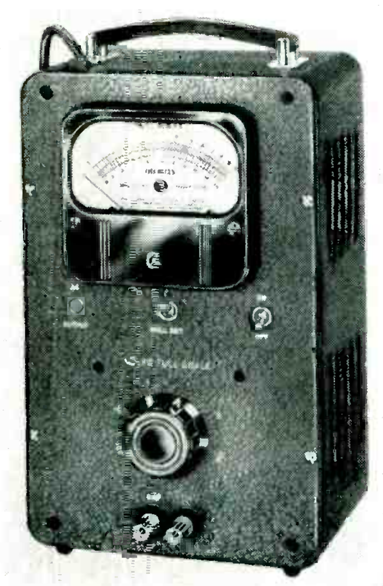
Miniature Relays

STRUTHERS-DUNN, INC., 150 N. 13th St., Philadelphia 7, Pa. A complete line of miniature d-c relays in 2, 3, 4 and 6-pole units with double-throw contacts has been developed for jet-propelled aircraft and guided missile uses. Designed to meet USAF Specification MIL-R-5757, the relays are supplied in type A style for operation at ambient temperatures up to 200 C, and type B for use where ambient temperature is limited to 85 C. They are available in hermetically sealed

metal containers $1\frac{1}{4}$ in. in diameter, $1\frac{1}{2}$ in. long and weighing only 3 ounces. Palladium contacts are nominally rated at 28 v d-c noninductive on permanent installations. For guided missile applications the contact rating may be increased to 12 amperes noninductive if the required number of relay operations does not exceed 50 to 100. Time of operation is less than 0.005 sec.

Electronic Voltmeter

BALLANTINE LABORATORIES, INC., Boonton, N. J. Model 310A electronic voltmeter measures 100 μv to 100 volts on a single logarithmic voltage scale by means of a six-decade range switch. Its accuracy at any point on the scale is 3 percent from 10 cycles up to 1 mc and 5 percent up to 2 mc. Input imped-



ance is 2 megohms shunted by 8 $\mu\mu$f on the two most sensitive ranges, and by 15 $\mu\mu$f on the other ranges. The amplifier section of the voltmeter may be used separately as amplifier flat within $\frac{1}{2}$ db up to 2 mc with a maximum gain of 60 db and an output impedance of 500 ohms.

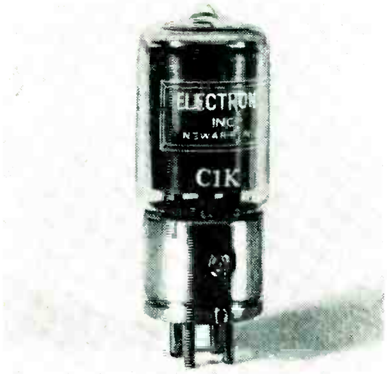
Adjustable Sealed Relay

G-V CONTROLS INC., 28 Hollywood Plaza, East Orange, N. J., has produced an hermetically sealed thermal time-delay relay designed to permit the adjustment of the time interval by the user while the relay remains completely sealed. Adjustment is made simply by turning a

screw located outside the sealed space. This screw permits the timing to be changed over a 5 to 1 range. The miniature size, $\frac{3}{4}$ in. in diameter and $2\frac{3}{8}$ in. seated height, fits a 7-pin miniature tube socket. Contacts are single pole, rated at 6 amperes. Relays are available for any energizing voltage up to 125 and operate interchangeably on a-c and d-c.

Gas-Filled Rectifier Tube

ELECTRONS, INC., 127 Sussex Ave., Newark 4, N. J. Type C1K xenon gas-filled grid-controlled rectifier tube has all electrode connections brought out to the metal-base pins. It may be used in such applications as precise motor control, high-speed or synchronous switching, servo amplifiers, temperature controls and regulated d-c power supplies. Average anode current is 1 ampere d-c;



peak anode current, 8 amperes; maximum peak inverse voltage, 1,250 v; maximum peak forward voltage, 1,000 v. Grid shielding results in a grid-anode capacitance of only 1 $\mu\mu$f with a grid-cathode capacitance of 10 $\mu\mu$f. Critical grid current is less than 5 μa.

Crystal Microphone

TURNER Co., 900 17th St. N.E., Cedar Rapids, Iowa. The Competitor, model 60X crystal microphone for hand, desk or stand use, is designed for amateurs and for economical public address and sound systems. Response is 70 to 7,000 cps. Level is 52 db below 1 volt per dyne per sq cm. It features a

moisture-sealed crystal. List price of the microphone complete with 6-ft cable and stand adaptor is $10.85.

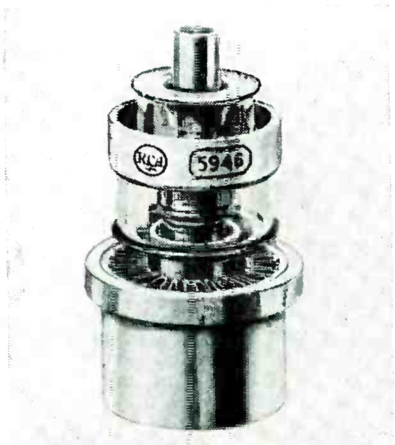
Video Amplifier

RIPLEY Co., INC., Middletown, Conn., has announced a video amplifier designed for complex wave form inspection in connection with an oscilloscope. Having a gain of 1,000, the frequency response is flat from 15 cps to 4 mc within 1.5 db of the 10-kc response point. A cathode-follower input stage is used for circuit isolation and includes an input attenuator providing 1 to 1, 1 to 10 and 1 to 100 attenuation ratios as indicated by a control knob on the front panel. Input impedance without probe is approximately 2.2 megohms and 40 $\mu\mu$f on all attenuator ranges. A gain control is provided for adjusting the output from 0 to 50 volts rms. Phase shift is minimized to provide

satisfactory reproduction of pulses on the order of one μsec and square waves at repetition rates as low as 100 per second.

Power Triode

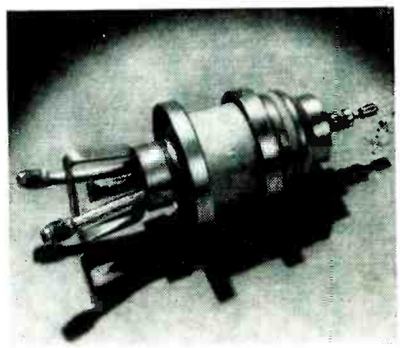
RADIO CORP. OF AMERICA, Harrison, N. J., recently announced a compact, forced-air-cooled power triode designed for uhf plate-pulsed oscillator and amplifier service. In such service the type 5946 triode has a maximum rated plate dissipation of 250 watts, and can be operated with full plate voltage at frequencies up to 1,300 mc. Featured in the design is a coaxial-electrode structure for use with circuits of



the coaxial-cylinder type. The design provides low-inductance, large-area, r-f electrode terminals for insertion into the cylinders and permits effective isolation of the plate from the cathode. The latter feature makes the tube particularly suitable for grounded-grid circuits.

Ceramic Transmitting Tube

GENERAL ELECTRIC Co., Syracuse, N. Y. Type GL-6019 all-ceramic tube was designed primarily for uhf tv transmitter service. This power tetrode is capable of operating up to and beyond 890 mc at 1-kw output. Maximum ratings at synchronizing level for class-B tv service include: d-c plate voltage,



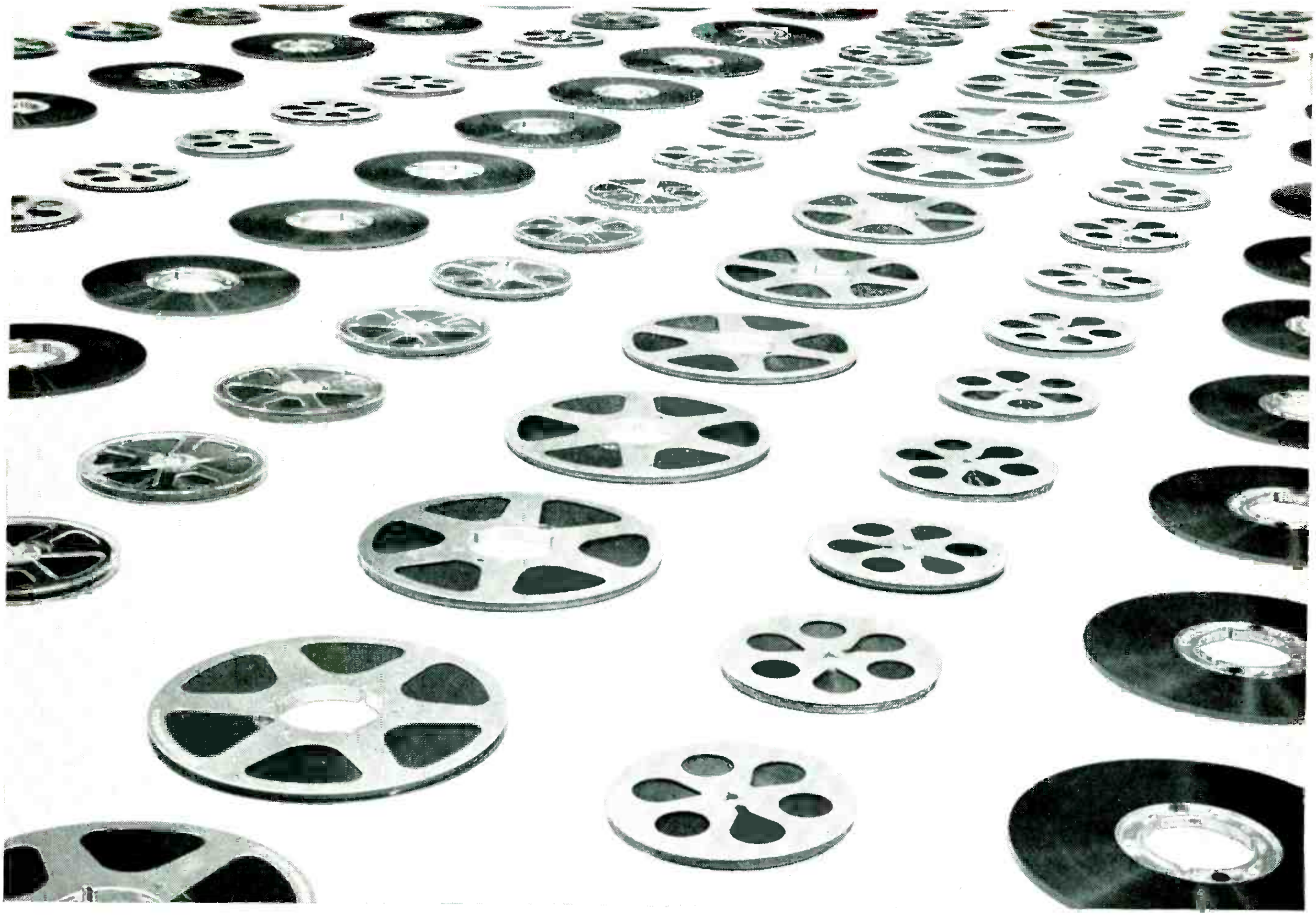
4,000 v; d-c screen voltage, 600 v; d-c plate current, 700 ma; plate input, 2.5 kw; plate dissipation, 2 kw.

Calibrator

RUTHERFORD ELECTRONICS Co., 3724½ So. Robertson Blvd., Culver City, Calif. Model D1 calibrator is a device for the accurate generation of pulse trains, having 16 different pulse rates available at the output connections. Coincidence circuits are employed to render negligible the phase lags between the various outputs. Particularly valuable for the calibration of synchroscopes, it may also be used as a secondary frequency standard, as a master timing oscillator for pulse equipment, for the generation of timing signals for oscillographic recording, and the detection of jitter in delayed signals. Simultaneous outputs having the following pulse

(Continued on page 220)

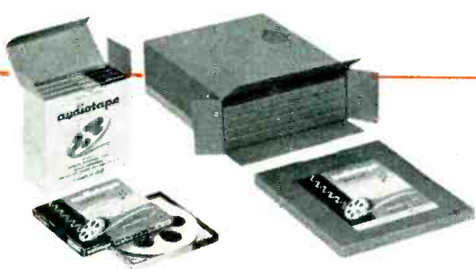
CONSISTENT UNIFORM QUALITY



. . . reel after reel after reel!

That's just one of the EXTRA VALUES that you get in **audiotape***

made by audio engineers, for audio engineers



NOW—output curves in every package!

Here's output uniformity that you can *see* for yourself. For every 5-reel package of plastic base Audiotape, in 1250 and 2500 ft sizes, now contains an Esterline-Angus output curve made from one of the reels in that package. And since all five reels are slit from the same roll after coating, it shows you the actual output characteristics of every reel—giving positive visual proof of unequalled uniformity.

● Yes—when you reach for a reel of Audiotape, you can be *sure* that you will have the finest recording that your equipment can produce. You *know* that the output volume will not vary more than ± ¼ db within every 1250 ft or 2500 ft reel of plastic base Audiotape. That is *guaranteed*. You *know* that these reels are entirely free from splices. That is guaranteed also. But, still more important, you know that you can depend on Audiotape for unequalled over-all performance—with maximum fidelity of reproduction and minimum surface noise and distortion.

In short, Audiotape *always* gives you the same consistent, uniform quality that has characterized Audiodiscs for more than a decade.

Have you heard about our new disc *recoating service?* We are now prepared to recoat your used discs for you—at a substantial saving over the cost of new discs. Your Audiodisc distributor will be glad to give you complete details.

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NEWS OF THE INDUSTRY

Edited by WILLIAM P. O'BRIEN

Engineering Positions Available

POSITIONS in the electric and electronic engineering fields are available with Headquarters of the Air Transport Service (MATS), Washington, D. C.

Men and women who meet the educational and practical experience requirements may apply for positions in one of these government service jobs with starting salaries from $5,400 to $6,400. Employees accepted will have the opportunity to be placed on permanent status.

Interested applicants may write to the Civilian Personnel Officer, Andrews AFB, Washington 25, D. C., for further information.

MATS is the integrated Air Force-Navy command utilizing personnel and equipment of both services in strategic air support of the U. S. Air Force. At present it is assisting United Nations forces in the Far East with an around-the-clock airlift of critical cargoes and high-priority personnel. On return trips, MATS planes carry ill and wounded from the fighting front.

Rad Lab Series Completed

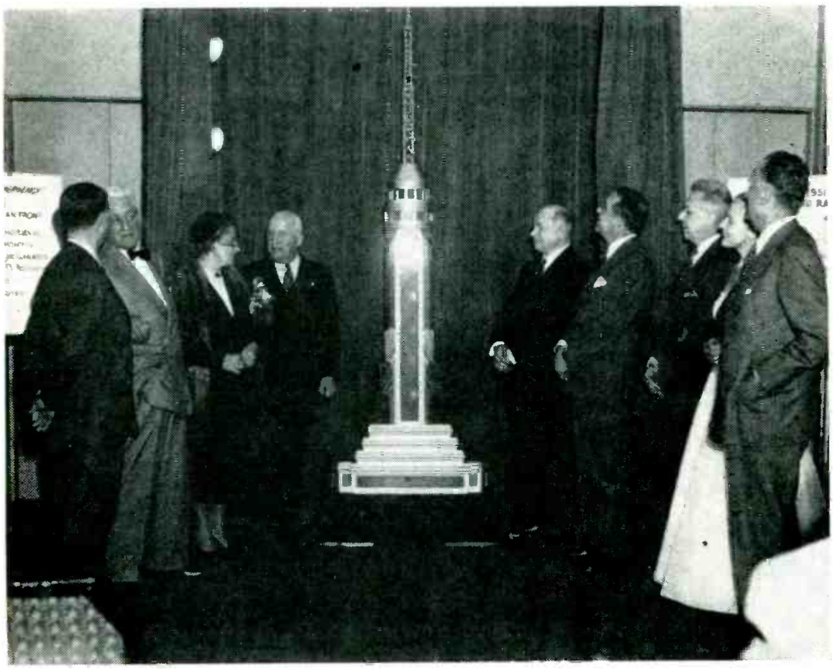
THE RADIATION Laboratory Series, a monumental technical series started in 1947 under the sponsorship of the wartime U. S. Office of Scientific Research and Development, was completed recently with the publication of the twenty-seventh and final volume in the series.

Published by the McGraw-Hill Book Company under contract with the Massachusetts Institute of Technology, this series contains in report form the vast results of five years of intensive work on radar done at the Radiation Laboratory of the Massachusetts Institute of Technology during World War II. The twenty-seven volumes total more than 16,000 pages. Over 150,000 copies of the published volumes have been sold to date.

This was the first time in history that a commercial firm had been allowed to produce an official technical publication of such large scale. The Government had a net saving of approximately $260,000 on the production of the volumes as official technical reports. In addition, the publisher has paid over $80,000 into the U. S. Treasury as royalty on sales here and abroad. Thus, the benefit to taxpayers already totals about $340,000. Additional royalty in substantial amounts will be paid into the Treasury during the next ten years.

McGraw-Hill officials expressed a hope that the success of the Radiation Laboratory Series would encourage government officials to arrange commercial publication of similar official reports and surveys that have large scientific and technical importance.

IRE SHOWS GIANT ANTENNA IN MINIATURE



Unveiling of the model of the Empire State Building tv antenna at the Waldorf-Astoria Hotel, N. Y. C., during the recent IRE Convention. Left to right are George Sterling, FCC Commissioner; Mortimer W. Loewi, director of the Du Mont television network; Frieda Hennock, FCC Commissioner; Hugh Drum, president of Empire State Building, Inc.; David Sarnoff, chairman of the board of RCA; Philip B. Stephens, business manager of the N. Y. Daily News (owner of station WPIX); E. M. Webster, FCC Commissioner; Kay Burke, "Miss Empire State;" and Edward J. Noble, chairman of the board of the American Broadcasting Co.

MIT Offers Servomechanisms Course

THEORY and applications of feedback control systems (servomechanisms), and the broad concept of system engineering, will be the subject of a special course during Summer Session 1951 at the Massachusetts Institute of Technology, from August 20 to 31.

Plans for the ten-day course were recently announced by Professor Donald P. Campbell, of the MIT department of electrical engineering. It will include a survey of the theory of feedback systems with emphasis on dynamic operations and system synthesis. Industrial applications of feedback control systems, or servomechanisms, in such diverse fields as steel making, printing, petroleum processing, wood working, textile manufacturing, chemical processing, and power distribution will be discussed.

Following morning lectures, demonstrations and laboratory work in

Instrument NEWS

Arco Cuts Testing Time 80% With Thickness Gage

Engineers of the Arco Company, Cleveland, Ohio, manufacturers of industrial finishes and coatings, say that they have cut testing time and costs 80 per cent by using a General Electric Type B magnetic thickness gage for quality control.

Every Arco finish is designed to be applied at a specific thickness for the best possible adhesion. Because the thickness gage makes it possible to check and control thickness quickly and accurately, the G-E gage has become a vital part of their manufacturing process.

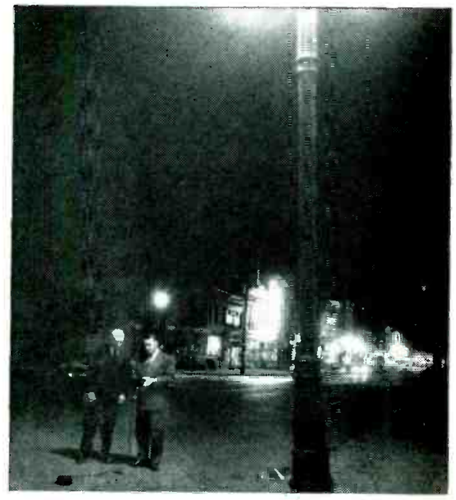
Arco Company also uses this gage to help determine the hardness of their paint. The standard Type B thickness gage has a range of 0.10 mils to 100 mils. Other instruments of this type with ranges from 0.10 mils to 300 mils can be furnished to measure the thickness of any non-magnetic material on a magnetic base.

CAPACITOR PEAK VOLTAGE in a jet-engine-ignition system is measured by a General Electric electrostatic voltmeter. It can measure peak voltages of critical ignition circuits without disturbing the ignition system itself.

SENSITIVE LIGHTMETER AIDS STUDY OF STREET LIGHTING FOR NIAGARA MOHAWK

Niagara Mohawk Power Corporation, Albany, N. Y. is currently using a G-E Type PF-13 sensitive lightmeter to aid its streetlighting surveys. "Because of its portability and high sensitivity, the PF-13 lightmeter enables us to check quickly and efficiently critical low-light intensities—both indoors and outdoors," reports Mr. C. E. Waldron, street-lighting advisor for Niagara Mohawk.

The Type PF-13 lightmeter, weighing only 14 pounds with carrying case, has its cell corrected for oblique angles of light by a cosine-corrected lens. With two ultra-sensitive ranges, 0-1 and 0-5 footcandles, streetlighting levels that before couldn't be determined without elaborate equipment are taken with ease.



In addition to use in utility-company surveys of street lighting, the meter is especially adaptable to surveys by law-enforcement, safety-lighting, and civic groups attempting to combat crime and to prevent motor-vehicle accidents through better lighting of streets and highways.

New "Radiation Monitor" Just Announced by G. E.

A new radiation detector, known as the "radiation monitor," has been announced by the General Electric Company. It is designed for the use of engineers, scientists, doctors, and technicians engaged in work where x-ray or gamma radiation is present. In addition, it may be a valuable tool for civilian defense radiation programs.

The monitor's high sensitivity detects much smaller amounts of gamma radiation than is permitted by the most stringent safety regulations. This sensitivity, coupled with continuously visible indication, quickly gives warning of a radiation hazard in areas where the monitor is placed.

Light weight (only fourteen ounces) adds to the convenience of the monitor. It's also small—about the size of a quart oil can. Since it has a self-contained power source, it can easily be moved about. Furthermore, it does not require tubes or batteries. Full-scale reading is from 0 to 20 millircentgens: accuracy is plus or minus ten per cent. The monitor can be recharged by merely turning it upside down.

SECTION A602-206, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins:
Indicate:
√ for reference only
X for planning on immediate project

☐ PF-13 Sensitive lightmeter (GEC-611)
☐ Type B Magnetic thickness gage (GEC-319)
☐ Radiation Monitor (GEC-778)
☐ Electrostatic Voltmeter (GEC-403)

NAME ....
COMPANY ....
STREET ....
CITY .... ZONE ... STATE ......

GENERAL ELECTRIC

afternoons during the course will make use of the student laboratories in the electrical engineering department. Measurement of system and component performances and methods of testing and evaluating process control equipment are to be included in the laboratory program.

Three members of the MIT faculty will assist Professor Campbell in presenting the course: Professor Gordon S. Brown, director of the MIT Servomechanisms Laboratory; and Paul E. Smith, Jr., and Leonard A. Gould, instructors in the electrical engineering feedback control laboratory.

The course is intended for engineers with a background in the problems of industrial engineering and production management. It will be open to those who have had no previous acquaintance with the servomechanisms field, though a familiarity with the engineering problems to be discussed will be helpful.

The course in feedback control systems is one of a series of special summer activities planned during 1951, under the general direction of Professor Walter H. Gale, director of the MIT Summer Session. All are designed to make MIT's technical and educational facilities available to those who cannot participate in the regular academic program.

Further information on this and other special summer activities may be obtained from Professor Gale at Room 3-107, Massachusetts Institute of Technology, Cambridge 39.

MEETINGS

APR. 30–MAY 4: SMPTE Spring Convention, Hotel Statler, N. Y.

MAY 21–23: 1951 Parts Distributors Show, Hotel Stevens, Chicago, Illinois.

MAY 23–24: Fifth National Convention, American Society for Quality Control, Hotel Cleveland, Cleveland, Ohio.

MAY 23–25: 1951 IRE Technical Conference on Airborne Electronics, Biltmore Hotel, Dayton, Ohio.

JUNE 18–22: ASTM Annual Meeting, Hotel Chalfonte-Haddon Hall, Atlantic City, N. J.

JUNE 20–22: IRE 7th Region Conference, U. of Washington, Seattle, Wash.

JUNE 25–29: AIEE Summer General Meeting, Royal York Hotel, Toronto, Ontario, Canada.

AUG. 15–18: 1951 APCO Conference. Everglades Hotel, Miami, Florida.

AUG. 20-23: AIEE Pacific General Meeting, Multnomah Hotel, Portland, Oregon.

AUG. 22–24: Seventh Annual Pacific Electronic Exhibit and West Coast Annual IRE Convention, San Francisco Civic Auditorium, San Francisco, Calif.

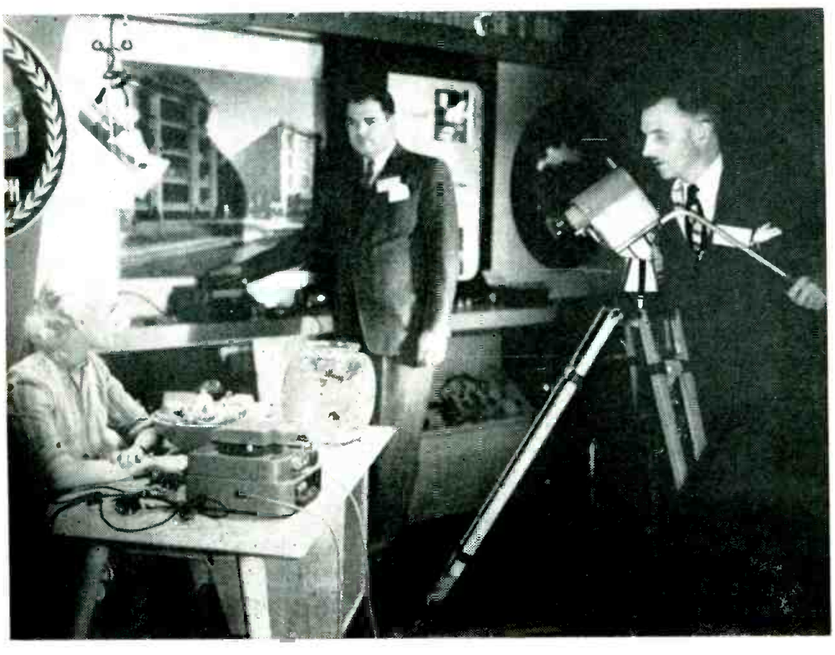
AUG. 28–SEPT. 8: Eighteenth British National Radio Show, Earls Court, London, England.

SEPT. 10–14: Sixth National Instrument Conference and Exhibit, sponsored by Instrument Society of America, Sam Houston Coliseum, Houston, Texas.

OCT. 22–26: AIEE Fall General Meeting, Hotel Cleveland, Cleveland, Ohio.

NOV. 12–15: NEMA Convention, Haddon Hall, Atlantic City, N. J.

INDUSTRIAL COLOR TV AT IRE SHOW



At the IRE annual exhibition at Grand Central Palace, N. Y., in March many visitors saw this demonstration of industrial color television. The color receivers used are a product of the Gray Research & Development Co., a subsidiary of The Gray Mfg. Co., and were designed in cooperation with CBS engineers. The camera chain, consisting of color camera and monitor, was operated from Gray's main floor booth. Additional receivers were in use on the third floor

Stanford Plans New Labs

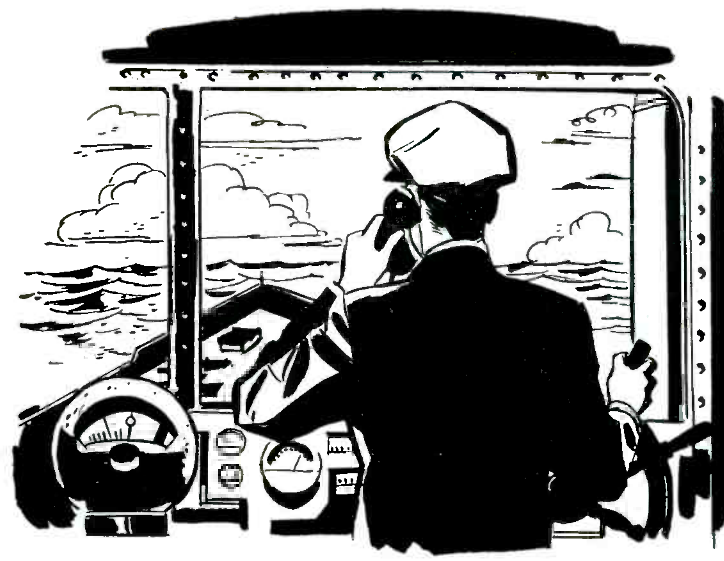
TWO NEW electronics laboratories, one for applied research and the other for student electrical engineering activities, will be constructed at Stanford University, California. The new facilities will represent a $250,000 outlay.

The university has received an Office of Naval Research contract for a research program in applied electronics. The grant supplements existing basic research contracts held by the university with ONR, the Air Force, Signal Corps and the National Bureau of Standards.

Construction of the student engineering laboratory was made possible through a gift from Hewlett-Packard Co. of Palo Alto, electronics equipment manufacturing firm.

The buildings will have 13,500 sq ft of floor space and will be about

(Continued on page 255)



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You'll find equipment of many leading manufacturers on the ships of these famous world-wide lines.

In radio and communications, especially, where reliability is indispensable, Sylvania tubes are constantly on watch.

For, Sylvania is a pioneer in the development of dependable radio tubes. Improved manufacturing techniques and quality control methods, over a period of 25 years, have resulted in Sylvania's recognized leadership in the radio and TV tube field. Receiving or transmitting, Sylvania tubes offer outstanding performance and long life.

Moreover, the Sylvania tube line is a complete line, including practically every known type . . . from tiny sub-miniatures to large TV picture tubes. For detailed information, ratings, prices, or deliveries write today to: Sylvania Electric Products Inc., Dept. R-1105, Emporium, Pa. *Sylvania representatives are also located in all foreign countries. Names on request.*

ALCOA STEAMSHIP COMPANY, INC.

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HOME LINES

ISBRANDTSEN CO., INC.

MATSON LINES

NORWEGIAN AMERICA LINE

PANAMA LINE

SCANDINAVIAN AMERICAN LINE

SWEDISH AMERICAN LINE

SYLVANIA ELECTRIC PRODUCTS INC. 1901-1951 50th ANNIVERSARY FIVE DECADES OF PROGRESS

SYLVANIA ELECTRIC

RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS

NEW BOOKS

Electrons and Holes in Semiconductors

BY WILLIAM SHOCKLEY. *Bell Laboratories Series, D. Van Nostrand Company, Inc., New York,* 1950, 558 *pages*, $9.75.

Reviewed and summarized by G. D. O'Neill, Head, Solid State Section, Physics Laboratories, Sylvania Electric Products Inc., Bayside, N. Y.

WHEN THE TRANSISTOR was announced in the summer of 1948, the imagination of physicists, electronics engineers and a large section of the general public was excited by the amazing news. The more naive, especially among those not in a position to make a reasonable evaluation of this most promising discovery, were led to expect too much too soon. Meanwhile, systematic investigation of the phenomena associated with transistor action has continued along scientific lines, with the certainty that out of this work will come devices of major importance. The present volume is, to a large extent, based upon a lecture series organized by Dr. Shockley as a part of the program of transistor research and development being carried out at the Bell Telephone Laboratories.

This book might be described as a set of three monographs of increasingly rigorous treatment. Part I, called "Introduction to Transistor Electronics", presents an elementary picture of semiconductor phenomena, the transistor as a circuit element and the physical theory of transistor action. The presentation is such that it will be easily understood by persons whose training in science or engineering does not in-

(Continued on p 263)

RELEASED THIS MONTH

Ferromagnetism; R. M. Bozorth; Van Nostrand; $17.50.

Servomechanisms and Regulating System Design; H. Chestnut and R. W. Mayer; Wiley; $7.75.

Short Wave Wireless Communication; A. W. Ladner and C. R. Stoner; Fifth Edition; Wiley; $8.00.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Wobble Organ

DEAR SIRS:

IN the article, Electronic Music For Four (Feb. 1951), the "wobble organ" is described as being representative of the present state of the art. Actually, it would be more appropriate to say that the monophonic electronic musical instrument of the crank-operated, continuously-tuned oscillator type built by the author represents the state of the art approximately 20 years ago. Except for the name, there is little if anything new in the "wobble organ".

In this connection, your attention may be directed to Péchadre's U. S. patent No. 1,791,374, corresponding to French patent No. 672,-968 (1929). The differences between Meachem's and Péchadre's structures are very minor and Péchadre's device may even be superior with respect to practical operation.

Another good example of electronic musical instruments of the crank-controlled type is described in Mager's German patent No. 536,-855 (1928). Bertrand's "Dynaphon", described in French patent No. 664,305 (1929) likewise employs a crank-type operating mechanism for a continuously-tuned audio oscillator.

Nor is Mr. Meachem the first one who has assigned an individual oscillator to each of four or more performers to produce polyphonic music. As far back as in 1932, the writer organized and directed the five-piece Emicon Electronic Or-

(continued on page 292)

Production of GLOBAR brand ceramic resistors is being directed to manufacturers of defense equipment in ever-increasing quantities. These manufacturers must, necessarily, receive first priority if they are to produce critically needed equipment during this national emergency.

However, our productive capacity is such that we are able to meet most needs of producers of civilian equipment—and will continue to do so in every way that does not affect defense production.

The unique characteristics of GLOBAR resistors have resulted in many improvements in circuit designs. Whether you are producing defense or civilian equipment, it will pay you to investigate the many types available. Our complete co-operation is assured. Write Dept. V-51, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

GLOBAR Ceramic Resistors

BY CARBORUNDUM

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And here's the other side of the story — by "Guide" advertisers.

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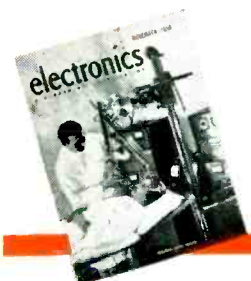
Your ELECTRONICS' representative will be glad to show you the letters from which these quotes were taken and many more—all telling the same story — the unparalleled use and sales value of ELECTRONICS BUYERS' GUIDE.



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When you consider that there are more than 2,000 widely diversified products sold to manufacturers and users of electronic equipment, the engineers' need for, and the sales-making success of the "Guide" *witnessed to by the quotes on the opposite page* become readily understandable.

The only publication of its kind, the "Guide" is the engineers' standard source of specifying and buying information on allied as well as electronic products . . . bearings, blowers, bobbins, bushings, ceramics, couplings, fasteners, gases, hand tools, heating tanks, ionization chambers, metals, moldings, motors, mountings, paper, plastics, rings, seals, solder, tapes, tubing, washers, wire and cable as well as amplifiers, antennas, capacitors, coils, controls, counters, crystals, deflection yokes, h-f generators and heating equipment, ion traps, isotopes, loudspeakers, oscillators, potentiometers, radar, receivers, resistors, spectrometers, standards, testers, thermistors, timers, transducers, transmitters, tubes and tube parts, varistors, wave guides, wave traps, and X-ray equipment . . . materials, components or packaged electronic equipment—getters or gear trains, coils or cabinets, servos or springs.

Designers and users of electronic equipment look to the "Guide" for product source and specifying information. Results of a just completed survey *available from your ELECTRONICS' representative* prove beyond question that ELECTRONICS BUYERS' GUIDE is not only the standard buying guide in the field, it is the only one with real, proven, sales potential for your products. You owe it to yourself to study this independent survey report. Copies available on request.

Advertising closing dates for the Guide are close at hand. Copy-to-set now; Complete plates May 1st. There is no time to lose in planning and preparing your product sales story for presentation to the most important audience as far as your products are concerned — the design engineer subscribers to ELECTRONICS who this year more than ever before are making your markets. Do it now. Begin by seeing if your questionnaire for free listings in the Guide has been properly filled-out and returned. That is the first step to sales through the Guide. It is the indexed-to-advertising, product directory listings that send your potential customers to the supporting sales data pages in the Guide that take your products to market and bring you sales.

THE DIRECT ROUTE TO — — — — — — A $2,000,000,000 MARKET PLACE

TUBES AT WORK

(continued from page 138)

of as high as 150 volts rms may be handled by the cathode followers without distortion. The low impedance gain controls in the output of the cathode followers have very little frequency discrimination.

The 10,000-ohm balance potentiometers are adjusted to give zero direct volts across the gain controls. In this way no transients due to charging and discharging of the 0.25-μf coupling capacitors will appear during gain control adjustments.

In order to improve stability and prevent line-voltage variations from being amplified and fed to the oscilloscope, the cathode-follower and switch-tube positive and negative power supplies are regulated. Four VR-150 (OD3) regulator tubes are used to give 300 volts positive and negative with respect to ground.

The oscillogram of Fig. 2 shows

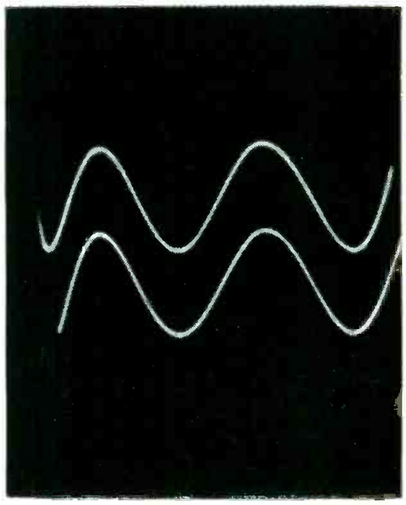

FIG. 2—Oscillogram with 30-kc signal applied simultaneously to both inputs and a sweep frequency of 10 kc

the switch operation with a 30-kc signal applied simultaneously to both inputs with a sweep frequency of 10 kc. With the circuit constants shown in the schematic diagram, satisfactory operation is obtained at sweep frequencies as high as 30 kc. The chief limiting factor is the frequency response of the flip-flop stage. If it is desired to switch at even higher frequencies, the plate load resistances for the flip-flop circuit may be lowered, necessitat-

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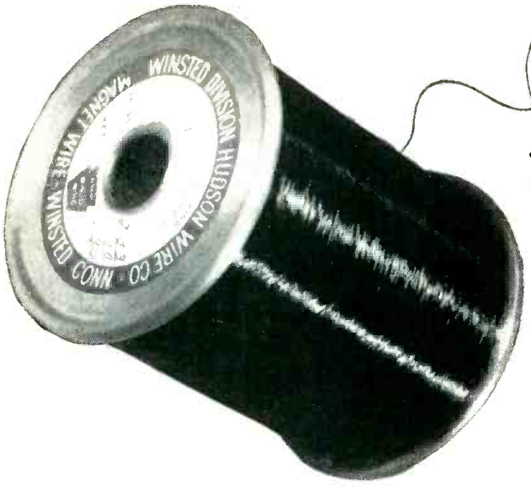

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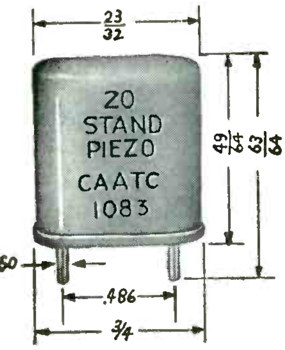

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The Dyna-Myke Model 129-B is a precision, high speed, dynamic micrometer using linear differential transformers as the sensing element. It measures and provides for recording such phenomena as force, torque, strain, vibration, acceleration, temperature, pressure, thickness, surface finish, etc., with a linear frequency response of DC to 1000 cps. Direct displacements are measured in five ranges from ±.1 inch to ±10 micro inches. On standard magnetic recorders a sensitivity of 1 micro inch per millimeter is available. A toggle switch converts the Dyna-Myke to a high frequency, high sensitivity strain gage indicator. The output is used to drive any type of magnetic, null balance or galvanometer recorder—or the DC or modulated carrier may be viewed on an Oscilloscope. Selsyn motors may be driven for remote indication or control. Request Technical Bulletin 129-B for full details.

DYNA-METER

The Dyna-Meter Model 144, when used with the Dyna-Myke, indicates by neon lights the peak amplitude of transients as fast as 1 millisecond. This indication may be instantaneous or a memory feature may be used to maintain the reading until reset. Built-in power relays provide on-or-off control to any plus or minus limits established by the Dyna-Myke. The combination of the Dyna-Myke and the Dyna-Meter offers many applications to industrial processes resulting in the elimination of scrap *at the source*. Uses in connection with machine tool operations are particularly impressive. Request Dyna-Meter Technical Bulletin 144.

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ing some adjustment in the other circuit components.

REFERENCE

(1) O. H. Schmitt, A Thermionic Trigger, *Jour. Sci. Inst.*, 15, p 24, Jan. 1938.

New High-Speed Facsimile System

THE HIGH-SPEED facsimile system recently developed by Western Union requires no processing at any time during transmission or reception. Transmission and recording in final form of 3,000 words of newsprint per minute is possible with the device.

Copy to be transmitted is placed in a horizontal transparent cylinder. When the end gate of the cylinder is closed transmission is automatically started. The copy is held in place in the transmitting cylinder by the centrifugal force of 1,800 cylinder revolutions per minute.

Two transmitting cylinders are used to keep the machine busy. The operator inserts copy in one cylinder while the other is transmitting, as shown in Fig. 1. Transmission shifts from one cylinder to the other automatically to give continuous operation.

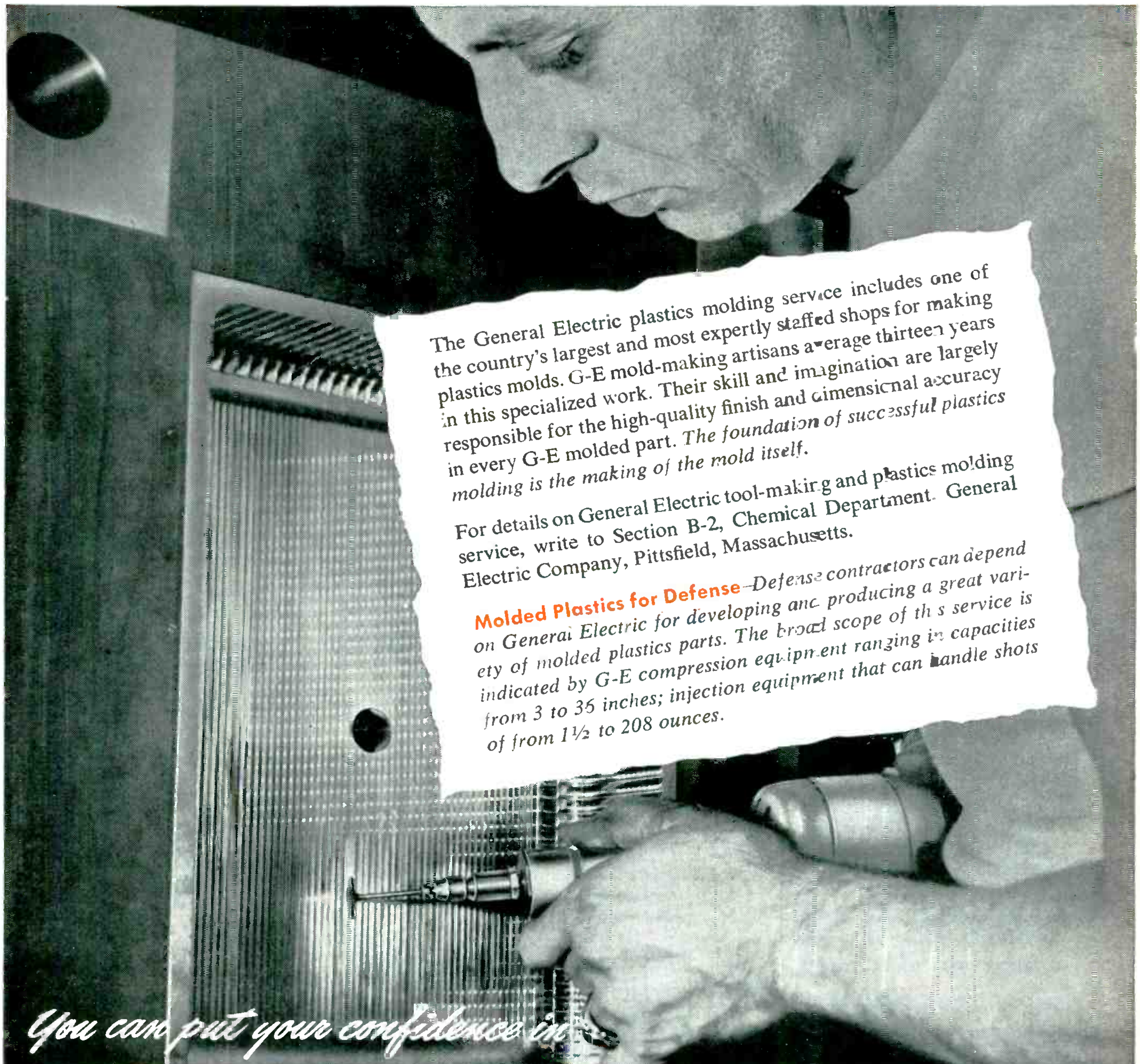
A pin point of light is focused on the revolving page and moves along a track parallel to the cylinder. A

FIG. 1—Transmitting cylinders of the new facsimile system. Lower cylinder is loaded and copy is being transmitted while operator prepares upper cylinder for automatic take-over

One of a series of messages to design engineers to show how General Electric's *specialized* plastics molding service is geared to highly efficient defense and industrial production.

HOW *Specialized* MOLDING SERVICE

ASSURES FINER QUALITY PLASTICS PARTS



The General Electric plastics molding service includes one of the country's largest and most expertly staffed shops for making plastics molds. G-E mold-making artisans average thirteen years in this specialized work. Their skill and imagination are largely responsible for the high-quality finish and dimensional accuracy in every G-E molded part. *The foundation of successful plastics molding is the making of the mold itself.*

For details on General Electric tool-making and plastics molding service, write to Section B-2, Chemical Department, General Electric Company, Pittsfield, Massachusetts.

Molded Plastics for Defense—*Defense contractors can depend on General Electric for developing and producing a great variety of molded plastics parts. The broad scope of this service is indicated by G-E compression equipment ranging in capacities from 3 to 35 inches; injection equipment that can handle shots of from 1½ to 208 ounces.*

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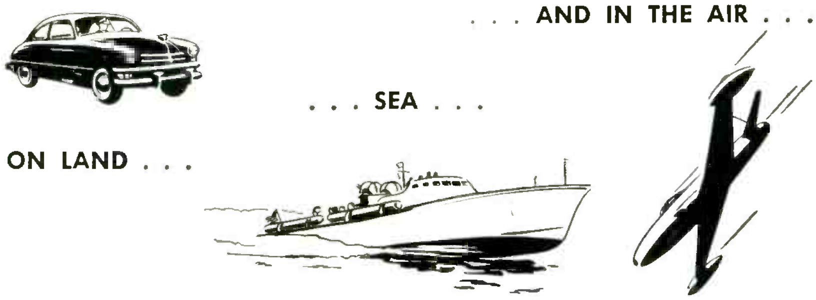

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A 1	74	1.7	0.11	0.36
A 2	74	1.3	0.24	0.44
A 34	73	0.6	1.5	0.88

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LOW CAPAC TYPES	CAPAC mmf/ft.	IMPED OHMS	ATTEN db/100ft 100Mc/s.	O.D."
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PC 1	10.2	132	3.1	0.36
C 11	6.3	173	3.2	0.36
C 2	6.3	171	2.15	0.44
C 22	5.5	184	2.8	0.44
C 3	5.4	197	1.9	0.64
C 33	4.8	220	2.4	0.64
C 44	4.1	252	2.1	1.03

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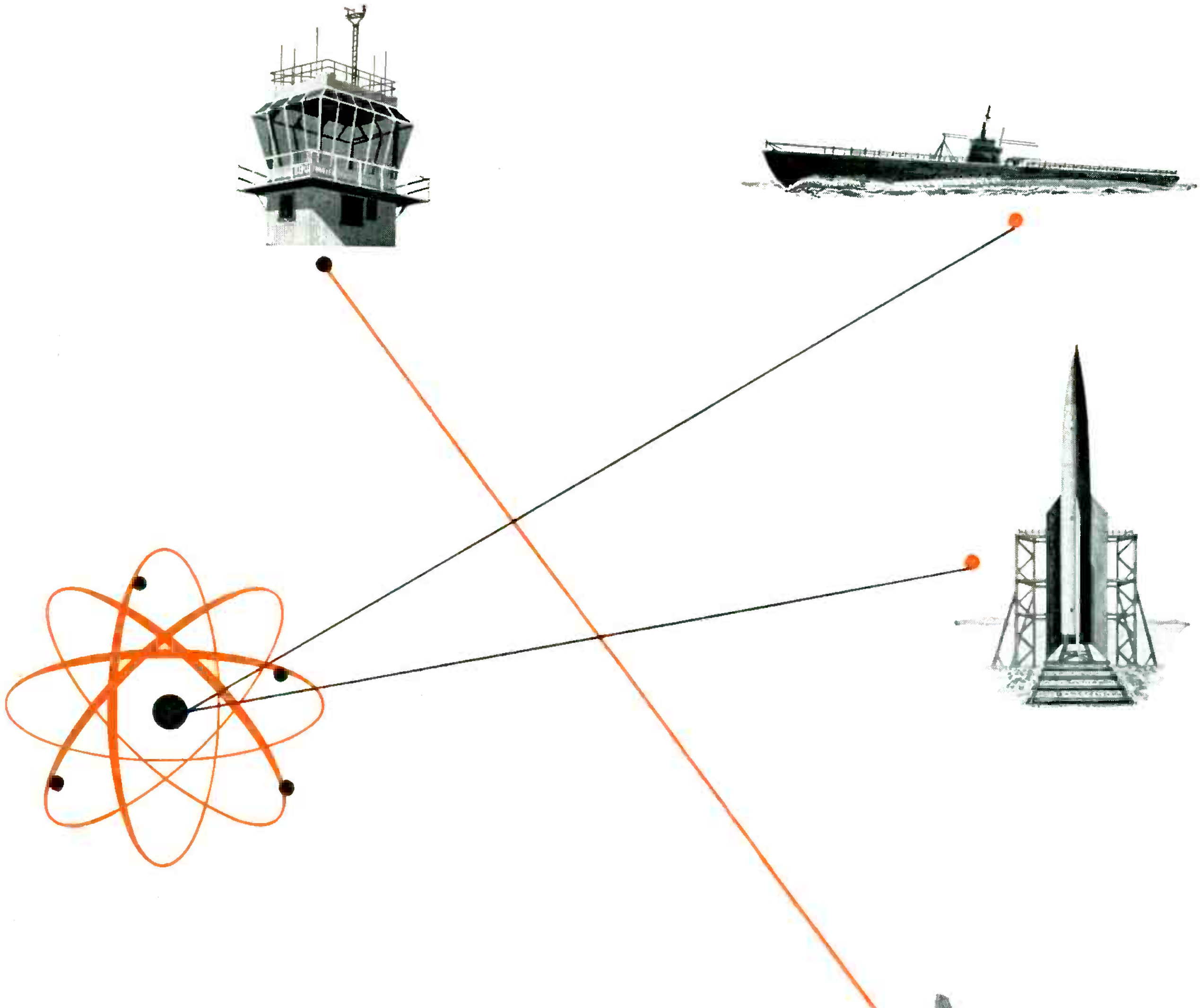

FIG. 2—Transmitted copy feeding from the recorder at a speed of ¼ inch per second

photocell reacts to the varying light from the page and causes a current to vary rapidly in proportion to the amount of light reflected. The page being transmitted is scanned in parallel lines, 120 to the inch.

Electrical impulses from the transmitter go to the distant recorder via a radio beam or wire circuit. The receiving machine, which operates at the same speed as the transmitter, receives the amplified pulses and reproduces the transmitted copy on an electrosensitive dry recording paper, as shown in Fig. 2.

High-Voltage Pulse Power Supply

By H. E. Brown
Naval Research Laboratory
Washington, D. C.

In the development of a special cathode-ray tube a high-voltage power supply was required having an output voltage adjustable between 5 and 15 kv. Because this range of adjustment is not easily obtainable with an r-f high-voltage power supply and because of the convenient availability of television horizontal sweep and high-voltage transformers, it was decided to use such a transformer in the supply.

Figure 1A shows the circuit diagram. A type 6N7 multivibrator is used to generate an approximate sawtooth waveform which drives

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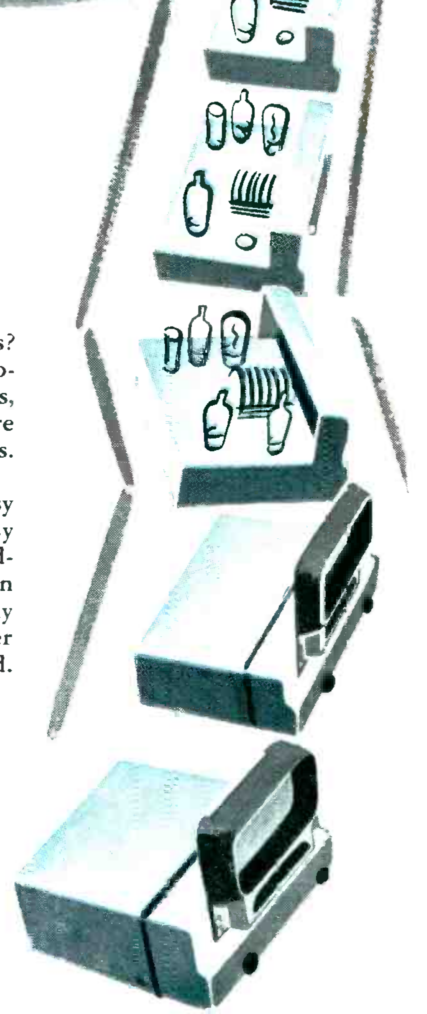
You see, we've really been busy . . . busy getting additional experience . . . busy acquiring greater facilities . . . busy finding new ways to increase production efficiency. And, today, we can truthfully say that we're better prepared than ever to serve our country. Just say the word. We're ready to go!



Delco Radio

DIVISION, GENERAL MOTORS CORPORATION
KOKOMO, INDIANA

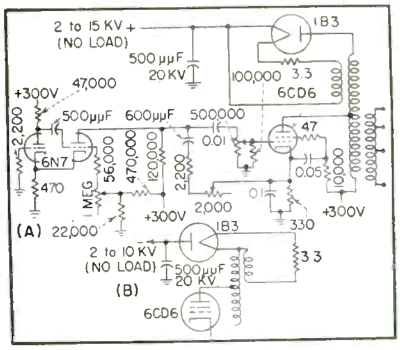


FIG. 1—Circuit of simple and inexpensive high-voltage pulse power supply. Output is adjustable from 5 to 15 kv and polarity may be reversed as shown in B

the grid of a type 6CD6 beam-power tube. The plate current of the 6CD6, in following the grid swing of voltage, decreases at a rapid rate during the discharge time of the saw tooth.

The rapid decrease in 6CD6 plate current generates a high negative voltage pulse in the primary of the horizontal deflection transformer. The voltage pulse is approximately doubled by the autotransformer tap and is changed to steady d-c by a type 1B3 rectifier and filter capacitor. The d-c output voltage may be reversed from positive to negative output by simply reversing the rectifier tube connections as shown in Fig. 1B. The transformer winding which connects to the horizontal deflection yoke in a television set is unused and remains an open circuit.

Since the source of the 1B3 filament voltage is the same as the high-voltage, the temperature of the 1B3 filament will vary when the high voltage is adjusted. This variation of temperature can be controlled to some extent by the frequency potentiometer control of the multivibrator, the temperature varying directly as the frequency of the driving pulse. Although the high-voltage transformer is noisy when the frequency of the driving signal is in the audio range, the power supply can be operated above these frequencies for all except the highest voltages.

The performance of the power supply at 300 volts at several settings of the controls is shown in Fig. 2. As shown by the dashed

Typical set-up for measuring characteristics of r-f coil. Types 1330-A Bridge Oscillator, 821-A Twin T Impedance Measuring Circuit and a communications-type receiver. The oscillator is equally suited to use with other bridges such as the Type 716-C Capacitance Bridge and the Types 916-A and 916-AL R-F Bridges.

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The new G-R Type 1330-A Bridge Oscillator is designed especially as a power source for bridge, antenna and general laboratory measurements. It is relatively inexpensive, has high output, excellent shielding and many operating conveniences. Among its features are:

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- **THREE MODULATION FREQUENCIES:** *internal a-m at line and at 400 c and 1,000 c, at two levels of approximately 30% and 60%*
- **GOOD OUTPUT:** *12 volts, open circuit; ¼ watt into 50-ohm load*
- **FREQUENCY ACCURACY:** *Carrier — ±2% above 150 kc, ±3% below, no load. Audio — ±5% for 400- and 1,000-cycles*
- **LOW LEAKAGE:** *about 50 µv per meter at 1 Mc, two feet from oscillator*
- **COAXIAL OUTPUT** *jacks, cable and adaptors permit complete shielding from oscillator to measuring instrument*
- **LOGARITHMIC DIAL:** *calibration logarithmic from 5 kc to 15 Mc*
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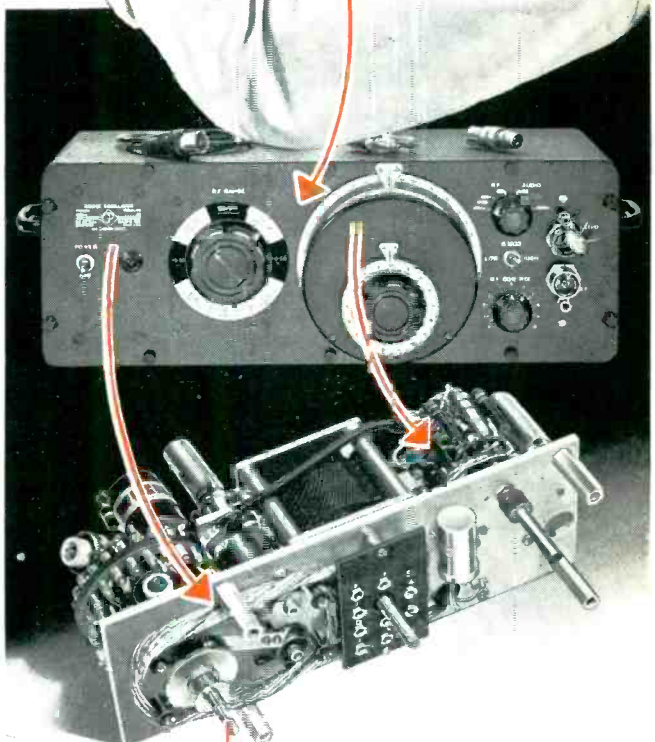

Excellent mechanical construction throughout. Oscillator assembly plugs into deep brass box; double cover completes shielding. Note servicing cable permitting instrument to be tested on bench.

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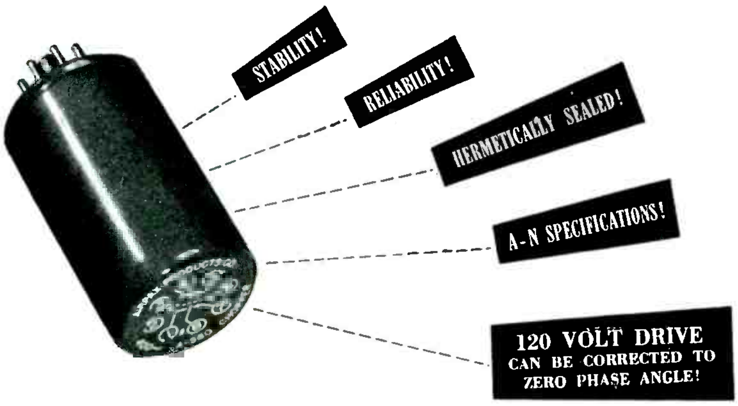

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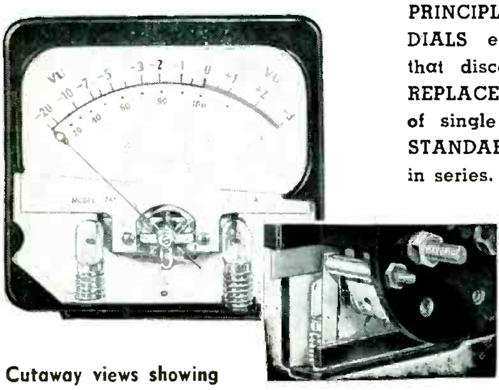

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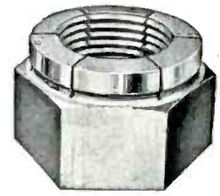

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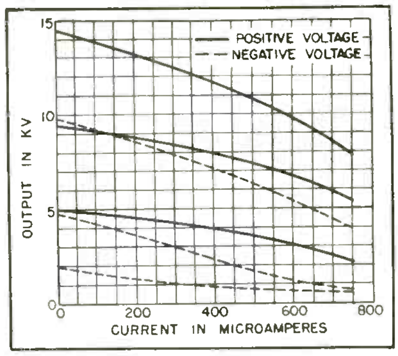


FIG. 2—Regulation curves for the high-voltage pulse power supply

curves, the negative output voltage obtained by reversing the 1B3 connections is somewhat less than the positive output voltage. The output voltage is adjusted by the potentiometer in the grid circuit of the 6CD6 with minor adjustments of the two other potentiometers at the extreme ranges. The maximum load currents of the 6CD6 and 6N7 are 100 ma and 10 ma respectively with a 300-volt power supply. With a higher power supply voltage a higher output voltage may be obtained.

Simple Phase-Sequence Indicator

By Alvin B. Kaufman
Los Angeles, Calif.

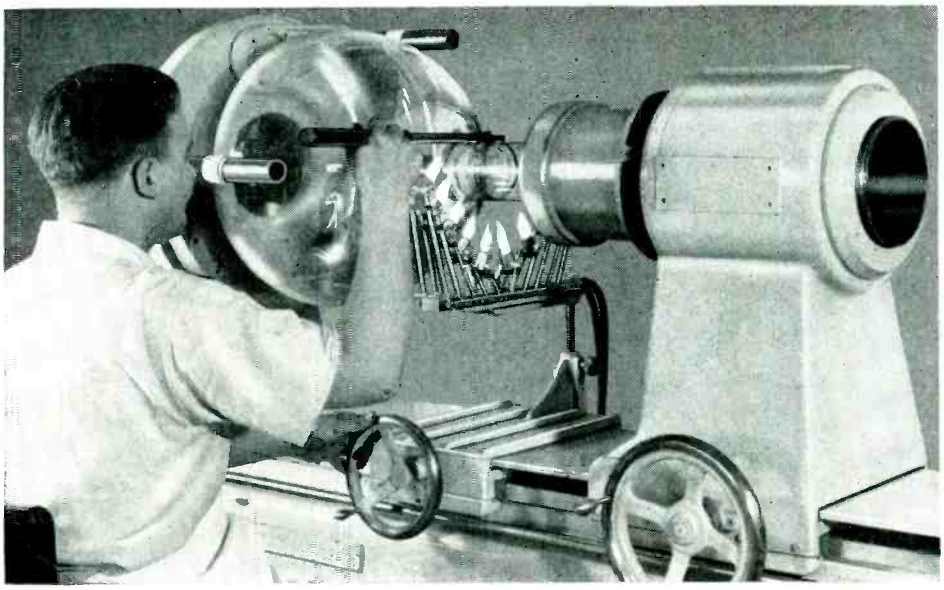
Wherever three-phase power sources are used, a question of phase sequence will often arise. The phase sequence or direction of rotation of voltages determines the direction in which a three-phase electric motor revolves and, therefore, indirectly affects gyro instruments, autopilots and other miscellaneous equipment.

In a powerhouse or other commercial power system, adequate instrumentation to determine phase sequence normally exists. In other industries, such as the aircraft industry, the equipment may not be on hand for economic reasons and a portable indicator may be desired.

The simple and inexpensive unit to be described is capable of field use without danger of breakage but is versatile enough so that it may be built into test equipment.

All phase-sequence indicators employ three test leads and these

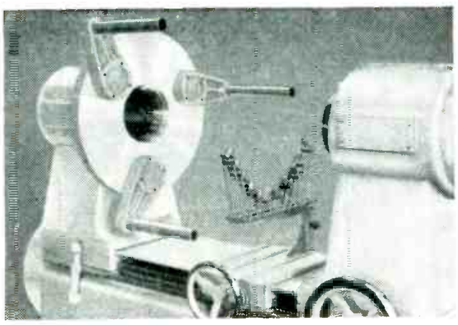
LITTON INDUSTRIES NEWS



LITTON GLASSWORKING LATHES SPEED PRECISION ASSEMBLY OF TV KINESCOPE, VACUUM TUBES

Modern vacuum tubes have extremely close alignment tolerances. Often, subassemblies must be separately aligned before junction. During sealing, both assemblies must be rotated in perfect phase to maintain this alignment.

Versatile, adaptable Litton Glassworking Lathes meet these requirements. They are built on a normalized cast iron bed, with precision ground ways and axial alignments of highest accuracy and positive phase. The lathes will chuck and hold units such as copper anodes to runouts of .001".



Close-up of spindle head, Litton Model K lathe, showing exceptionally large diameter opening of universal chuck

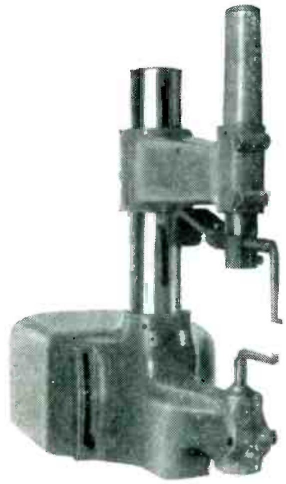
Air passages are arranged to avoid contamination, yet permit use of neutral gasses when sealing glass to metal. Burners provide the narrowest possible heating area commensurate with ample total heat. Continuously variable spindle speed, which makes possible much glassworking without blowing, is optional on all models. Foot pedals control the air or neutral gas supply, and the oxygen and gas volume. Convenient hand controls govern carburetion and air intake to the spindles.

Leading TV tube makers use Litton Glassworking Lathes to speed production of kinescope tubes 10" to 27" in diameter. Manufacturers find that the speed and handling ease of Litton lathes enable glassworkers to seal tube funnels to domes in minimum time—with complete control of glass distribution. Since most manufacturers align sub-assemblies on the lathe, the accurate phasing of Litton spindle heads is also an important factor.

Reliable Litton Glassworking Lathes are adaptable to the widest possible variety of glassworking jobs. Five models offer a choice of radial clearance ranging from 4" to 17½", and axial working lengths from 20¾" to 75½".

LITTON SPOTWELDERS OFFER HIGH POWER, EXTREME FLEXIBILITY FOR PRECISION JOBS

Litton Model A Precision Spotwelder offers broad applicability of use in the manufacture of vacuum tubes. It makes possible the quick altering of production setups. Rated 2 kva continuous duty, it efficiently handles average sized



or very precise jobs. Accurate alignment and absence of side play permit butt welding or parallel welding of small wires without rolling. Foot pedals and switches control top mandrel and power supply. Model A spotwelder has 6½" throat depth and extension jaws can be added.

SPOTWELDER TIMER

A new timer for the Litton Model A Spotwelder has been developed by Litton Industries and will be available for delivery soon. The timer employs two simple controls. One adjusts weld time in steps of 1, 2, 3, 5, 7, 10, 15, 25 and 60 cps. The other adjusts heat control in 6 steps. Proper adjustment of these controls makes possible precision welds up to the 2 kva rating of the welder.

LITTON INDUSTRIES

SAN CARLOS, CALIFORNIA, U. S. A.

DESIGNERS AND MANUFACTURERS of: Glassworking Lathes and Accessories, Vertical Sealing Machines, Burner Equipment, Precision Spotwelders, Oil Vapor Vacuum Pumps, Glass Baking Ovens, Vacuum Tubes and Tube Components, Magnetrons, High Vacuum Malube Oil, Microwave Equipment.

Permafil D-C CAPACITORS

General Electric Permafil capacitors are designed for use at extremes in temperature—in high ambients—or in high altitudes where extreme cold is encountered. They are suitable for all blocking, by-pass and filtering applications.

These capacitors, while using paper dielectric, are treated with a plastic compound that retains its electrical stability at both high and low operating temperatures. Units are available in case styles CP-53, 61, 63, 65 and 70, as covered by specifications JAN-C-25—in ratings of .05 to 2.0 muf, 400 volts DC. Containers are metallic and are sealed with G-E long-life all-silicone bushings.

For full information on Permafil capacitors see your local G-E representative. Or write *Apparatus Department, General Electric Company, Schenectady 5, New York.*

Where space or weight are especially important

Permafil capacitors will average about 1/10 the size and weight of liquid-filled capacitors when designed to operate at 125° C.

Where short-life characteristics are permissible additional savings in size and weight are possible. If you have a short-life capacitor application in mind, G-E engineers would like to discuss it with you.

GENERAL ELECTRIC

407-302

three leads may be rotated, but not interchanged, around the three power wires and still indicate the same phase sequence. Any leg can be taken as the starting point and if it is arbitrarily assigned the symbol A, then B and C can be located.

By referring to the schematic diagram of Fig. 1, it can be seen that two lamps and one capacitor or inductor are required. The lamps may be 110-volt 6-watt types, in which case satisfactory operation may be had on both 26 and 110 volts. Normally, for three-phase 26-volt 400-cycle aircraft systems, two 28-volt aircraft panel bulbs would be used with a 1-μf capacitor. The lamps used should be of the same voltage rating as the three-phase line.

The capacitor or inductor value is not critical but should be selected

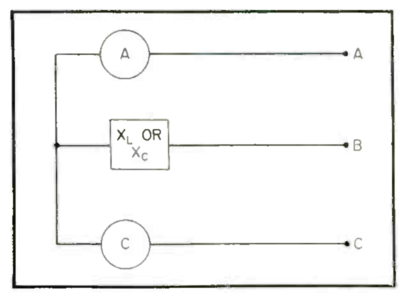


FIG. 1—Circuit for the phase-sequence indicator

for the line frequency utilized. The impedance value of the capacitor or inductor determines the brightness at which the two lamps will operate. Too high an impedance will cause the lamps to light dimly while too low an impedance will cause full brilliance of each lamp. The impedance should be approximately the same as the resistance of one lamp.

Commercially and economically, it is easier to employ a capacitor for the unit than an inductor. The voltage rating of the capacitor should be in proportion to the line voltage, the d-c rating approximately three times the a-c line voltage.

The capacitor value must be calculated for each tester and depends to a large extent upon the voltage and wattage rating of the lamps and the line frequency. The capacitance

NEW INDICATOR ION TRAP

A Rauland "Exclusive"

Helps you Cut Production Costs

Rauland's new Indicator Ion Trap can help you in your battle to cut pennies off production costs and thereby to price receivers competitively.

First of all, the Indicator Ion Trap completely eliminates the need for any equipment and any trained judgment in the adjustment of ion trap magnets. Adjustment can be made faster than equipment could be attached. The ion trap magnet is simply moved until the green glow signal is reduced to minimum. It can be done in seconds with absolute accuracy—without even seeing the front of the picture tube.

Second, the Rauland Tilted Offset Gun which incorporates this Indicator Ion Trap requires only one Ion Trap Magnet instead of two, nibbling a little more off production costs. Yet it gives better results—the electron beam is bent only once and is focused to maximum sharpness.

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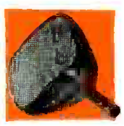

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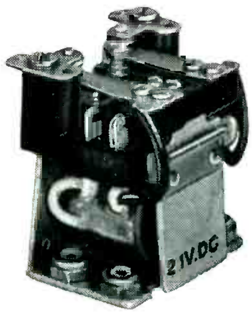

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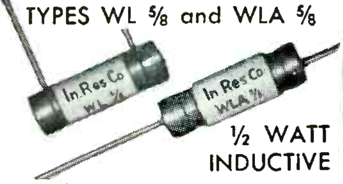


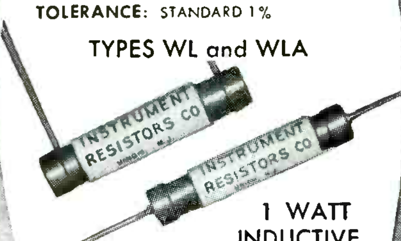
½ WATT INDUCTIVE

MAX. RES: .01 to 7,500 ohm (331 Alloy)
.01 to 4,000 ohm (Nichrome)
.01 to 1,250 ohm (Manganin)

BODY SIZE: ⅝" lg. by 3/16" diam.

TOLERANCE: STANDARD 1%

TYPES WL and WLA



1 WATT INDUCTIVE

MAX. RES: .01 to 15,000 ohm (331 Alloy)
.01 to 8,000 ohm (Nichrome)
.01 to 2,500 ohm (Manganin)

BODY SIZE: 1" lg. by 3/16" diam.

TOLERANCE: STANDARD 1%

Can be supplied non-inductive with one-half indicated maximum resistance.

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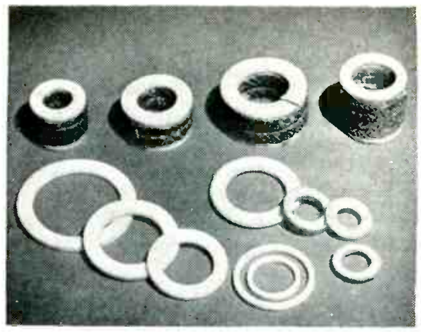

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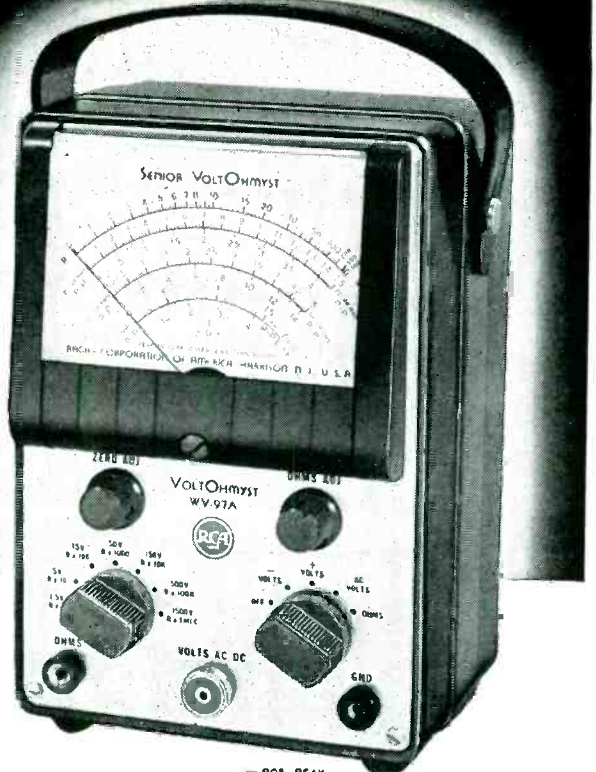
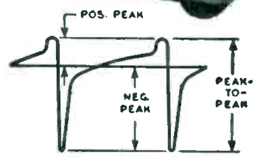
Includes direct probe and cable, dc probe, ohms lead, and ground lead



TEN WAYS BETTER!

1. Directly measures complex waves from 0.2 volt to 2000 volts, peak-to-peak.
2. Has an over-all accuracy for dc measurements of ±3% of full scale.
3. Measures dc voltages from 0.02 volt to 1500 volts.
4. Measures rms values of sine-wave voltages from 0.1 volt to 1500 volts.
5. Has 7 non-skip ranges for both resistance and voltage.
6. All full-scale voltage points increase in a uniform "3-to-1" ratio.
7. Frequency response flat from 30 cps to approximately 3 Mc.
8. Negative-feedback circuit provides better over-all stability.
9. Fully enclosed metal case shields sensitive electronic-bridge from rf fields.
10. More convenient to use because of smaller size and new slip-on probes.

The **WV-97A** measures peak-to-peak voltages directly. Hence, it quickly provides information essential for servicing TV receivers with their pulse-type waveforms.



The WV-97A has a range of usefulness extending beyond that of any other instrument in the field. Its quality, dependability, and accuracy make it a true laboratory instrument; it is exactly what is needed for television in the design laboratory, factory, and service shop.

The new Senior VoltOhmyst measures dc voltages in high-impedance circuits, even with ac present. It reads the rms values of sine waves and the peak-to-peak values of complex waves or recurrent pulses, even in the presence of dc. Its electronic ohmmeter has a range of ten billion to one.

Like all RCA VoltOhmysts, it features high input resistance, electronic protection from meter burn-out, zero-center scale for discriminator alignment, molded-plastic meter case, a 1-megohm isolating resistor in the dc probe, and sturdy metal case for good rf shielding.

An outstanding feature is its usefulness as a television signal tracer . . . made possible by its high input resistance, wide frequency range, and direct reading of peak-to-peak voltages.

For complete information on the new RCA WV-97A Senior VoltOhmyst, see your RCA Test Equipment Distributor, or write RCA, Commercial Engineering, Section 42EX, Harrison, New Jersey.

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SPECIFICATIONS

DC VOLTMETER:
Seven continuous ranges....0 to 1.5, 5, 15, 50, 150, 500, 1500 volts
Input resistance (including 1 megohm in dc probe):
All ranges....11 megohms
Sensitivity for the 1.5 volt range....7.3 megohms-per-volt
Over-all Accuracy....±3% of full scale
AC VOLTMETER—Fourteen continuous ranges:
Peak-to-peak ranges....0 to 4, 14, 42, 140, 420, 1400, 4200 volts
Maximum peak-to-peak input voltage for complex waves, 2000 volts
RMS ranges (for sine waves)....0 to 1.5, 5, 15, 50, 150, 500, 1500 volts
Input Resistance and Capacitance with WG-218 Direct Probe and Cable:
1.5, 5, 15, 50, 150-volt ranges... 0.83 megohm shunted by 70 $\mu\mu f$
500-volt range.... 1.3 megohms shunted by 60 $\mu\mu f$
1500-volt range.... 1.5 megohms shunted by 60 $\mu\mu f$
Frequency Response with WG-218 Direct Probe and Cable:
1.5, 5, 15, 50, 150, 500-volt ranges flat from 30 cps to 3 Mc for voltage source having 100-ohm impedance
Overall Accuracy:
1.5, 15, 50, 150, 500, 1500-volt ranges....±5% of full scale
OHMMETER:
Seven continuous ranges....0.2 ohm to 1000 megohms
Center scale values....10, 100, 1000, 10,000 ohms; 0.1, 1, 10 megohms
DIMENSIONS: 7⅞" high; 5¾" wide, 4½" deep
AVAILABLE ACCESSORIES:
WG-264 Crystal Diode Probe. Extends range to 250 Mc ($7.75 suggested user price)
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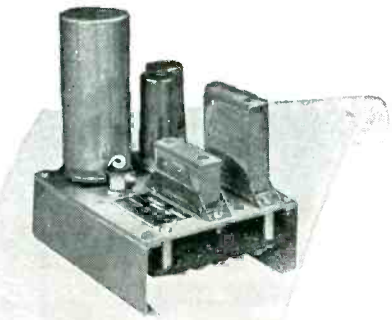
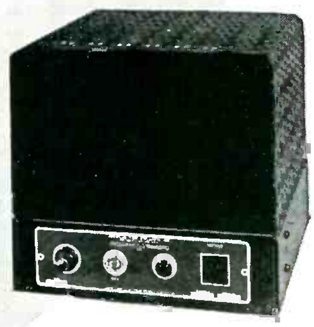


TYPE 2001-2. BASIC UNIT
Frequencies, 200 to 1500 cycles. Dividers and Multipliers available for lower and higher frequencies. Miniaturized and JAN construction. Output, 6 volts.



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consists of Type 2001-2 and booster to provide 10 watts at 110 V at 60 cyc. Input, 50-100 cyc.

TYPE 2121A. LAB. STANDARD
Outputs, 60 cycle, 0-110 Volts. 120-240 cycle impulses. Input, 50-400 cycles, 45 W.

TYPE 2111. POWER UNIT
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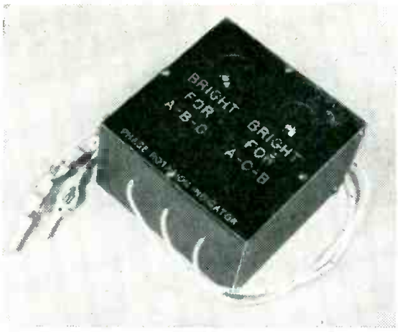


Typical 115-volt 400-cycle tester

required may be found by the formula

$$C = \frac{10^6}{2\pi f X_c}$$

where X_c is the hot resistance of one of the two lamps. The hot resistance of the lamp may be found by

$$R = \frac{E^2}{P}$$

where E is the line voltage and P the wattage rating of the lamp.

Single lamp units of different designs are not too satisfactory. The test-lead coding may be selected to have the lamp either on or off for correct sequence but if the off system were used there would always be a question of whether the lamp was burnt out or the tester not completely connected. Using the on system, the unit would be susceptible to error from line-voltage change or frequency variation with any large deviation causing false indication of phase rotation.

All testers using lamps should be constructed so that the bulb is clearly visible. Any jewels should be removed from the light socket assemblies. Jewels cause the light intensity of the two lamps to appear similar because of the faceting of the glass.

Voltage regulation of from 110 to 120 volts is desirable when testing for sequence. The test voltmeter should be connected across each of the three phases in succession in order to determine the voltage of each phase. If this is satisfactory, the two lamps and a reactance may be connected according to Fig. 1.

Brightness of the lamps is an indication of the phase sequence of the power leads. When an inductive reactance is used, the correct sequence *A-C-B* is indicated if lamp *C* is brighter than lamp *A*. When a capacitive reactance is used, the correct sequence is indicated if lamp *A* is brighter.

In trouble shooting, if both lamps light to the same brightness, lead *B* is open or the reactance value selected is of too low or high an impedance. With proper selection of the reactance, one lamp will be almost completely out and the other will light to full brilliance.

Where it is desirable to use an inductance, its value may be calculated from the formula

$$L = \frac{X_L}{2\pi f}$$

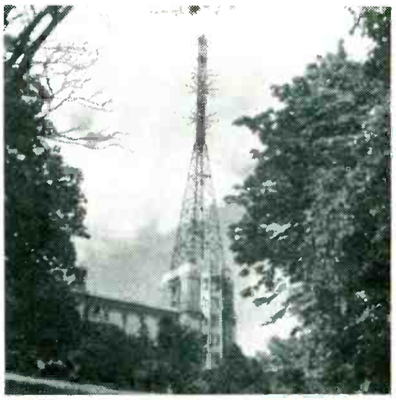
where X_L is the hot resistance of one lamp.

Television in Britain

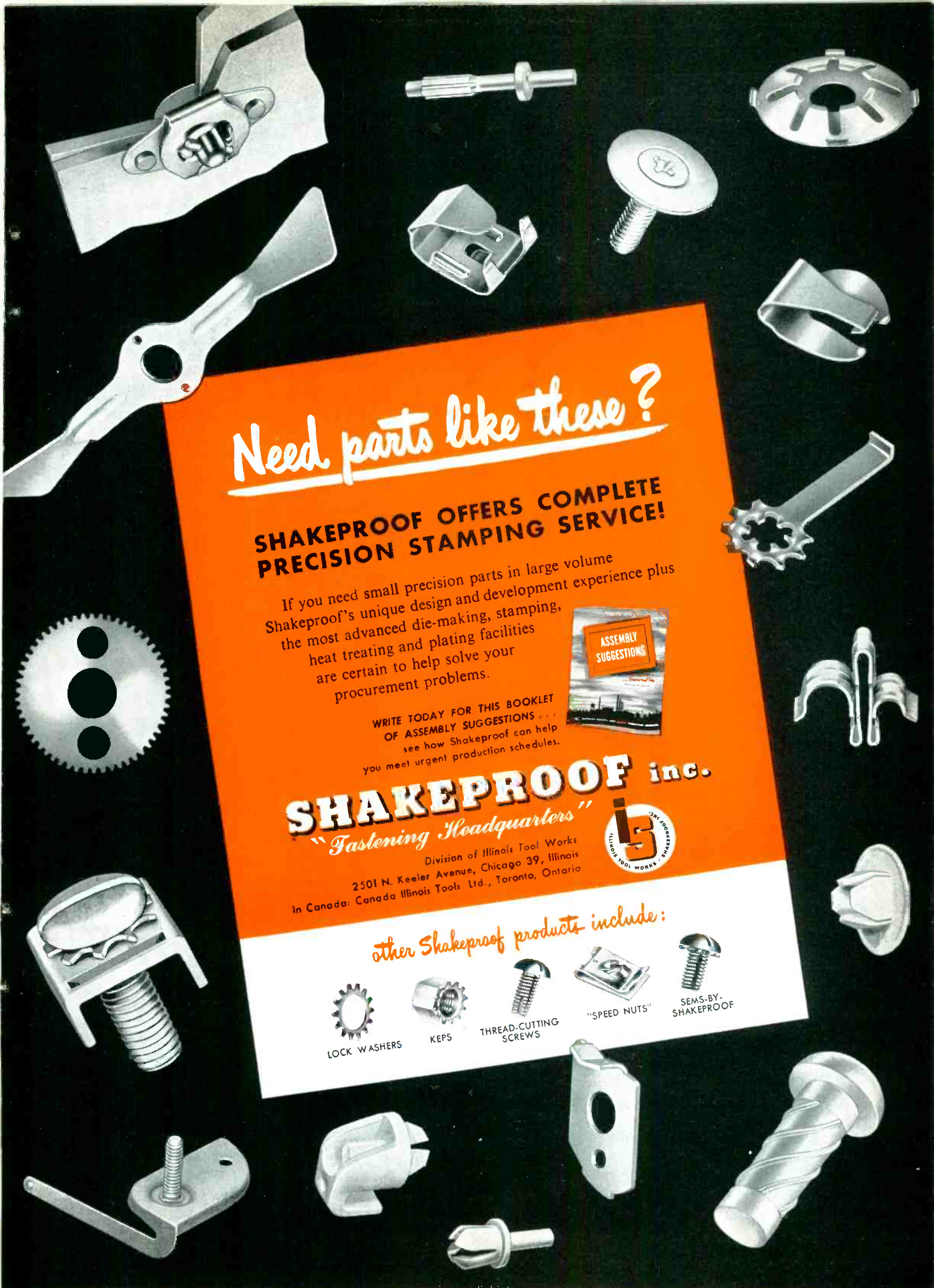
More than half a million people in Britain now have television sets and, if the proposed expansion program is carried through, every home in the country will be within range of a transmitting station by 1954.

Television sets may be obtained in Britain for less than about $135, but the average price is higher. Besides the initial cost, other expenses are for installation charges and for a combined sound and vision receiving license, which costs a little oved $5 a year. More than half of the tv set owners, concentrated at present in the southern half of the country, are in the lower middle and working classes.

The two transmitting stations in



Alexandra Palace station's 300-foot tv antenna at Muswell Hill, London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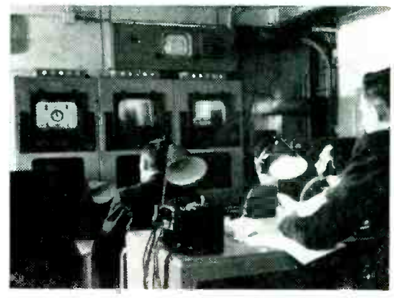
operation now are Alexandra Palace in London and Sutton Coldfield in the Midlands. Alexandra Palace operates at 17 kw on a video frequency of 45 mc with sound at 3 kw on 41.5 mc. Sutton Coldfield operates at 35 kw on a video frequency of 61.75 mc with sound at



Control room at Lime Grove studio, Shepherd's Bush. Screen at bottom right shows picture being transmitted from Lime Grove. Upper screen shows cricket score being transmitted from Alexandra Palace

12 kw on 58.25 mc. In Britain, 405 lines per picture and 25 frames per second are used.

A third station is due to be opened next summer at Holme Moss, on the moors near Huddersfield, in Yorkshire, and a fourth station at Kirk o'Shotts, midway between Edinburgh and Glasgow is scheduled to open at the end of 1951. Other stations are planned to serve Wales, the South West of England, Aberdeen, Belfast, Newcastle, Southampton and Plymouth.

Video Diplexer

A unique device known as a diplexer which does about the same kind of work as a hybrid transformer in telephone line equipment will be used in the new tv transmitting stations. It combines sound and video signals so that a single antenna array can handle both. The diplexer serves another purpose in preventing video power from being fed back into the sound feeding system. Both the video and sound feeding systems will employ 53-ohm coaxial feeders.

The present $2,700,000 a year service provides afternoon and evening programs consisting of studio shows, outside broadcasts and films. Films are mainly of the documentary type and comprise the smallest part of the programming.

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Current (ma)	65	75	100	150	200	250

Type No.	RS300	RS350	RS400	RS500	RS1000
Current (ma)	300	350	400	500	1000

SEND FOR TECHNICAL AND DESCRIPTIVE BULLETIN NO. IS-1249

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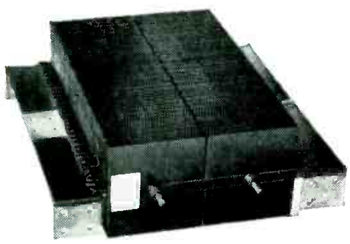

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Suitable for Oil Immersion

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THE ELECTRON ART

(continued on p 140)

shown in Fig. 1. The horizontal line corresponds to f_A, the inclined dashed line, to f_B. At time T the two frequencies are equal. The line with spikes corresponds to the rate of change of phase of the resultant when the two signals A and B have passed through a limiter.

It is seen that as the beat frequency increases in numerical value, the spikes increase in size and occur more frequently. At time T when the beat frequency is zero the spikes disappear. Before time T the spikes are negative while after time T they are positive. That is so if the intensity of A is less than B. If A were greater than B the reverse would be the case. The important point for the present purpose is that the direction of the spikes changes as the beat frequency passes through zero. The direction of the spikes indicates therefore whether the beats are positive or negative, that is whether the frequency of A is greater or less than that of B.

The spiked line is readily turned into a voltage of the same wave form by means of a discriminator or the equivalent. By finding from this wave form whether the positive peaks are greater or smaller than the negative peaks it is therefore possible to ascertain the polarity of the beat frequency provided the ratio r remains either greater or less than unity.

Circuit

A circuit for this purpose is shown in block diagram in Fig. 2.

The signal B is amplified, then limited and passed through a filter. The purpose of this limiter and filter is to obtain a signal of predetermined amplitude. An oscillator set at the desired frequency is added to this signal, its amplitude being either slightly greater or

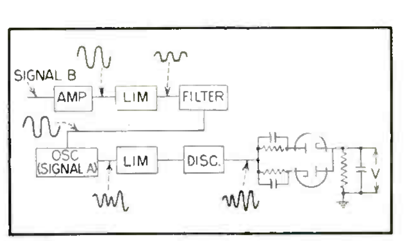
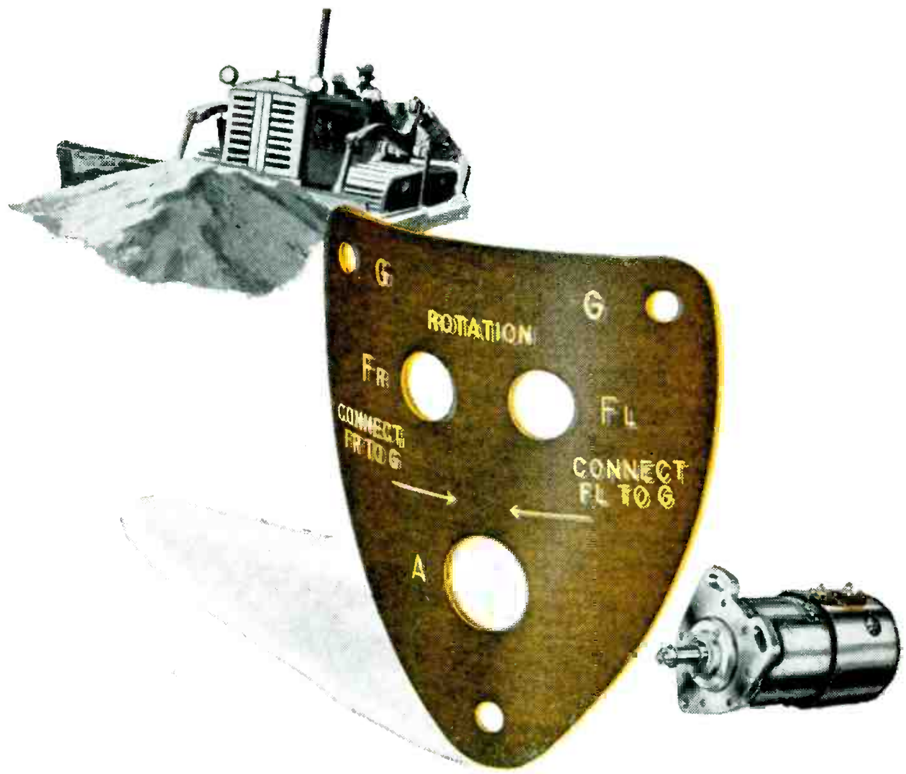


FIG. 2—Block diagram of equipment for determining exact instant when one variable frequency is of same value as another



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PLASTICS WHERE PLASTICS BELONG **SYNTHANE** S slightly less than the signal B at that point of the circuit. It is important that the ratio of the signal intensities remains substantially the same and does not pass through unity. The two signals A and B are passed through a limiter and discriminator which produces the spiked wave form shown in Fig. 1. This output is then analyzed by means of two diodes to establish whether the positive maximum is greater or less than the negative maximum. The polarity of the voltage V provides the required indication. When V is zero the frequencies of A and B are equal. Thus the time T is obtained.

A corrolary to this system can be developed into a means for finding accurately when the amplitude of a signal equals that of another. If the frequency of signal A is greater than that of signal B, the spikes will be negative when the amplitude of signal A is greater than that of signal B, and vice versa. The method consists, therefore, of making the frequency of signal A always either consistently greater or consistently less than that of B and finding whether the spikes are positive or negative by a circuit similar to that described. The point at which the spikes change sign is very sharp and indicates the point of equal amplitude of the two signals.

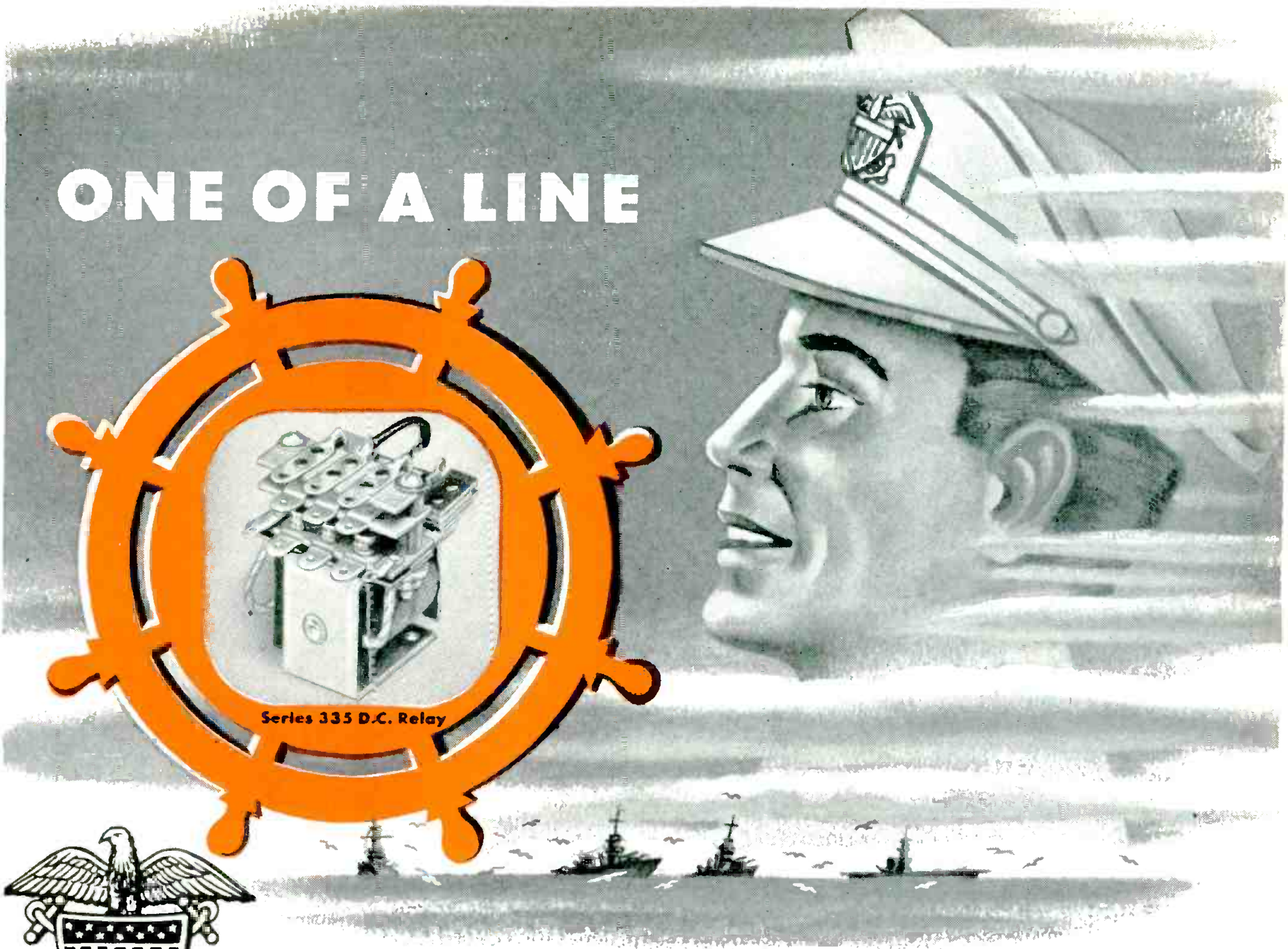
Multiple-Channel D-C Amplifier

By Leonard Goldberg
Reeves Instrument Corporation
New York, N. Y.

D-C AMPLIFIERS employing negative feedback are universally used as operational amplifiers in d-c analog computers, each desired operation requiring one amplifier. This article describes a new type of amplifier which will perform any number of operations simultaneously, thereby substituting one amplifier for several standard ones. Greater economy may be expected through the use of fewer tubes and other components.

Open Loop

The new circuit may best be described by comparison to a con-



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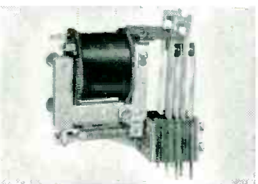

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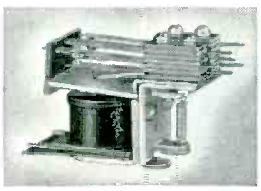

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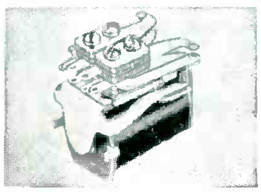

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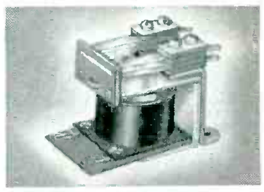

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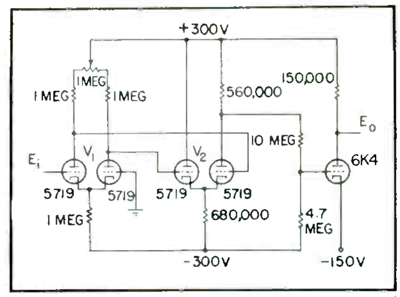

FIG. 1—Conventional single-channel amplifier

ventional single-channel amplifier, such as illustrated in Fig. 1. Other basic designs may just as easily be employed; the only requirement is that the circuit have a differential first stage. This is a three-stage amplifier using five tubes. The grid of V_1 is grounded so as to establish the input grid at a virtual ground, when connected closed loop. Tube V_2 is necessary to maintain a constant cathode current in the second stage. Furthermore, V_1 and V_2 are employed for compensation against variations in filament and supply voltages. The circuit equation is

$$E_o = -AE_i \qquad (1)$$

where A is the gain of the amplifier.

The multiple-channel amplifier, as illustrated in Fig. 2, may be designed by a direct expansion of the single-channel amplifier. The purpose of tubes V_1 and V_2 is the same as before, yet the total number of these compensatory tubes is two, regardless of the number of channels employed. The circuit equations for N channels are

$$E_{ao} = -AE_{ai} + \frac{A}{N}\underbrace{(E_{bi} + E_{ci} + \ldots E_{ni})}_{(N-1)\text{ terms}} \qquad (2)$$

$$E_{no} = -AE_{ni} + \frac{A}{N}\underbrace{(E_{ai} + E_{bi} + \ldots E_{(n-1)i})}_{(N-1)\text{ terms}} \qquad (3)$$

For closed loop operation, each input-output pair may be treated as an independent amplifier.

The degree of independence of one amplifier to another (interaction between channels) is defined as the effective zero shift at the input of any one channel caused by a sig-

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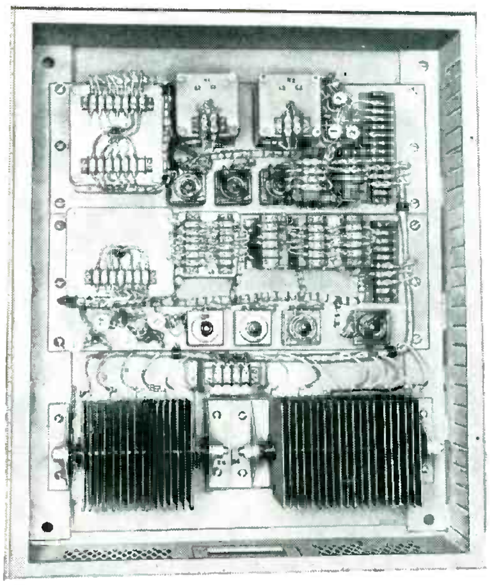

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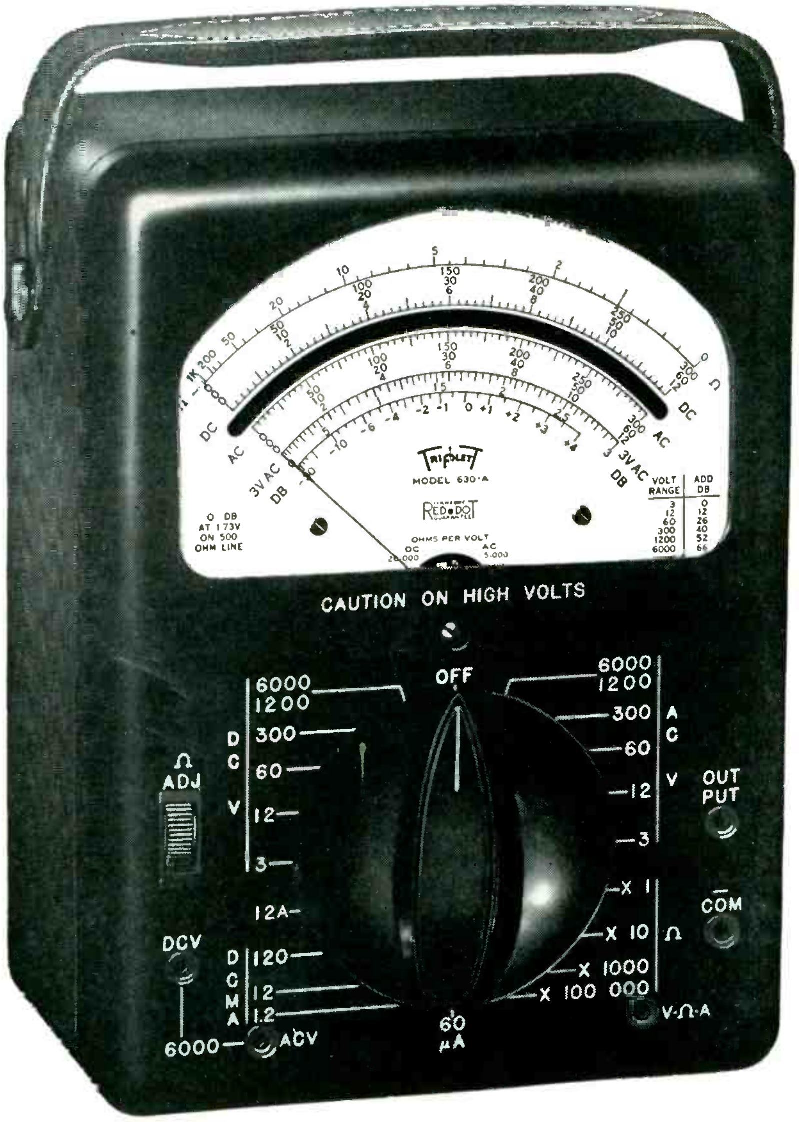

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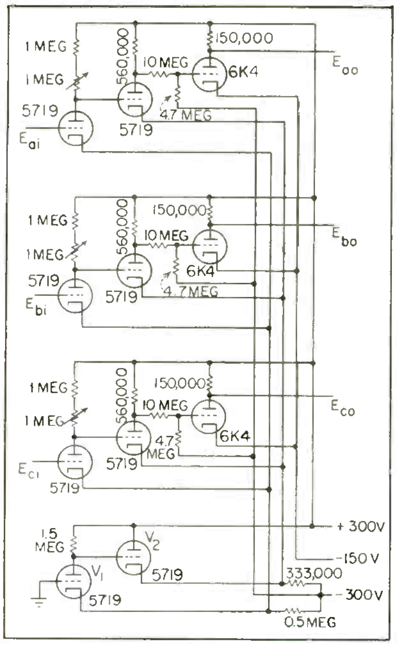

FIG. 2—Multiple-channel amplifier (three channels shown) using basic design of Fig. 1

nal being impressed at a different channel. Expressed another way: what new voltage is required at the input to channel N (E_{ni}), such as to maintain its output (E_{no}) at zero? This is easily derived from Eq. 3; set $E_{no} = 0$, and solve for E_{ni}.

$$E_{ni}\,(E_{no} = 0) = -\frac{1}{N}\overbrace{(E_{ai} + E_{bi} + \ldots E_{(n-1)i})}^{N-1 \text{ terms}} \qquad (4)$$

Equation 4 states that the zero position of any input grid is equal to the algebraic average of all the other grid voltages in the first stage, including the grounded grid of V_1.

However, since E_{ai}, E_{bi}, and so on, are usually not known and are not of primary interest, this equation is not in usable form. It is neither simple nor useful to solve this equation in the general case (free choice of external circuitry for all channels), although interaction may be easily determined in any particular closed-loop circuit. Two examples, therefore, are given. The effect of one channel upon all the others is derived from the circuit of Fig. 3A; the effect of all but one channel upon the one remaining is derived from the circuit of Fig. 3B.

Consider the circuit of Figure

3A. The appropriate equations are

$$E_{bi} = E_{ci} = \ldots E_{ni} = E_{bo} = E_{co} = \ldots E_{no} \text{ (circuit symmetry)} \quad (5)$$

$$E_{ai} = \frac{N-1}{N} E_{ni} - \frac{E_{ao}}{A} \quad (6)$$

(from Eq. 2 and 5)

$$E_{ni} = \frac{A}{2A+N} E_{ai}$$

(from Eq. 3 and 5) (7)

$$E_{ni} = -\frac{N}{A(N+1)+N^2} E_{ao} \quad (8)$$

(from Eq. 6 and 7)

Since A may be expected to be considerably larger than N, Eq. 8 may be rewritten

$$E_{ni} \cong -\frac{N}{A(N+1)} E_{ao} \quad (9)$$

Equation 9 states that the effective zero shift at any input grid caused by a signal being impressed at a different channel is a function of both the open-loop gain of the amplifier A, and of the number of channels N. It is evident from this expression that it is desirable to make A as large as is feasible. Note further that

$$E_{ai} = -\frac{N(2A+N)}{A(A+AN+N^2)} E_{ao} \quad (10)$$

(from Eq. 6 and 7)

which, since A is large, may be rewritten

$$E_{ai} \cong -\frac{2N}{A(N+1)} E_{ao} \quad (11)$$

This states that the effective open

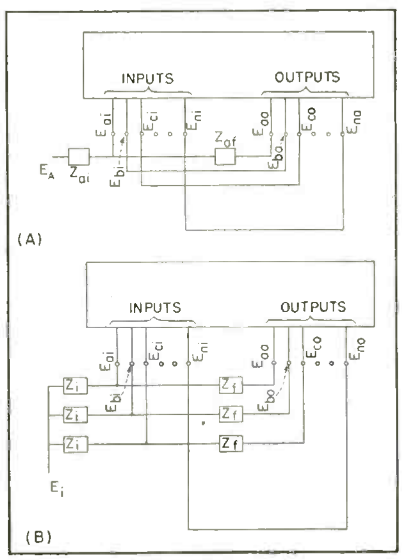

FIG. 3—Multiple-channel amplifiers (*N* channels) with only *A* channel connected in usual manner (A) and with all but *N* channel connected in usual manner (B)

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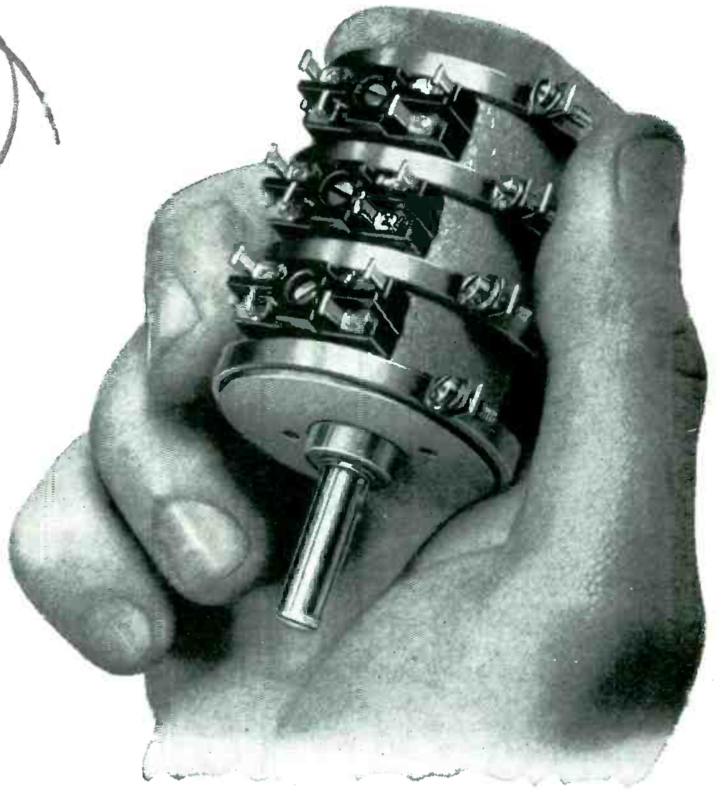

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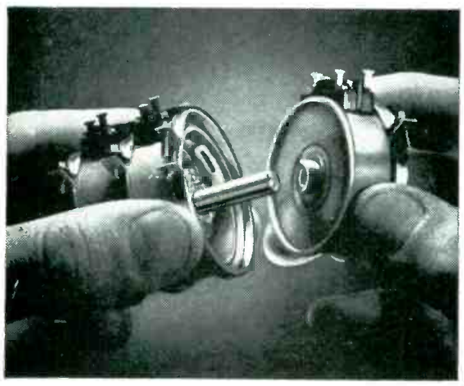

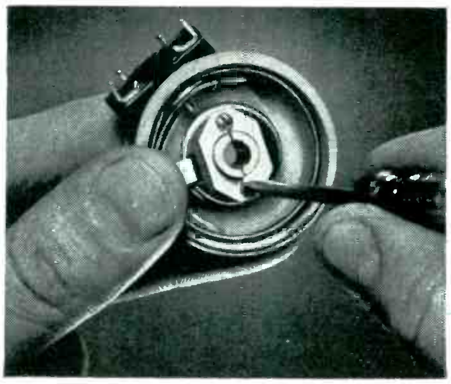

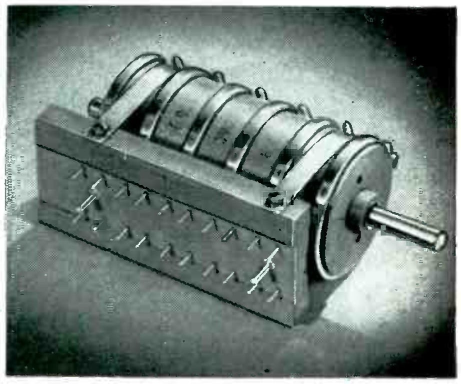

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Torque—1.5 oz-in.

Dimensions—diameter 1.750 max.; length (1 cup) .800 in. ±.009 in.; added length per unit ganged .580 in. ±.002 in.

Case—grey anodized aluminum

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loop gain of the amplifier is reduced by the factor $(N + 1)/2N$ from that of the equivalent single channel amplifier. Note, however, that this reduction in gain can never exceed 1/2, as $(N + 1)/2N$ is always greater than 1/2.

Consider next the circuit of Fig. 3B:

$$E_{ai} = E_{bi} = \ldots E_{(n-1)i} \quad \text{(circuit symmetry)} \tag{12}$$

$$E_{ao} = E_{bo} = \ldots E_{(n-1)o} \quad \text{(circuit symmetry)} \tag{13}$$

$$E_{ni} = E_{no} \tag{14}$$

$$E_{ai} = \frac{1}{2} E_{ni} - \frac{N}{2A} E_{ao} \tag{15}$$

(from Eq. 2 and 12)

$$E_{ni} = \frac{A(N-1)}{N(A+1)} E_{ai} \tag{16}$$

(from Eq. 3, 12 and 14)

$$E_{ni} = -\frac{N(N-1)}{2N + AN + A} E_{ao} \tag{17}$$

(from Eq. 15 and 16)

Since A may be expected to be considerably larger than N, Eq. 17 may be rewritten

$$E_{ni} \cong -\frac{N(N-1)}{A(N+1)} E_{ao} \tag{18}$$

Comparing Eq. 9 and 18 it is seen that the effective zero shift at channel n is the algebraic sum of the zero shifts caused by each of the other channels, from which the general expression for interaction may be induced:

$$E_{ni} \cong -\frac{N}{A(N+1)} \times (E_{ao} + E_{bo} + \ldots E_{(n-1)o}) \tag{19}$$

It might be wise at this point to cite an example of Eq. 19 so as to illustrate the order of expected interaction between channels. In the worst case, if E_{ao} thru $E_{(n-1)o}$ are equal and large, say 100 volts, $N = 10$, and $A = 10{,}000$, then $E_{ni} = -82$ millivolts. Since interaction

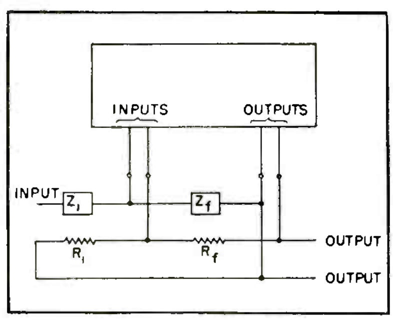

FIG. 4—Two channel amplifier connected with one independent and one slave channel. When R_1 equals R_f this is typical push-pull operation

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may be thought of as a new source of drift, 82 millivolts would in most cases be prohibitive.

Therefore, the use of the multiple channel amplifier should be limited, as follows: (a) Open-loop gain as large as is feasible, (b) Not too many independent channels. Slave channels (wherein the input of one channel is fed from the output of another) need not be considered independent in this regard. (c) The maximum output voltage should be kept low.

Conclusion

In general, the advantages of the multiple-channel amplifier are as follows: (a) Uses fewer tubes and other components. It is therefore of great value wherever size, weight, and power consumption are at a premium—such as airborne and other portable equipment. (b) This amplifier is particularly well adapted for slave channel operation, such as push-pull output from a single signal (see Fig. 4), or in general for any set of channels wherein there is actually but one variable input voltage. When operated in this manner, interaction may be completely eliminated by a slight readjustment of the feedback resistors in the slave channels. (c) It lends itself well to plug-in construction techniques. To the basic circuit of Fig. 1 may be added any number of additional

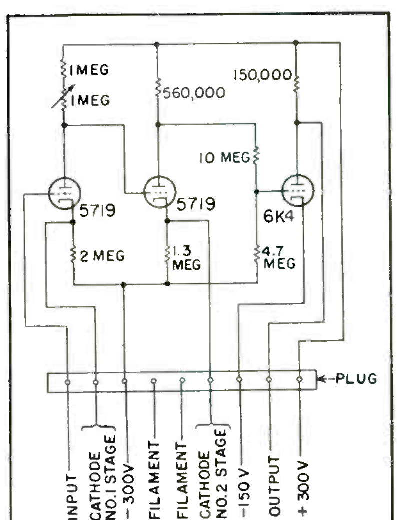

FIG. 5—Circuit for each additional channel illustrates possibility of plug-in technique

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amplifiers, such as illustrated in Fig. 5, with no other effect upon remaining channels than to necessitate a slight rezeroing.

The disadvantages include: (a) Output impedance slightly higher (by factor $2N/(N+1)$). (b) Interaction between channels resulting in a loss of accuracy. (c) While this amplifier may replace any number of inverse gain amplifiers, it cannot perform all the operations of the universal d-c amplifier to be described in a future issue of ELECTRONICS. (d) A practical difficulty may be encountered in trying to locate $N+1$ nearly matched triodes for the first stage.

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National Bureau of Standards
Washington, D. C.

THE RESONATORS discussed in this note have been used successfully as oscillator tank circuits between 50 and 550 megacycles. Their large tuning range suggests that they may be useful in uhf television receivers or in laboratory oscillators. Work on the resonators was inspired by Aske's description[1] of a single-ended variable capacitance-inductance tuned circuit. Two experimental balanced types, drawings of which are shown in Fig. 1, were machined from brass tubing. Tuning is effected by moving a cylindrical conducting slug axially through the resonator. Terminals of the resonators are located at points x. There is a superficial resemblance to the coaxial butterfly circuits described by Karplus[2], but the resonators are essentially lumped-constant devices rather than transmission line sections.

The resonator of Fig. 1A consists of a single-loop inductance connected to capacitors made up of two short half-cylinders and the tuning slug. The minimum frequency is produced when the slug is entirely contained by the half-cylinders, since then both the capacitance and the inductance are at a maximum. Conversely, the maximum frequency is produced when slug is contained by the loop. The

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3738 *Applications*

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- POTTING JOBS which require its distinctive properties.
- SEALING SOCKETS AND SCREW HOLES for which a filling composition with good adhesion and high cold-flow temperature are specified.

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- HIGH COLD-FLOW TEMPERATURE COUPLED WITH LOW-POURING TEMPERATURE facilitates potting high operating temperature units which contain delicate parts that would be damaged by compounds poured at high temperatures. The low pouring viscosity of 3738 recommends its application to potted units in which minimum clearances of small filling holes require a free flowing composition.

  The combination of viscosity and cold-flow, in 3738, permits rapid application of dip-coatings to resist sagging and sweating at temperatures above 105°C.
- GOOD FLEXIBILITY AND ADHESION permit good moisture seals around leads and physical shock-resistance on both dip-coated and potted units.
- RAPID RATE OF SET speeds production when used for dip-coating, potting or sealing.
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Methods of Application

- POTTING AND SEALING: The viscosities of 3738 differ appreciably between the upper and lower limits of the suggested pouring temperature range. To obtain higher or lower pouring viscosities, temperatures below or above this range can be employed.

Best adhesion, without surface priming, is obtained by pouring at temperatures in the upper portion of the suggested range or by preheating the unit.

Although 3738 has a low-pouring viscosity, preheating is recommended when filling close tolerance areas where a quick chill may be caused by cold parts. Preheating is suggested since 3738 sets at relatively high temperatures.

DIP-COATING: The thickness of 3738 on a single dip can be varied considerably. Generally higher bath temperatures and shorter periods of immersion will control thickness or thinness of coating.

3738 *Specifications*

Cold Flow (M-R)..248/253 F

Penetrations

32/200/60 1-2
77/100/5 7-8
115/50/5 10-12

Color ....Black

Softening Point (B&R) ....254/259 F

Pouring Temperature....340/390 F

Specific Gravity 1.03

Flash Point ....480 F

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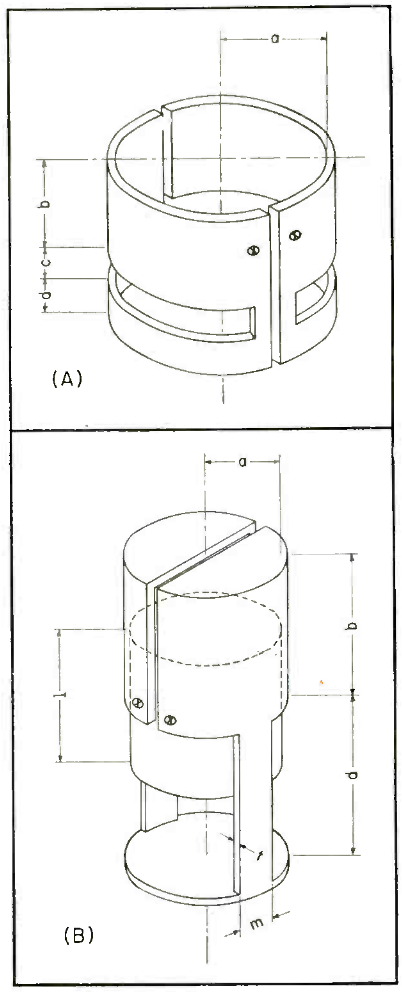


FIG. 1—Experimental vhf-uhf resonators, having frequency ranges from 50 to approximately 550 mc

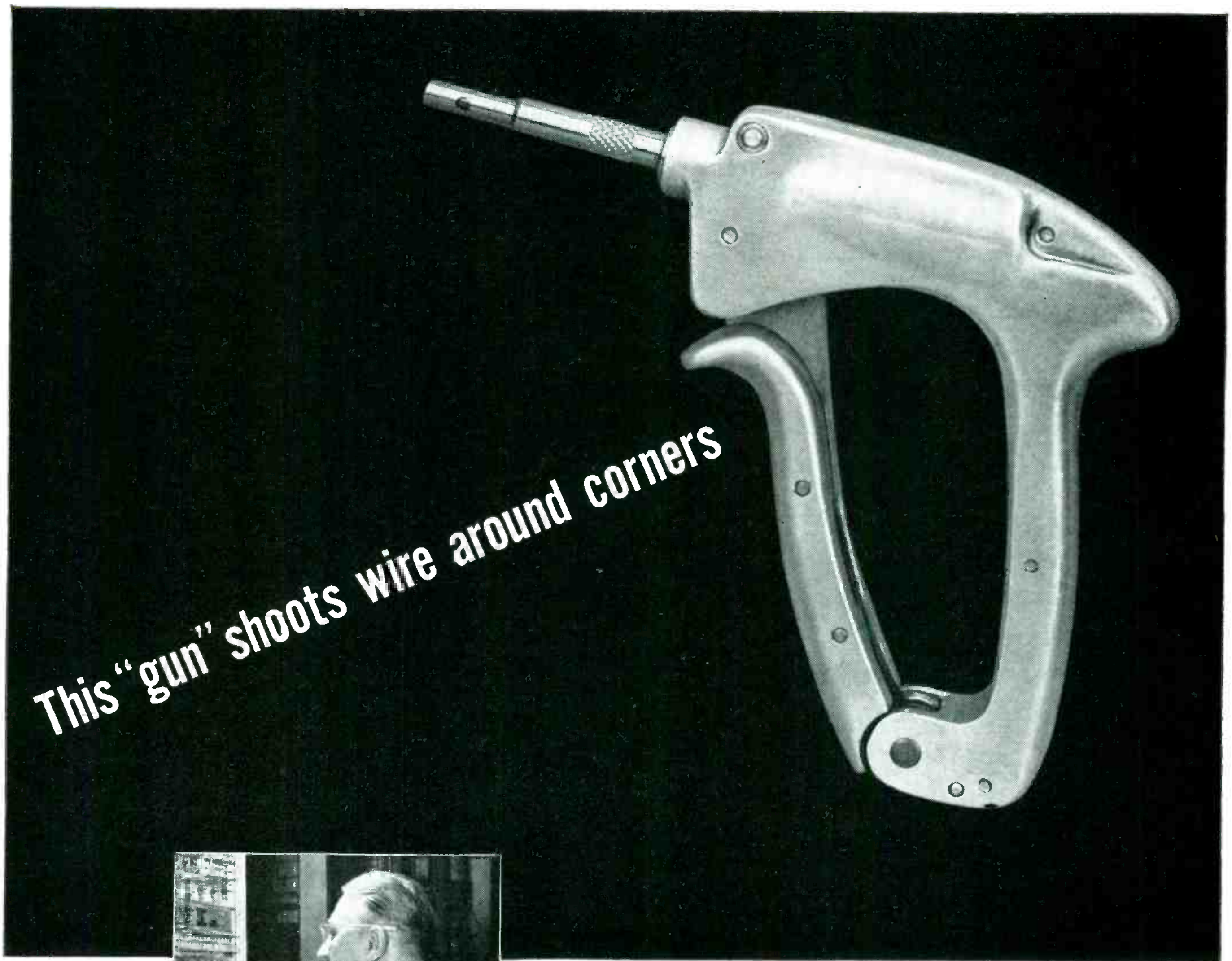
resonator shown in Fig. 1B is similar in that half-cylinders are employed for capacitors; however, the inductors consist of two parallel strips, as shown. The tuning mechanism is essentially the same as for the first resonator.

Optimum ratios of the resonator dimensions for maximum tuning range are probably best determined by experiment. But if it is assumed that the tuning slug shall always remain inside the resonator, then it appears that maximum variation in the capacitive and inductive parts of the resonator will be obtained for $b = c + d$ in Fig. 1A and for $b = d$ in Fig. 1B.

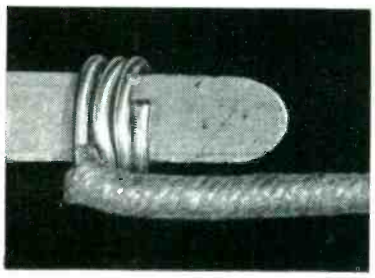
In Fig. 1A, assume that the dimensions are fixed at

$$a = b = 2c = 2d$$

and that the slug length is b. Then the maximum capacitance with air



Bell Telephone Company craftsman wraps a wire to complete a connection. Wire is inserted into the nozzle and a rotating spindle whips it around terminals.



Close-up of connection made with new tool—neat, tight windings.

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$$C = \frac{0.225\,\pi\,a^2}{2\,r}\ \mu\mu f,$$

where r is the radial clearance between slug and resonator, the dimensions being in inches. The corresponding maximum inductance, assuming a thin conductor and neglecting skin effect, will be, approximately,

$$L = 0.071\,a\,\mu h$$

and the minimum resonant frequency will be

$$f \approx 1{,}000\sqrt{\frac{r}{a^3}}\ \text{mc}$$

If r/a is a constant k, then

$$f \approx 1{,}000\,\frac{\sqrt{k}}{a}\ \text{mc}$$

where a is in inches.

In Fig. 1B, assume that

$$b = d = l = 2a = 5m = 24t$$

Then the maximum capacitance will be, approximately,

$$C = 0.112\left(\frac{\pi\,ab}{r} + \frac{\pi\,a^2}{2r}\right)$$

$$= \frac{0.28\,\pi\,a^2}{r}\ \mu\mu f$$

where r is both the radial clearance and the axial clearance between the slug and the inside end of the resonator.

The corresponding maximum inductance will be, approximately,

$$L = 0.04\,a\,\mu h,$$

and the minimum resonant frequency will be

$$f \approx 850\sqrt{\frac{r}{a^3}}\ \text{mc}$$

If r/a is a constant k, then

$$f \approx 850\,\frac{\sqrt{k}}{a}\ \text{mc}$$

where a is in inches.

Three experimental resonators are pictured in Fig. 2. The one at the left, which is the type drawn in Fig. 1B, has the largest tuning range. With no external connections, the resonant frequency tunes from about 50 to 600 mc. When the resonator is used as an oscillator with a 6K4 tube having one-half-inch external leads, the frequency range is 50 to 500 mc.

The medium-size resonator in the center of Fig. 2 is the type drawn

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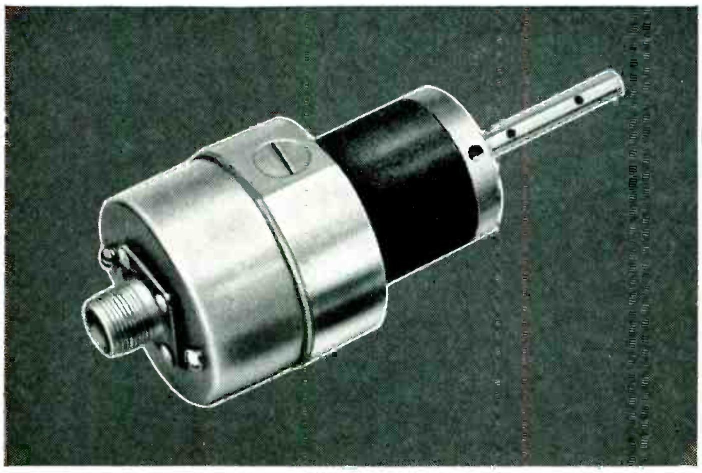

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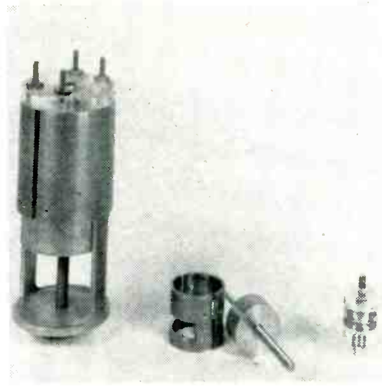

FIG. 2—Photograph of three experimental wide-range resonators that may be applicable to uhf and vhf television

in Fig. 1A. With the same 6K4 tube, the oscillation range is 220 to 520 mc. The small resonator at the right is the same type. With no external connections, the tuning range is 440 to 1,900 mc; with the 6K4 tube, the oscillation range is 340 to 550 mc.

As oscillators, the maximum frequencies of all three resonators appear to be limited by tube capacitances and lead inductances. For applications where there is no appreciable external loading of the resonator, such as an absorption wavemeter, the frequency range is limited by the smallest radial clearance that can be obtained between the tuning slug and the resonator's inner surface.

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(1) Vernon H. Aske, Front End Design for a 400-Mc Receiver, *Tele-Tech* 9, p 46, Sept. 1950.

(2) Eduard Karplus, Wide-Range Tuned Circuits and Oscillators for High Frequencies, *Proc. IRE* 33, p 426, July 1945.

Boucherot Compensation

BY HANS E. HOLLMANN

Oxnard, California

THE ELECTRONICS QUIZ in the December 1950 and January 1951 issues of ELECTRONICS deserves more attention for it reveals the phenomenon of aperiodically compensating any impedance by a conjugate impedance. This compensation, based on a theorem of complex algebra, has important application in the Boucherot circuit named after the French inventor.

We are dealing with the theorem that any complex number $Z' = a + jb$, where j can be made real

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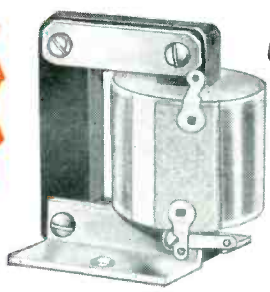

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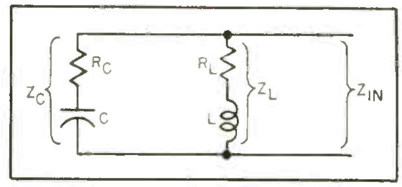

FIG. 1—Basic circuit shown in Electronics Quiz problem

with the aid of another complex number $Z'' = c - jd$. A simple addition yields: $Z_{IN} = Z' + Z'' = a + c + j\,(b - d)$ which becomes real for $d = b$. Another combination is the reciprocal sum of the reciprocals

$$Z_{IN} = \frac{1}{\dfrac{1}{Z'} + \dfrac{1}{Z''}} = \frac{Z'\,Z''}{Z' + Z''}$$

$$= \frac{ac + bd + j\,(bc - ad)}{a + c + j\,(b - d)}$$

Now, there exist two conditions for making the expression real. The first is $c = a$ and $d = b$ because the imaginary terms disappear separately in numerator and denominator so that $Z_{IN}' = (a^2 + b^2)/2a$. The second condition is $c = a = \sqrt{bd}$, and yields

$$Z_{IN}'' = \frac{2a^2 + ja\,(b - a^2/b)}{2a + j\,(b - a^2/b)} = a$$

According to Fig. 1 let us examine the impedance $Z_c = R_c + 1/j\omega C$ of the capacitive branch shunted by the inductive branch having the impedance $Z_L = R_L + j\omega L$. If we assume $R_C = R_L = R$, the impedance of the network becomes:

$$Z_{IN} = \frac{Z_L\,Z_C}{Z_L + Z_C} = \frac{(R + j\,\omega L)\,(R - j/\omega C)}{R + R + j\,(\omega L - 1/\omega C)}$$

$$= R\,\frac{L/RC + R + j\,(\omega L - 1/\omega C)}{R + R + j\,(\omega L - 1/\omega C)}$$

Following the outline, Z_{IN} becomes real if both imaginary terms disappear. That is the condition $L = C$ of parallel resonance with $Z_{IN}' = (1 + R^2)/2R \rightarrow R/2$. On the other hand, numerator and denominator differ only by their first terms. Hence, setting $L/RC = R$ or (in accordance with $a = \sqrt{bd}$) $R = \sqrt{L/C}$ yields $Z_{IN}'' = R$, the aperiodic or antiresonance case of the quiz problem.

The conversion of an originally complex network into a real one, that is, into a resistance, by supplementing a complex conjugate impedance, either in series or in paral-

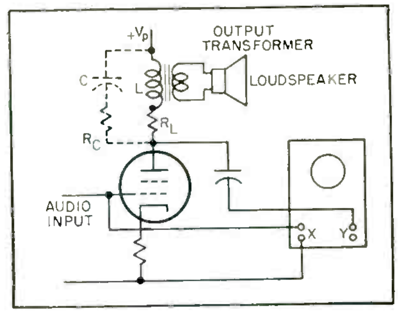

FIG. 2—Loudspeaker analogy studied after Boucherot

lel, is of great importance for many practical purposes. A typical example is the Boucherot compensation in the end stage of an audio amplifier, a triode, pentode, or beam tetrode loaded with a matching transformer as shown in Fig. 2. As is well known, the equivalent network of the transformer seen from the plate, in fairly good approximation, is an inductance L in series with a resistor R_L. The reactive component brings the tube out-of-phase so that harmonic as well as intermodulation distortions occur. These distortions limit the value of a multigrid tube as compared to a simple triode and counterbalance the inherent advantage of the higher gain. Today there are two conflicting opinions in rating an end triode exhibiting a lower plate resistance and useful efficiency under low distortions as compared to multigrid tubes requiring less driving power at the expense of distortions even at moderately high frequencies.

In order to shift the balance in favor of multigrid tubes, the Boucherot compensation is of significant importance because it makes the multigrid tubes operate purely in-phase and improves the power output versus distortion figure. The suggestion: "go ahead by going back—back to triodes"[1] seems to be premature as long as the Boucherot compensation is not taken into consideration.

The improvement which is achieved by the Boucherot network is clearly demonstrated by means of the dynamic transfer characteristic. According to Fig. 2, the end stage is driven by an a-f voltage which also controls the X-input of the oscilloscope, the Y-deflection of which is produced by the plate voltage. If the test device is driven


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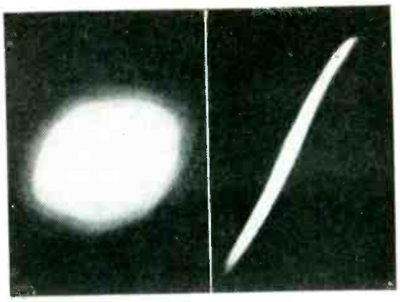


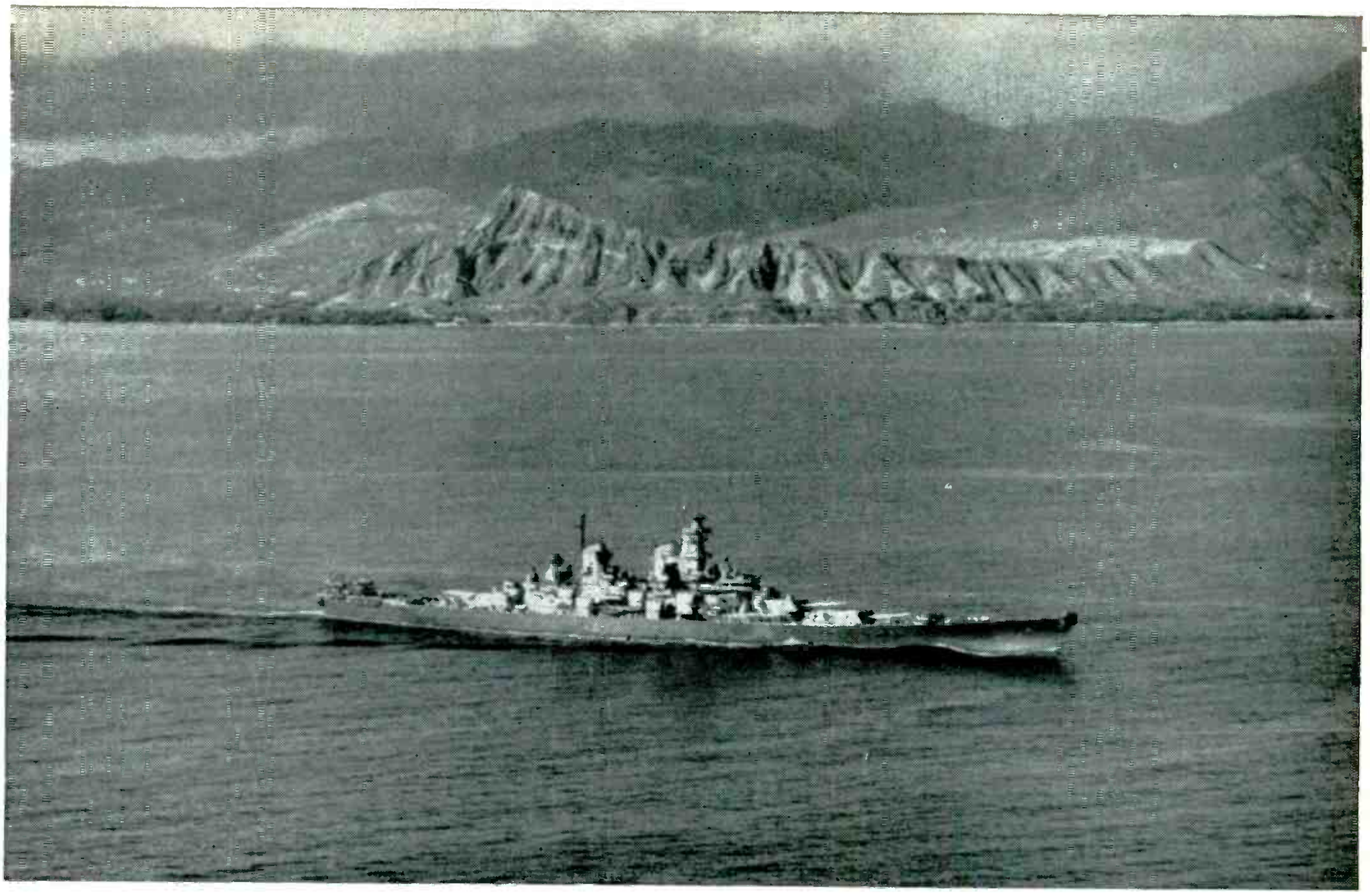
FIG. 3—Oscilloscope figures show improvement in performance

with various frequencies, as delivered by a radio or phonograph pickup in the form of music or speech, the resulting Lissajous figure on the oscilloscope screen fluctuates according to the momentary frequencies and amplitudes. The result, taken during sufficiently long exposure time, is the blurred figure shown at the left in Fig. 3, disclosing innumerable Lissajous ellipses of various forms and sizes superimposed upon each other during exposure.

As soon as the output transformer is compensated by the dotted Boucherot network, the end stage operates in-phase and the Lissajous ellipses contract to the pure-in-phase characteristic shown at the right in Fig. 3. Needless to say, the harmonic and intermodulation distortions diminish to a considerable extent bringing to the listener a faithful reproduction of the original speech or music.

The oscillogram reveals the effect of the Boucherot compensation only in a qualitative manner. A better insight is obtained by measuring the harmonic or the intermodulation distortions with and without Boucherot compensation. Figure 4 illustrates such an experiment[2], namely the intermodulation factor of an end tetrode in relation to the measuring frequency when the tube is driven by a constant input voltage. While the output phase condition produces increasing modulation, the distortions decrease slightly as soon as the Boucherot compensation is applied.

Certainly the Boucherot circuit is not perfect and cannot produce an ideal condition of operation. In comparison to the evident advantages, however, the following disadvantages must be mentioned. First, the equivalent network of the transformer and its loudspeaker



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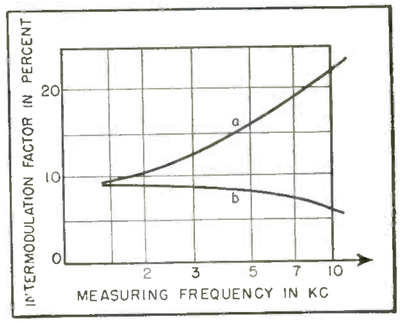

FIG. 4—Curves show actual measurements on equipment using Boucherot compensation

load holds only within certain limitations. Second, there is a power loss in the compensating branch which increases toward higher frequencies thus making the frequency response poorer. This can be compensated for by other means, for example, by filter circuits in the driver stage or in the feedback loop.

After all, the disadvantages do not count too seriously when compared with the pure-in-phase condition and the associated reduction of distortions in the most important output stage.

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(2) A. V. Lüpke, Verbesserung der Wiedergabe mit Lautsprechern hinter Mehrgitterröhren durch Verwendung der Boucherot-Schaltung (Improvement of loudspeaker quality when driven by multigrid tubes with the aid of the Boucherot circuit), *Zeits. für Tech. Physik*, Vol. 23, p 119, 1942.

Noise Figure Standards

THE NOISE FIGURE, a fundamental measure of the quality of linear electrical networks, is of basic importance in radar, telemetering, and all communications. In these systems some of the limitations on reliability, sensitivity, and distance are set by the type and magnitude of noise in the device as well as by the noise produced ahead of the network input terminals. In order to assist laboratories and industry in the evaluation of this important factor, the National Bureau of Standards is offering a calibration service for the noise figure in the frequency range of 500 kc to 30 mc.

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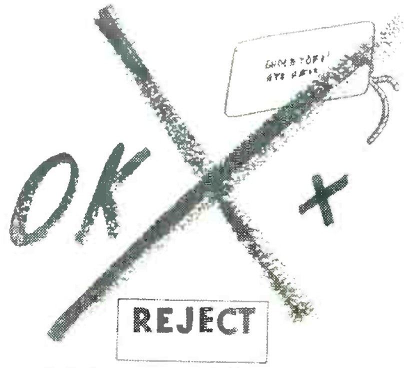

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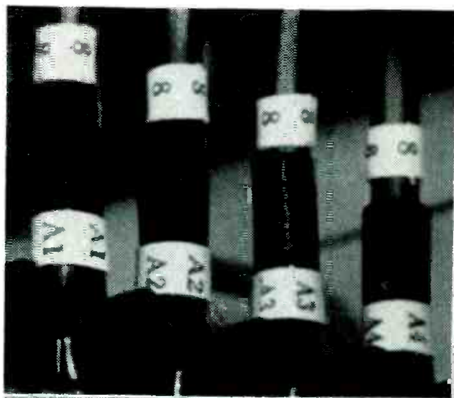

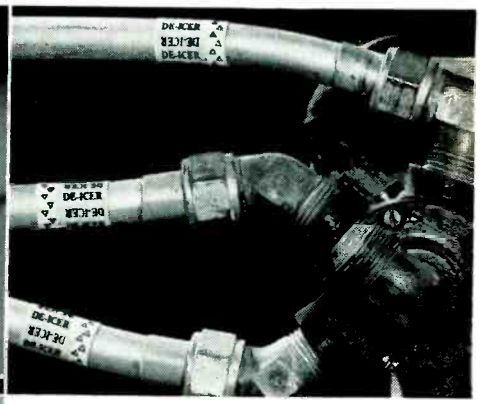

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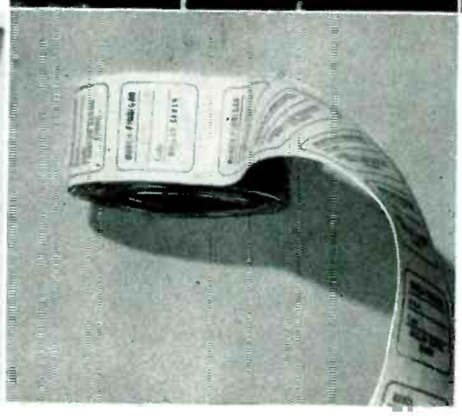

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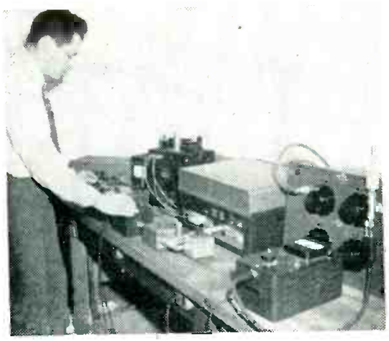

Set-up at National Bureau of Standards for noise figure calibration. At left arm of tee is the noise diode, and the right arm is a two-terminal network simulating the source. At right is a precision attenuator with a voltmeter directly in front of it

tal network and source noise) to the available noise power at the output source alone. Noise power in an electrical network is generated by the network resistance (Johnson noise) and its vacuum tubes (shot noise). The noise figure is a function of frequency and of the network and source impedance; both are measurable to a high degree of accuracy by various independent techniques. With these important parameters of a unit accurately evaluated, calibration can now be made. The Bureau's calibration method breaks down into one involving only five components—a temperature-limited noise diode, a two-terminal source network, a four-terminal network under calibration, an attenuator, and a sensitive voltmeter.

The equivalent noise resistance used in evaluating the technique utilizes the concept that the noise power from the network can be represented by the Johnson noise of this resistance. Experimental verification of this theory was made with eleven different values of test impedance and at frequencies of 0.5, 4.3, 12, and 30 mc. Measurements made with the temperature-limited diode conclusively proved that the equivalent noise resistance was constant for all the values of test network impedance at each frequency. The evaluation has shown that the Bureau's calibration method will yield precise noise figures. It was also proved that this method of calibrating noise figures is valid for a matched or unmatched condition of input impedance. In

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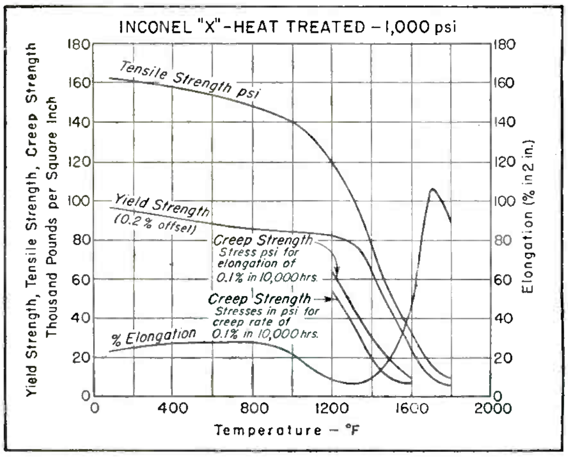
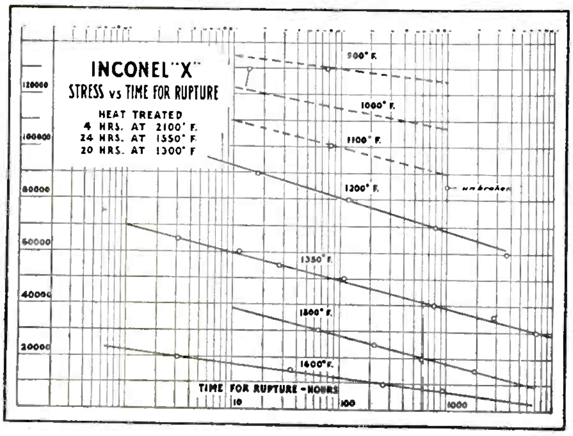


Short-time high-temperature properties of fully heat-treated Inconel "X".



High-temperature stress-to-rupture properties of fully heat-treated Inconel "X".

- **Impact Strength**—For fully heat-treated Inconel "X", typical impact strength values are: 33 ft. lbs. at −320°F, 37 ft. lbs. at room temperature, 67 ft. lbs. at 1500°F, and 113 ft. lbs. at 1600°F.
- **Hardness**—By proper heat treatment, the room temperature hardness of Inconel "X" can be developed as desired from BHN 140 to BHN 400.
- **Spring Properties**—By a combination of heat treatment and cold working, Inconel "X" develops unusually high spring properties. For spring applications from sub-zero temperatures up to about 650°F, it is useful where otherwise unusually strong ferrous springs must be used. Up to 1100°F, Inconel "X" springs will give useful performance where few other metals can be relied on.
- **Machining**—Inconel "X" is machinable in all conditions. Because of its strength and toughness, it cannot be machined as easily as softer metals; it can, however, be machined at satisfactory rates.
- **Forging**—No unusual difficulties are encountered in forging Inconel "X", though heavier equipment than that used on ordinary steels is required.
- **Welding**—Inconel "X" can be welded by nearly all commonly used methods including: metal arc, inert gas metal arc, atomic hydrogen arc, resistance spot and seam, resistance butt welding. Satisfactory joints have been made between two parts of Inconel "X", and also between Inconel "X" and other alloys including standard Inconel, Stainless Steels types 310 and 347, and cast Stellite 21 and 30.
- **Applications**—Inconel "X" is used for springs supporting television tubes in a face coating dryer. Also for highly stressed bolts and for expansion bellows . . . wherever a combination of high stress and extreme heat must be met.
- **Forms Produced**—Inconel "X" is produced in most commonly used mill forms—billets, rod, flats, rounds, hexagons, sheet, strip, bar, wire, seamless tubes, and welding rods. Like all alloys containing nickel, it is in very limited supply except for defense use.

FURTHER DATA AVAILABLE

A 79-page reference manual "Inconel 'X', Data and Information," *contains all the engineering information compiled to date on this alloy. This publication is available, free, for your information.*

And for technical help on specific problems involving metals at high temperatures, write, outlining your problems, to Inco's Technical Service Section.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
NICKEL INCO ALLOYS

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL • "S"® MONEL
NICKEL • LOW CARBON NICKEL • DURANICKEL®
INCONEL® • INCONEL "X"®

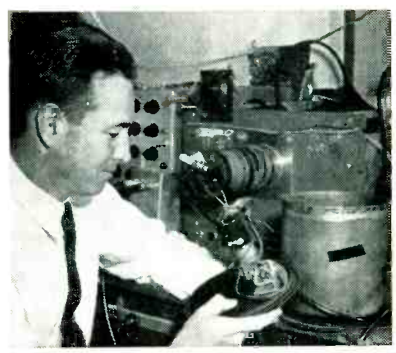
addition this method may be successfully applied to measuring the impedance of two-terminal networks.

Thus, with the theory verified by a wide range of experiments, the Bureau is equipped to provide standards for noise figure measurements. Calibrations can be made for high gain, linear, four-terminal networks such as radio receivers and amplifiers (10 to 150 ohms) source impedances) to ±0.2 decibel and at frequencies up to 30 mc. Work is in progress to extend noise figure standards to 300 mc.

Super-Speed Scintillation Counting

BY PLACING 4,000 volts on a conventional multiplier phototube instead of the prescribed 1,000, Stanford University researchers have succeeded in extending the range of scintillation counters.

The use of such high voltage is made possible by cutting down on duty factor. The counter is being used to study the operation of Stanford's linear accelerator, which operates for approximately one microsecond once every 1/60 second. Certain studies require that the



Operating multiplier phototube at 4,000 volts for short periods of time, instead of 1,000 volts prescribed, extends range of scintillation counter

scintillation counters be operative for only a billionth of a second, thus permitting the higher voltage to be applied without inflicting permanent damage to the tube.

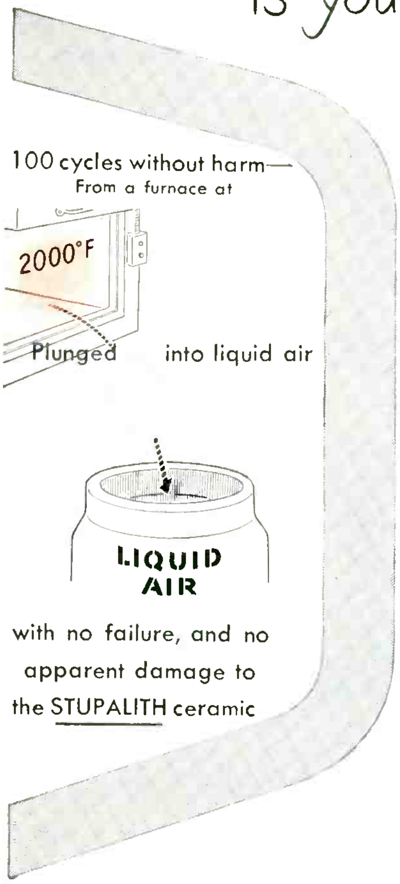
It is hoped that the stepped-up counting speed will enable time-in-flight measurements to be made with sufficient accuracy to facilitate direct mass measurements of particles.

Looking for a material to withstand

EXTREME THERMAL SHOCK?

STUPALITH

is your answer!

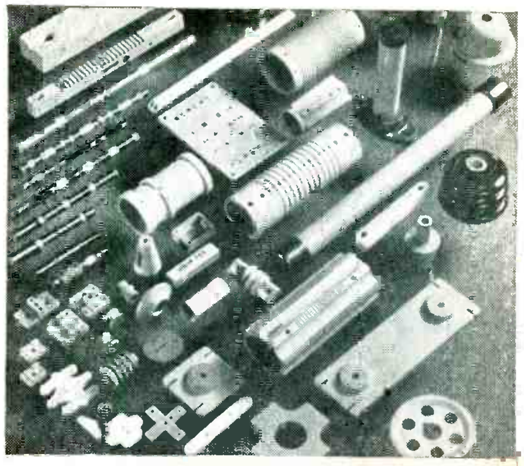


Remarkably low thermal-expansion characteristics make STUPALITH *ideal* for applications where conditions of extreme thermal shock are present.

Stupalith may be formulated and processed to possess Zero, Low-Positive and Low-Negative expansivities. Formed by conventional methods—pressing, extrusion or casting—STUPALITH may be machined or ground to precision tolerances. Can be safely used at temperatures up to 2200° F.

The demonstration described in the illustration at the left shows the amazing ability of STUPALITH to withstand thermal shock.

We will be glad to send you a copy of Bulletin 849, which gives full details of this remarkable group of ceramics.



STUPAKOFF PRODUCTS

For Electrical and Electronics Applications

ASSEMBLIES—Stupakoff assemblies include Induction COILS for radio receivers and transmitters; SHAFTS for air-tuning condensers; METALLIZED PLATES for making fixed rigid assemblies.

CERAMICS—Stupakoff has long been a leading supplier of ceramic products for a wide variety of electrical and electronic applications—precision made for all voltages, frequencies and temperatures.

RESISTOR CERAMICS—Stupakoff Temperature-Sensitive Resistors are used for temperature indicating or measuring equipment such as Radiosonde, for infra-red light source and for heating elements. Supplied complete with terminals, in the form of rods, tubes, discs, bars, rings, etc.

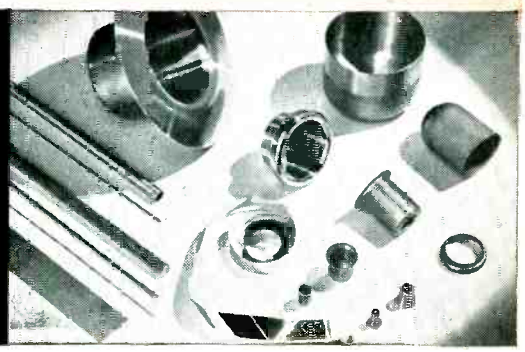
SEALS—KOVAR METAL TO GLASS—Terminals; Lead-ins; Standoffs—for hermetically sealing for mechanical construction in radio, television, electronic and electrical apparatus. Single or multiple terminal units, in a wide variety of sizes and artings.

KOVAR METAL—Kovar is the ideal alloy for sealing to hard glass. Used for making hermetic attachments for electrical and electronic products. Available in the form of rod, wire, sheet, foil—or as cups, eyelets or other fabricated shapes.

STUPAKOFF

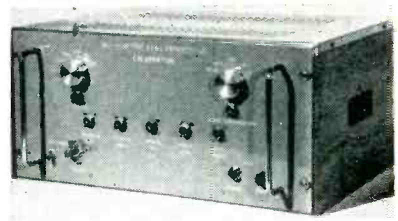
CERAMIC AND MANUFACTURING CO.

Latrobe, Pa.



NEW PRODUCTS

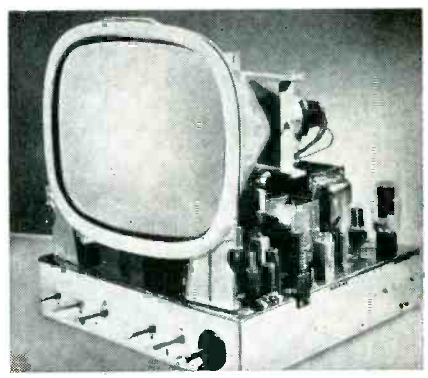
(continued from page 144)



spacings are available: 10, 100, 1,000, 10,000 and 100,000 μsec. Additionally a selection of one of the following pulse spacings is available: 20, 50, 200, 500, 2,000, 5,000, 20,000, 50,000 and 200,000 μsec. The foregoing pulses are generated by blocking oscillators.

Mounting-Insulating Ring

ANCHOR INDUSTRIAL Co., 533 Canal St., New York, N. Y., has developed a new type mounting and high-voltage insulating ring and sleeve for the 17-in. rectangular metal tube. The ring and sleeve, which permit mounting the metal picture tube on a metal chassis, are of the

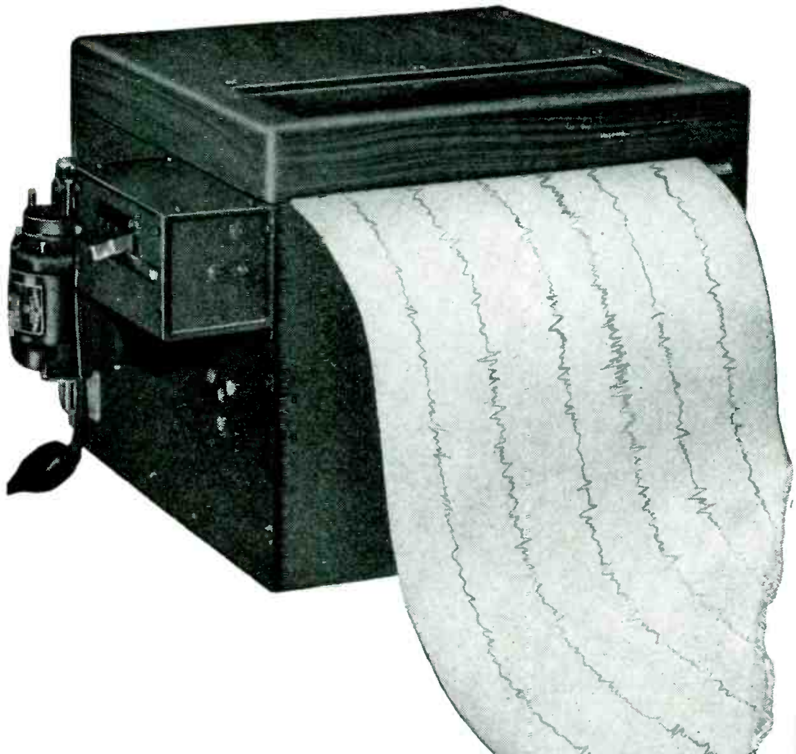


same general type as those at present supplied to almost all major television manufacturers. Specially engineered models are available for all round and rectangular metal picture tubes.

Tube Cap

ALDEN PRODUCTS Co., 117 North Main St., Brockton 64, Mass., has developed the 90 ISTL one-piece tube cap for miniature tube applications. Designed for use with a 1X2 tube or tubes of similar physical dimensions, it has a long skirt that prevents danger of flashover from grid cap to chassis when operated at high voltages. The wire insulation and grid cap molded as

THE OFFNER DYNOGRAPH RECORDER



drift-free d-c recording

SPEED

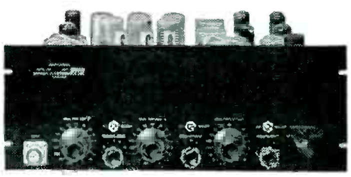
TEMPERATURE

PRESSURE

VIBRATIONS

POSITION

OTHER VARIABLES



Type 133 Amplifier

check these exclusive Dynograph features

Pen Deflection Linearity of 1% with pen response of 1/120th of a second.

Sensitivity of 150 microvolts d-c per centimeter of pen deflection.

Stability and drift-free operation through a special chopper type amplifier.

No extra equipment needed with reluctance type pick-ups.

True Differential input obtained through special transformer coupling.

Offner Electronics Inc., the original manufacturer of precision, direct writing oscillographs, now offers to industry the Dynograph Recorder—a direct writing, high speed oscillograph with microvolt d-c sensitivity.

Operating at approximately 100 times the speed of other industrial recorders with comparative sensitivity, the Dynograph simultaneously records many variables formerly recorded only by photographic means.

Now you can obtain a precise record of transients in the operation of various equipment through a ruggedly built, easy to maintain, versatile d-c recorder—the Dynograph.

Write Today for Bulletin L-311—Complete Specifications and Construction Details of the Dynograph

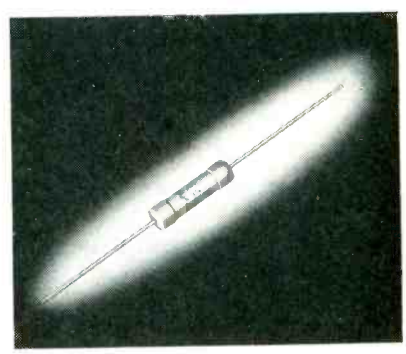
OFFNER ELECTRONICS INC.

5320 N. KEDZIE AVENUE **CHICAGO, 25**

one unit in polyethylene give positive strain relief of leads against vibration twisting or strain and gives complete insulation. Elimination of sharp edges and multiple fingers with a smooth metal clip of two curved surfaces reduces possibility of corona.

Deposited Carbon Resistors

ELECTRA MFG. CO., Resistor Division, 2537 Madison Ave., Kansas City 8, Missouri, is manufacturing deposited carbon resistors in ½-watt size with values to customers' specifications. They are particularly adapted to high-frequency applica-



tions in which high stability and close tolerance of resistance values is a must. The resistors are supplied with 1-percent tolerance and are calibrated within tolerance at 25 C (77 F).

Beacon Antenna

WORKSHOP ASSOCIATES, INC., 135 Crescent Road, Needham Heights, Mass., has in production the model 6HW high-gain beacon antenna for 450 to 470 mc. It consists of 6 half-wave dipoles with an overall gain of

For all your potentiometer needs check this complete L&N line

When you're looking for the right potentiometer to do a specific job, it will pay you to check the *complete* L&N line first. Whether you need the extreme precision of an N.B.S.-certified Wenner, the convenience of a Micromax or Speedomax recorder, or an intermediate instrument, you'll find the characteristics you want in a soundly engineered L&N potentiometer.

More than a score of models comprise the line. Just glance at the table below. There's a potentiometer for practically any purpose—measurement of low voltages, temperature vs. temperature-difference, calorimetry, pH and other emf cell work . . . self-contained portables for temperature and pyrometer checking . . . and the popular, general-purpose Type K's. Models run from highest to moderate precision. They come in convenient single, double, even triple ranges . . . to suit the job at hand.

Naturally, we can't begin to tell you all you want to know in so short a table. So for complete details, let us send you catalog information. Simply write our nearest office, or 4979 Stenton Ave., Phila. 44, Pa.

MODEL	CAT. NO.	PURPOSE	LIMIT OF ERROR† better than .01%	.01%	.02%	.03% to .1%	.3% of range	RANGE
Wenner (N.B.S.-certified)	7559	thermocouple; other low voltages	x					0 to 0.011111 v; 0 to 0.11111 v
	7558	maintain primary standards	x					0 to 0.19111 v; 0 to 1.9111 v
White (Single)	7620	thermocouple voltages; calorimetry			x			0 to 0.01 v
	7621	thermocouple voltages; calorimetry			x			0 to 0.1 v
White (Double)	7622	temp; temp-difference;			x			0 to 0.01 v
	7623	temp-current; etc.			x			0 to 0.1 v
Type K-1	7551	general		x				0 to 0.161 v; 0 to 1.61 v
Type K-2	7552	general		x				0 to 0.0161 v; 0 to 0.161 v; 0 to 1.61 v
Students'	7651	general				x		0 to 0.016 v; 0 to 1.6 v
Indicator *	7655	pH, emf's				x		0 to 1.110 v
Millivolt Indicator *	7659	corrosion testing					x	triple; 0 to 4.1 v total
*	8667	pyrometer check (lab.); temp.				x		0 to 111 mv
*	8656 B,D,X	pyrometer check (plant); temp.					x	0 to 16 mv; 0 to 70 mv; or as spec.
*	8657	pyrometer check (plant); temp.					x	0 to 16 mv & 16 to 64 mv; or as spec.
*	8662	pyrom. check (lab. & plant); temp.				x		0 to 16.1 mv; 0 to 80.5 mv
Temperature Indicator *	8658	pyrom. check (lab. & plant); temp.					x	single; direct-reading temp.
*	8659	pyrom. check (lab. & plant); temp.					x	double; direct-reading temp.
*	8663-CD	body temps.					x	25 to 125 F; −3.9 to +51.7 C
*	8663-X	temp. check (lab. or plant)					x	single or double, as spec.
Panel Indicator *	8671-76	temp. meas.					x	single or double, as spec.
pH Indicator *	7663-A1	pH; emf cell potentials					x	0 to 13 pH; 0 to 1.100 v
Brooks (Deflection)	7630	ammeter, voltmeter, wattmeter test.				x		0 to 153 mv (used with volt boxes and shunts)
	7640	lamp efficiency test.				x		0 to 1.53 v (used with volt boxes and shunts)
Micromax *		automatic indicating, recording, controlling: voltage, temp., pH, etc.					x	as spec.
Speedomax *							x	as spec.

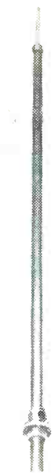
*Self-contained

†Under normal operating conditions, except when using lowest part of ranges.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

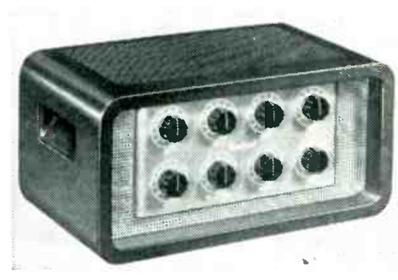
Jrl. Ad EN(12)



nearly 8 db. Impedance is 50 ohms with vswr of less than 2 to 1. The new antenna is helping to provide dependable mobile communications at the higher frequencies. The vertical radiation pattern is narrowed to concentrate energy on the horizon, enabling greater distance coverage, and horizontal radiation is nondirectional.

Mixer-Preamplifier

RAULAND-BORG CORP., 3515 Addison St., Chicago 18, Ill. Model 1904 mixer-preamplifier is designed to mix four a-f inputs and to feed the program over remote line to main amplifying equipment located at any required distance away. It features master gain control, separate bass and treble controls, self-

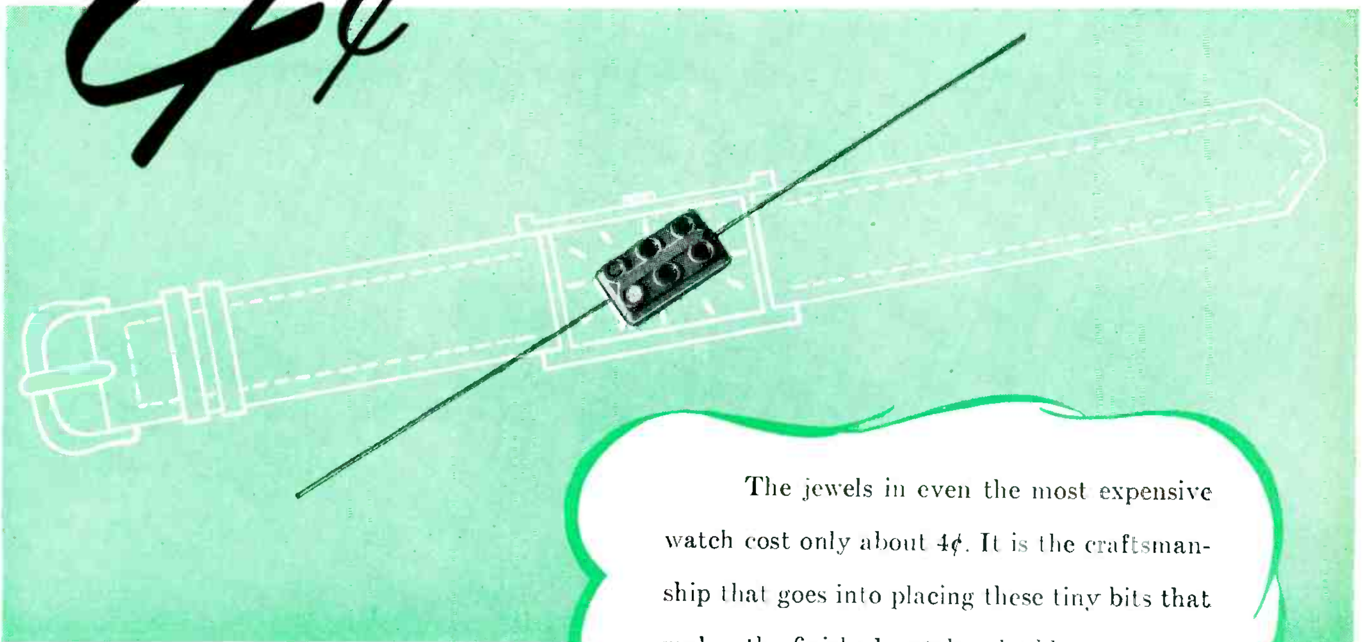


contained 24-volt a-c supply and switch for remote relay control of main amplifying equipment. Output, measured at 100, 400 and 5,000 cps is 300 mw, 2 percent at 600 ohms. Frequency response is ±1 db, 40 to 20,000 cps.

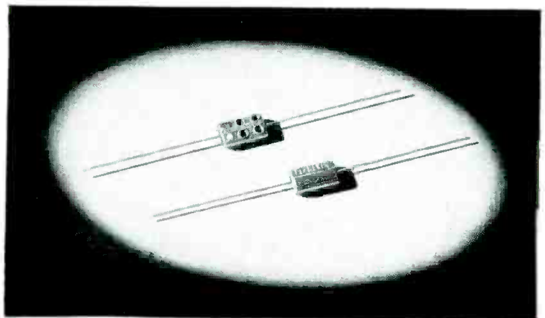
UHF TV Transmitter

GENERAL ELECTRIC CO., Syracuse, N. Y., has developed a uhf tv trans-

4¢ WORTH OF JEWELS



The jewels in even the most expensive watch cost only about 4¢. It is the craftsmanship that goes into placing these tiny bits that makes the finished watch valuable.



CM-15 MINIATURE CAPACITOR
Actual Size 9/32″ x 1/2″ x 3/16″

- For Television, Radio and other Electronic Applications.
- 2 mmf. to 420 mmf. cap. at 500v DCw.
- 2 mmf. to 525 mmf. cap. at 300v DCw.
- Temp. Co-efficient ± 50 parts per million per degree C for most capacity values.
- 6-dot color coded.

The same may be said of the El-Menco CM-15 Capacitor. Tested for dielectric strength at *double* its working voltage, this mighty mite surpasses the strictest requirements of the Army and Navy. It withstands extraordinary strain under the most critical operating conditions — in any climate. Put it in your product — for peak performance.

A COMPLETE LINE OF CAPACITORS TO MEET EVERY REQUIREMENT

THE ELECTRO MOTIVE MFG. CO., Inc.
WILLIMANTIC CONNECTICUT

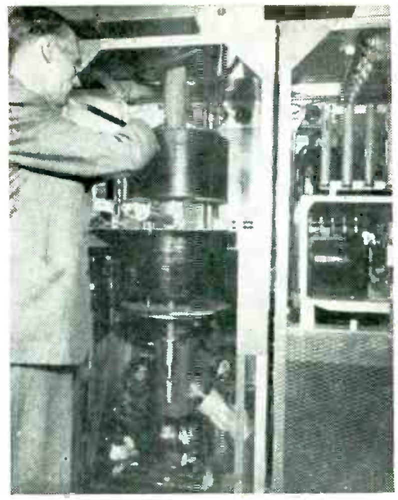
Write on your firm letterhead for Catalog and Samples.

MOLDED MICA **El-Menco** **MICA TRIMMER**

CAPACITORS

FOREIGN RADIO AND ELECTRONIC MANUFACTURERS COMMUNICATE DIRECT WITH OUR EXPORT DEPT. AT WILLIMANTIC, CONN. FOR INFORMATION.

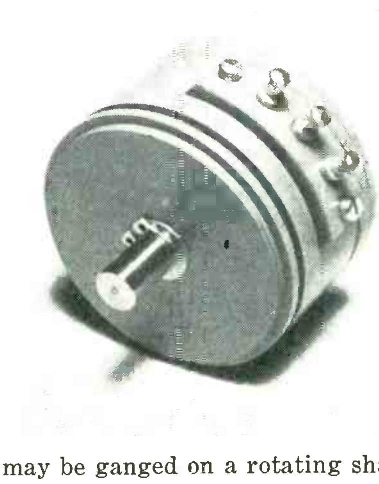
ARCO ELECTRONICS, INC., 103 Lafayette St., New York, N.Y.—Sole Agent for Jobbers and Distributors in U.S. and Canada



mitter with an effective radiated power of 100 kw. This is made possible by the development of a new type of uhf velocity-modulation 5-kw tube (illustrated) and a radically new type of antenna which increases the effective radiated power by 20 times. The transmitter will operate in the 500-mc region. The company has applied for FCC authorization to conduct transmission tests.

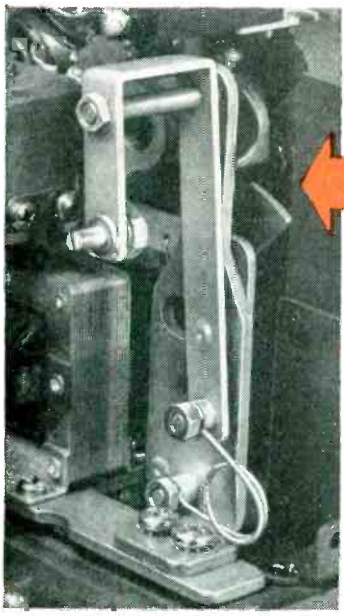
Precision Potentiometers

GEORGE RATTRAY & CO., INC., 92–32 Union Hall St., Jamaica 5, N. Y., has in production precision wire-wound potentiometers of the single-turn linear and nonlinear types. Size of the type 162 potentiometers ($1\frac{5}{8}$ in. in diameter) enables the units to replace larger types in the interest of miniaturization. They



may be ganged on a rotating shaft. Mechanical rotation is continuous and a maximum electrical angle of up to 350 deg is obtainable. Operational life is better than 1 million

5 WALDES TRUARC RINGS ELIMINATE 4 TOOLING OPERATIONS... SAVE 22½¢ PER 100 UNITS

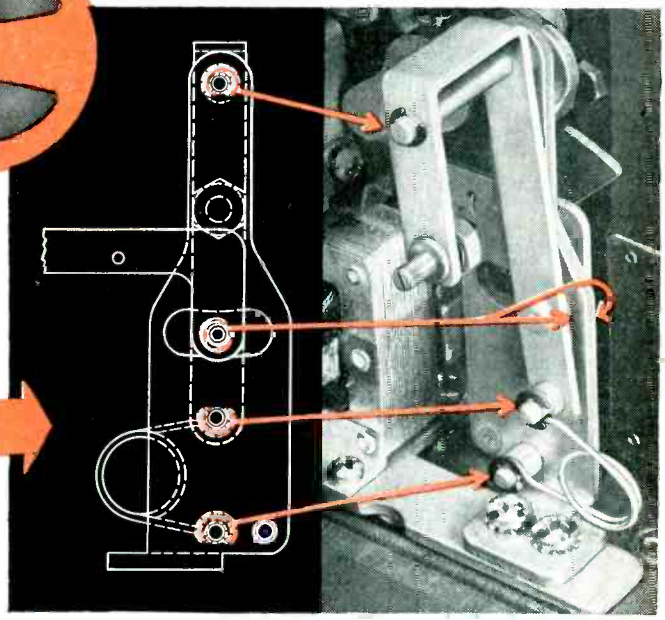


OLD WAY

Unit requires 4 hex head nuts, 4 washers, 4 shoulders, threading of 4 shafts. Clearance and end-play specifications necessary . . . constant maintenance.

NEW WAY

Just 5 Truarc "E" Rings set into predetermined grooves secure parts permanently. Assembly is simple, economical. No clearance specifications . . . no maintenance!



5 Waldes Truarc Retaining Rings in one assembly of the Dictaphone Time-Master dictating machine brought great savings to Dictaphone Corp., Bridgeport, Conn. And this is just one of three different applications where Truarc Rings cut material, tooling and assembling costs for this product.

Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Truarc Rings are precision-engineered...quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

Waldes Truarc Retaining Rings are available for immediate delivery from stock, from leading ball bearing distributors throughout the country.

REDESIGN WITH 5 TRUARC "E" RINGS BRING THESE BIG SAVINGS...

Assembly time per unit using screws and washers . 24 seconds

Assembly time per unit using Truarc Rings . . . . 15 seconds

- Time saved per unit with Truarc Rings . . . . . . 9 seconds
- Eliminates skilled labor milling and threading operations
- Eliminates maintenance
- **TOTAL MATERIAL AND LABOR COST SAVINGS PER 100 UNITS . . 22½¢**

SEND FOR NEW BULLETINS

WALDES TRUARC REG. U. S. PAT. OFF. **RETAINING RINGS**

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY THE FOLLOWING PATENT NUMBERS: U. S. PAT. 2,382,948; 2,420,921; 2,411,761; 2,487,803; 2,487,802; 2,491,306 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-16 Austel Place
Long Island City 1, N. Y. E-053

Please send Bulletins 6, 7 and 8—giving engineering specifications for all types of Waldes Truarc Rings.

Name__________

Title__________

Company__________

Business Address__________

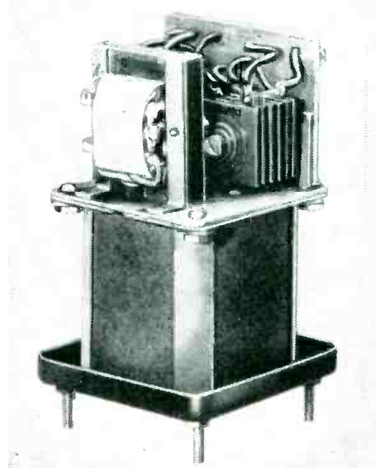
City__________ Zone_____ State__________

678

cycles for speeds up to 100 rpm. Capacitance to ground is approximately 40 $\mu\mu$f from winding to case.

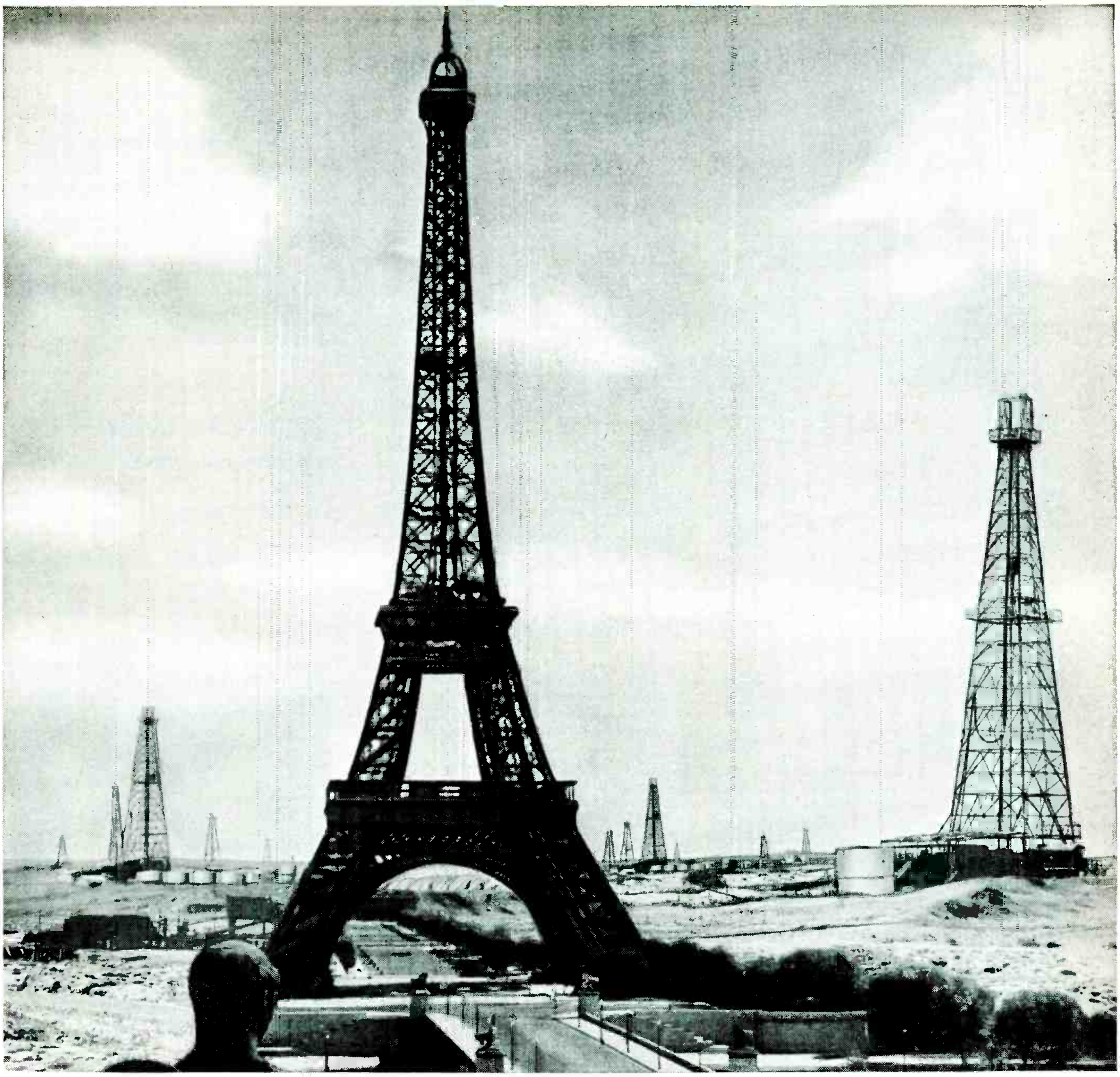
Magnetic Amplifiers

MAGNETIC AMPLIFIERS, INC., 11-54 44th Drive, Long Island City 1, N. Y., has announced a new line of packaged, standard magnetic amplifiers for automatic control and servomechanism application at powerline frequencies of 60 and 400 cps and with power-handling capacities up to approximately 350 watts. Aside from the completely self-contained type of unit illustrated, amplifiers are built to customer specifications. Literature is available.



Voltmeter

THE DAVEN CO., 191 Central Ave., Newark 4, N. J. Type 170 electronic voltmeter covers a frequency range from 10 cycles to 250 kc with an accuracy of ±2 percent. Its high stability circuit, with internal regulated power supply, makes its



They brought Paris to the oil fields

A wonderful new fashion show was held in Paris . . .

One week later, the same show was staged—in Texas!

The place was Neiman-Marcus of Dallas, one of the most remarkable stores in the world. Though hundreds of miles from the "fashion capitals," they sell more exclusives from more top designers than any other store in the U. S.

After new Paris creations arrive in New York, it's only a matter of hours before they're displayed in the N-M salons!

Want to know their secret?

When Neiman-Marcus want a fashion scoop, they bring their high-fashions in at high altitudes. They use Air Express!

You don't have to be a Texan to want the *fastest* service in the world. Your business doesn't have to be fashions to profit from regular use of Air Express. Here are its unique advantages:

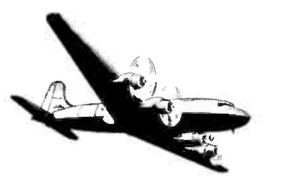
IT'S FASTEST — Air Express gives the fastest, most complete door-to-door pick up and delivery service in all cities and principal towns, *at no extra cost.*

IT'S MORE CONVENIENT — One call to Air Express Division of the Railway Express Agency arranges everything.

IT'S DEPENDABLE — Air Express provides one-carrier responsibility all the way and gets a *receipt upon delivery.*

IT'S PROFITABLE—Air Express expands profit-making opportunities in distribution and merchandising.

For more facts call Air Express Division of Railway Express Agency.



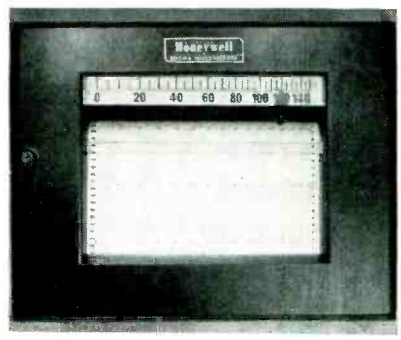
AIR EXPRESS

GETS THERE FIRST

readings independent of normal power line variations. It has a high input impedance of 500,000 ohms and its cathode follower input provides an effective input capacitance as low as 6 $\mu\mu$f. The multiplier control provides four additional ranges of 20 db in addition to the decibel range meter scale, 0 to 20 db. The voltmeter may also be used as a wide-range, high-gain amplifier, due to its output jack and separate volume control.

Temperature Recorder

MINNEAPOLIS-HONEYWELL REGULATOR CO., Brown Instruments Division, 2753 Fourth Ave. S., Minneapolis, Minn. An electronic recorder for accurately and quickly measuring temperature of the rotor in large electric generators has been developed. The ElectroniK was designed to provide a better and more economical instrument to assist operators in avoiding overloads. In addition it furnishes a 12-inch strip chart record which can be used as a guide for gradually cooling a generator. The recorder has a range of 0 to 150 C, a limit error of 1.5 C, a dead zone of 0.3 C and a pen speed of 1.4 minutes full scale. Its range of rotor winding resistance is 0.1 to 4.0 ohms and it has a dielectric test of 1,500 volts rms for one minute.



Dynamic Microphone

THE TURNER CO., 909 17th St., N. E., Cedar Rapids, Iowa. The 50D Aristocrat dynamic microphone, designed for use in tv, broadcast, recording and public address, is laboratory calibrated to a response of 50 to 15,000 cps, flat within ± 2.5 db. Swivel-type mounted for stand

Little lamps flash warnings—prevent accidents

WHEN you can show a customer that your product is safer to use than your competitor's, you've got a big start toward clinching the sale.

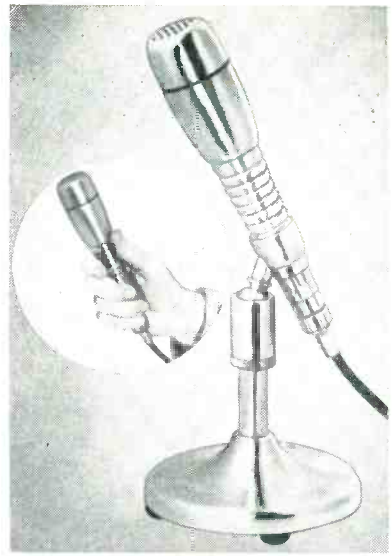
General Electric miniature lamps can add extra safety and utility to your product. As indicator lights, they can be used to tell whether current is on or off, to flash a warning of high temperature or voltage. Used as dial lights, they make it easier for operators to read dials and gauges quickly, help spot trouble before it happens.

Plan now to design greater safety and utility into your product with General Electric miniature lamps. They're available in both filament and neon glow, in many types and sizes. You're always sure of long, dependable service from G-E lamps because General Electric Lamp research is always at work to make G-E lamps *Stay Brighter Longer*. Lamp Department, General Electric Co., Nela Park, Cleveland 12, Ohio.

LAMPS

You can put your confidence in—

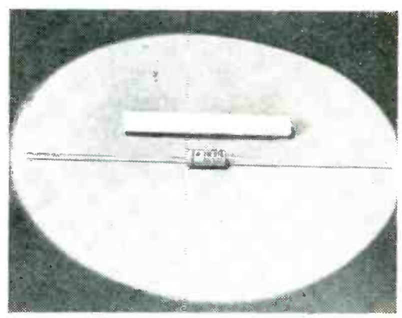
GENERAL ELECTRIC



or boom use, it is quickly detachable for hand use. It is omnidirectional and available in 15,200 ohm or high impedance. Sensitivity is 56 db below 1 volt per dyne per sq cm.

Miniature Tubulars

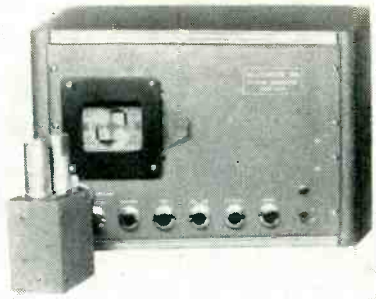
PYRAMID ELECTRIC CO., 1445 Hudson Blvd., North Bergen, N. J. Type 85LPT miniature tubular paper capacitors are designed to withstand a life test of 250 hours at 85 C. Available in rated voltages of 200, 400 or 600 volts d-c working, they will withstand $2\frac{1}{2}$ times rated voltage for 5 seconds. The capaci-



tors are sturdily built in phenolic-impregnated tubes, plastic end-filled. Capacitances, dimensions and prices for the whole line are given in form LPT-1.

Video Picture Generator

TELECHROME, INC., 88 Merrick Road, Amityville, L. I., N. Y., has developed the model 300-A flying spot low-cost tv picture generator



using 3 × 4-in. slide transparencies and negatives. It is designed to supplement or replace monoscopes, camera chains in tv stations, laboratories, factories, schools and colleges. It is completely self-contained with regulated power supplies. Resolution greater than 500 lines meets RTMA picture quality specifications. It will run on standard driving pulses, off-the-air sync, or on self-contained sweep generators.

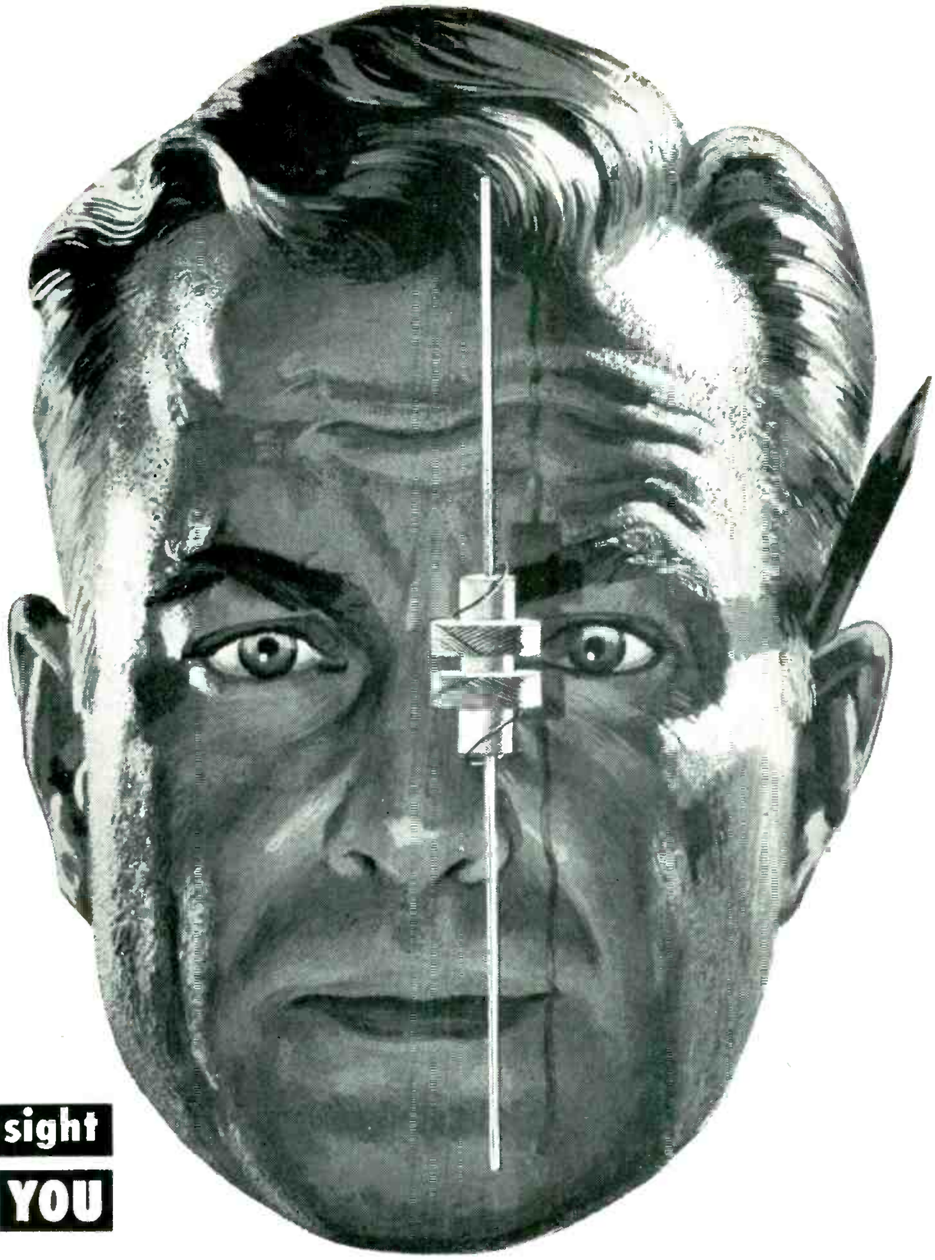
Fractional H-P-Motor

JOHN OSTER MFG. CO., Racine, Wisc., has added a new 400-cycle current motor to its fractional h-p electric motor line. It is available as a capacitor-run single-phase or

polyphase induction motor. Typical ratings for continuous duty are 1/100 h-p at 7,000 rpm on 400-cycle current or 1/300 h-p at 3,000 rpm on 60-cycle current. The type is especially suited to needs calling for high speeds and plenty of power.

Grid-Dip Meter

JAMES MILLEN MFG. CO., INC., 150 Exchange St., Malden 48, Mass., has announced a new industrial version of its grid-dip meter. In addition to having an individually hand-calibrated direct-reading dial the model 90662 meter has an extended fre-



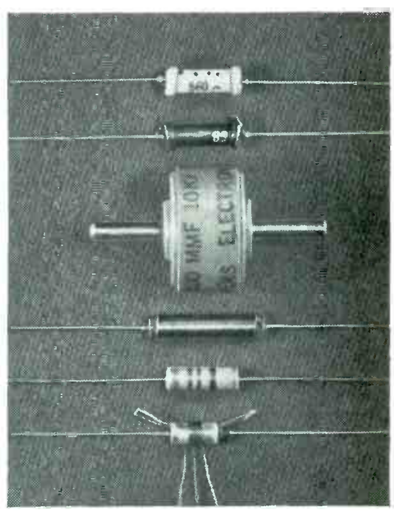
we'll sight our

engineering insight

especially for YOU

...if electronic components, such as chokes, are your problem

Other electronic components also
built in quantity
to your most exacting specifications
for stability in service



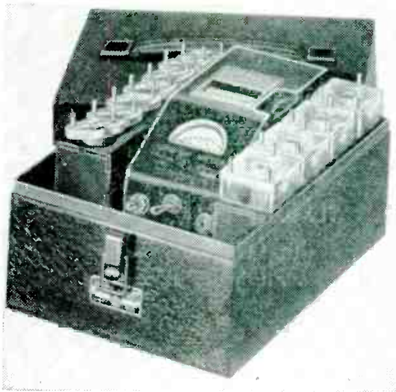
JEFFERS Electronics INC.

A SPEER CARBON COMPANY SUBSIDIARY

DU BOIS, PENNSYLVANIA

Complete your Circuits with Resistors, Coil Forms and Iron Cores by Speer Resistor Corp., St. Marys, Pa. another SPEER CARBON CO. subsidiary

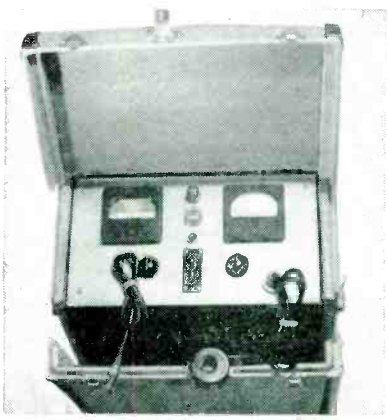
7276



quency range to cover the entire spectrum from 200 kc to 300 mc. Included with the meter is also a remote probe for coupling into extremely small and normally inaccessible places.

Gas Ratio Meter

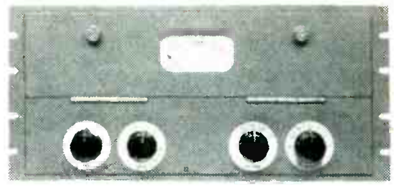
RESEARCH ELECTRONICS LABORATORY, 2459 Susquehanna Road, Roslyn, Pa. The gas ratio meter illustrated permits checking up to 200 (preheated) c-r tubes per hour with accurate, stable gas readings. Particularly adapted to in-line production, it is also portable, a-c operated and as easily used in ware-



house or laboratory. An adaptation of the JAN gas ratio formulas uses standard, stabilized, regulated circuits for utilizing the c-r gun as its own ionization gage. A 3-in. meter reading 0.2 at midscale measures all electromagnetic types.

Limiting Amplifier

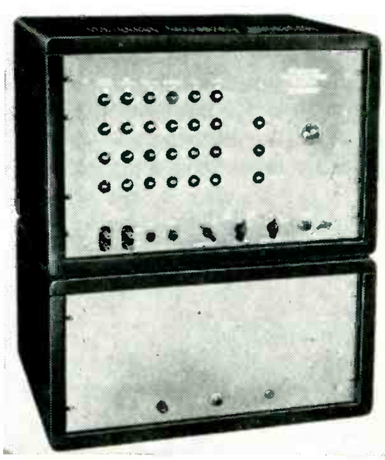
RADIO CORP. OF AMERICA, Camden, N. J. Type BA-6A amplifier limits the high peaks that occasionally occur during a-m and f-m broadcast-



ing and prevents overmodulation of the transmitter, thus permitting substantial increase in the average modulation level and a greater transmitting range with the same carrier power. In recording applications it prevents overcutting of the recording disc on heavy passages and allows a marked improvement in signal-to-noise ratio. It features a 54-db gain below the verge of limiting, and a maximum output level of 30 dbm at the verge of limiting. Frequency response is approximately ± 1 db from 30 to 15,000 cps, while harmonic distortion is less than 1 percent rms from 100 to 15,000 cps at 15-db gain reduction. Signal-to-noise ratio is 83 db at verge of limiting, and compression ratio above verge of limiting is 20 db into 2 db.

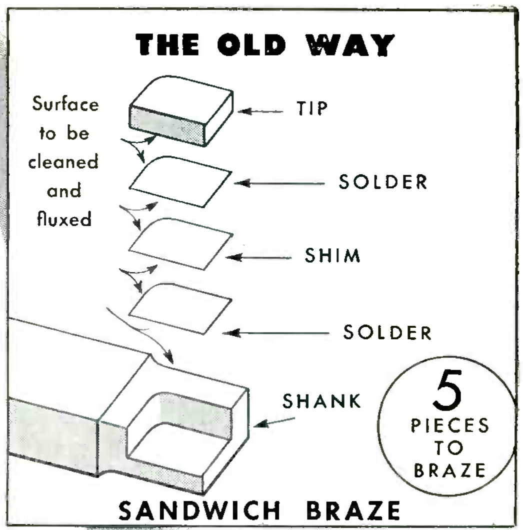
Frequency-Time Counter

POTTER INSTRUMENT CO., INC., 115 Cutter Mill Road, Great Neck, N. Y. Model 801 megacycle frequency-time counter can be used for frequency measurements, time interval measurements and frequency ratios and, in addition, can be used as a secondary frequency standard, a 1-mc totalizing electronic counter and a direct-reading rpm tachometer. The instrument incorporates two



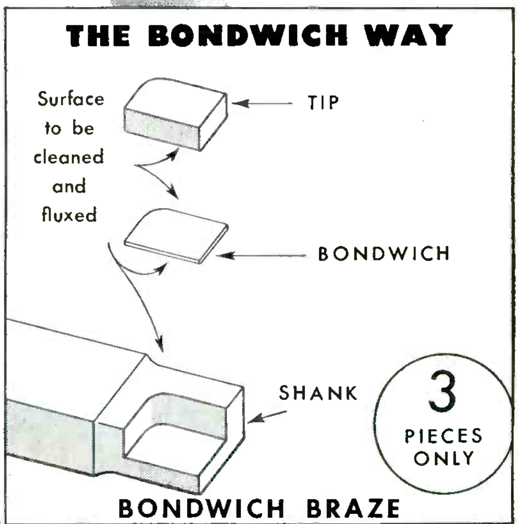
Problem:

How to Speed Up Sandwich Brazing Carbide Tool Tips



General Plate:

Provided the Solution with "BONDWICH"... a Composite Metal Combination



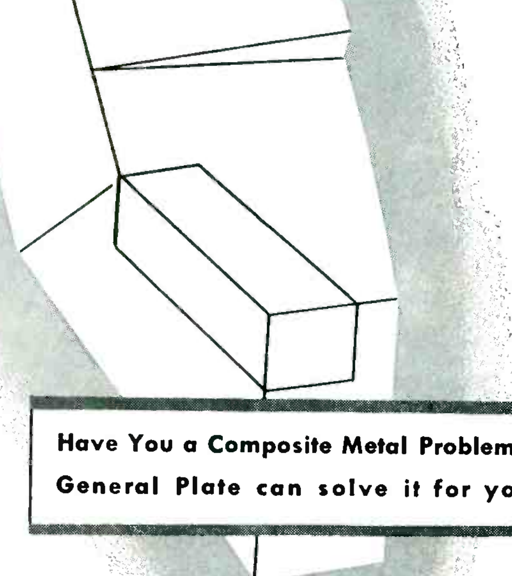
Carbide tipped tools give best results if the tip is brazed to the shank by sandwich brazing. However, the disadvantage of this method is the work involved in cleaning, fluxing, and positioning the three separate pieces of brazing alloy and shim material in addition to the tip and shank.

General Plate engineers solved the problem by bonding *into a single sheet* the three mentioned pieces. The result . . . a *General Plate composite metal* called "BONDWICH."

The two outer layers of "BONDWICH" are brazing alloy . . . the center piece a ductile shim. The bond is so perfect that when the brazing temperature is reached, complete wetting takes place. There are minimum voids in the final braze as the evenly wetted shim carries the braze all over. In addition to providing a better braze, "BONDWICH" speeds up carbide tip tool brazing, cuts production costs.

No matter what your metal problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals or base to base metals can overcome your problems . . . often reduce costs.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Alcuplate (copper and aluminum), Silver Solders, Composite contacts, buttons and rivets, Platinum fabrication and refining, Age-hardenable #720 Manganese Alloy. Write for information.



Have You a Composite Metal Problem?
General Plate can solve it for you

GENERAL PLATE

Division of Metals & Controls Corporation

305 FOREST STREET, ATTLEBORO, MASS.

complete electronic counting chains, a 100,000-cps crystal oscillator frequency standard and unique electronic switching and gating circuits. Frequency measurements up to 1 million cps may be made in a few seconds with a minimum accuracy of 0.001 percent. Time intervals up to 10 seconds may be measured in increments of 10 μsec from common or separate input lines.

Literature

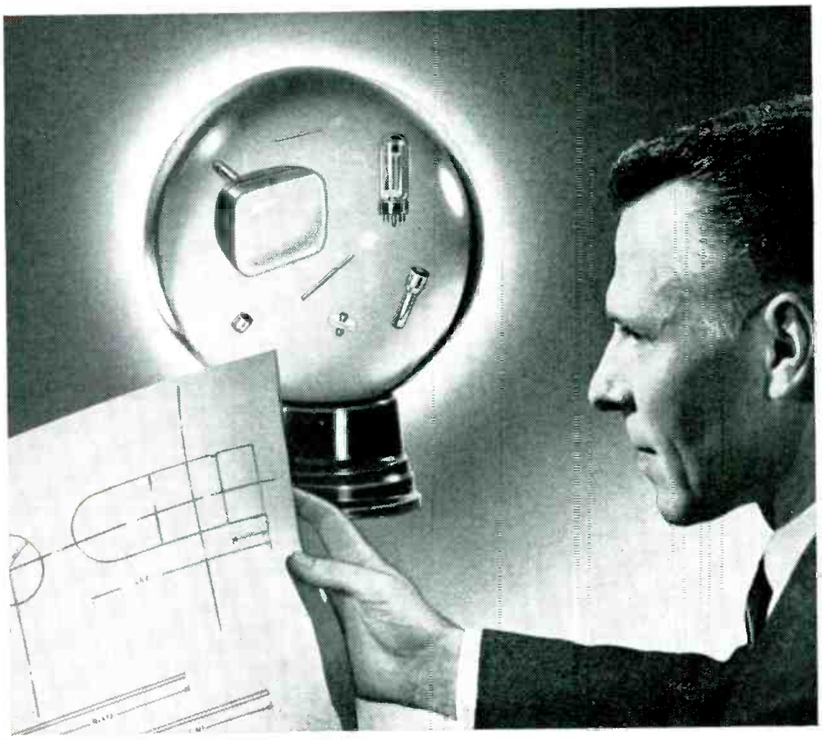
Injection Molding Powders. Rohm & Haas Co., Washington Square, Philadelphia 5, Pa. Booklet PL-35 is a 12-page brochure giving reference data for the man who has to design molded acrylic parts and for the men who mold them. Techniques included are design, predrying the powder, and typical molding conditions. Suggested steps to produce high quality Plexiglas molded parts are shown in tabular form under the headings, defects and suggested remedies.

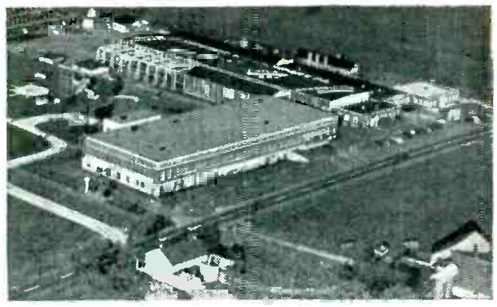
Control Track Generator. Fairchild Recording Equipment Corp., 154 St. & 7th Ave., Whitestone, N. Y. A single-page bulletin tells how the control track generator makes possible picture synchronous sound-track recording with any tape recorder with response good to 14 kc. The unit described and illustrated has a minimum number of controls and connections, and is compact and portable.

Electronic Transformers. Triad Transformer Mfg. Co., 2254 Sepulveda Blvd., Los Angeles 64, Calif. Catalog TR-51 contains detailed specifications, illustrations and prices on a line of electronic transformers. The publication features 35 new items, including a series of transformers developed especially for regulated power supplies, tv components and complete details on the HF-10 Hi-Fidelity amplifier kit.

R-F Gear-Hardening Machine. Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa. Detailed operational information about the

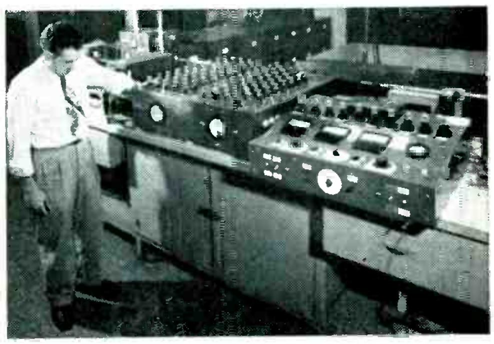
With our hands full today...we've our eye on tomorrow





Buildings . . . enclosing more than 4 acres —all devoted to the development, production and testing of fine small tubing.

Men and Machines...fabricating, inspecting and finishing parts to meet the most exacting specifications.



Engineering . . . laboratory equipment for all kinds of testing, including emission characteristics of nickel cathode materials.

Here at Superior we produce quantities of quality parts for the Electronics Industry. Our research engineers are constantly at work to improve these products and to develop new parts to do the job better. Production-wise we're working just as constantly to produce more and more of these better products for you.

From 1949 to '50, we doubled our disc cathode capacity, added over 50% to Seamless cathode capacity. Through the same period we almost doubled the number of machines making Lockseam cathodes . . . more than doubled capacity. 1950 production of Lockseam cathodes increased 280% over 1949. Demand kept pace with the increase.

Plans for the future include the installation of new machines and the improvement of already good processes so that the Electronics Industry's coming needs may be as well met as its past demands.

Then as now, we at Superior will deliver truly superior small tubing products to do tough jobs better. Superior Tube Company, 2500 Germantown Ave., Norristown, Pa.

Which Is The Better For Your Product . . .

SEAMLESS . . . ? The finest tubes that can be made. Standard production is .010" to .121" O.D. inclusive, with wall thicknesses of .0015" to .005". Cathodes with larger diameters and heavier walls will be produced to customer specification.

Or LOCKSEAM* . . . ? Produced directly from thin nickel alloy strip stock, .040" to .100" O.D. in standard length range of 11.5 mm to 42 mm. Round, rectangular or oval, cut to specified lengths, beaded or plain.

Superior

THE BIG NAME IN SMALL TUBING

All analyses .010" to 5/8" O.D.

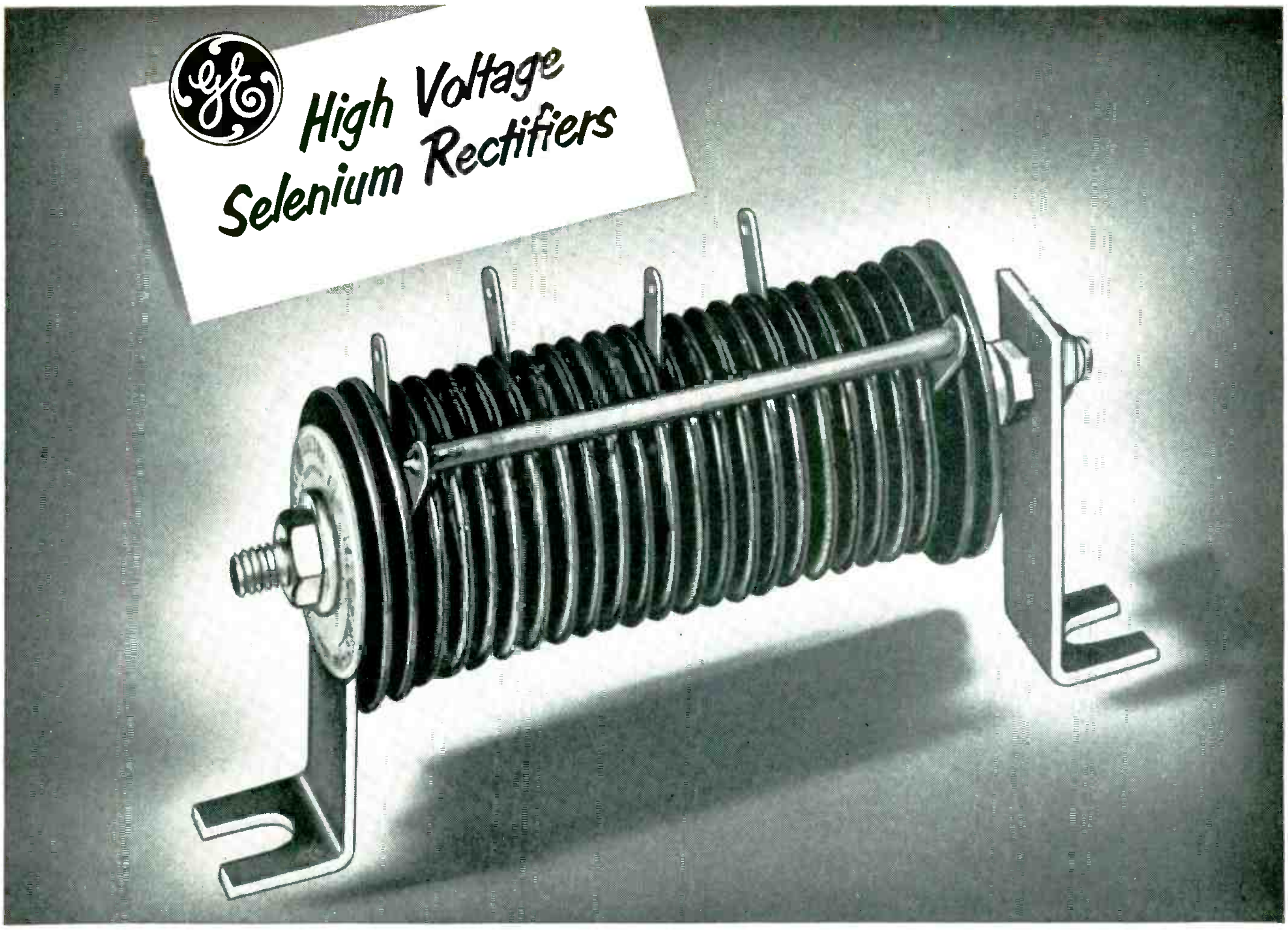
Certain analyses (.035" max. wall) Up to 1 1/2" O.D.

*MFD. UNDER U. S. PATS. *SUPERIOR TUBE COMPANY • Electronic Products for export through Driver-Harris Company, Harrison, New Jersey • Harrison 6-4800* new radio-frequency gear-hardening machine, the Inductall, is presented in booklet B-5259. Adaptability of the unit described in handling spindle gears, spur gears, cluster gears and shafts for either through or contour hardening is explained with the help of diagrams and photographs. Versatility of operation, the booklet points out, is achieved by use of a single-spindle type of feed that makes setups simple and fast.

Laminating Resin. Houghton Laboratories, Inc., 322 Bush St., Olean, N. Y. Sales bulletins No. 615 and 613 deal with Hysol 6102, and 6101 respectively. The former describes a new type of low-pressure laminating resin, supplied in two components and characterized by excellent electrical properties and outstanding resistance to acids and alkali. The latter treats of a new resin (for use in coating electronic equipment subjected to corrosive conditions) that can be used at 230 to 250 F continuously without embrittlement. Specifications and properties are included.

Rubber-Sealed Plugs. Cannon Electric Development Co., Div. of Cannon Mfg. Corp., 3209 Humboldt St., Los Angeles 31, Calif., has issued a four-page bulletin (RS-1) on its new line of RS hermetically-sealed (rubber-sealed) plugs used largely on aircraft relays and other sealed components. Two basic variations comprise the series described: those with coupling nuts and those with barrels only. Inserts discussed are made of polychloroprene rubber with high insulation resistance and dielectric strength, and hold standard AN-type pin contacts only.

Servicing with VTVM. Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y., has announced a new 48-page booklet with comprehensive information on the use of vacuum-tube voltmeters in radio and tv servicing. The booklet is divided into five chapters of concise instructive text describing different types of vtvm's, their adjustment and application for: radio receiver tests



HOW TO TEST RECTIFIER QUALITY

Whether you buy selenium rectifiers for your own use or to build into your product, you want to know just what you are getting. We want you to compare G-E rectifiers with other rectifiers of the same rating. That way you can see for yourself the superior qualities of G-E selenium rectifiers before you buy.

Read these suggestions and then send for the testing bulletin.

COMPARE FORWARD RESISTANCE—Comparison will show the extremely low forward resistance of G-E cells—will show you why they deliver higher output voltage—will show how you can cut costs in circuit components and design.

COMPARE BACK LEAKAGE—Comparison will show the low back leakage of G-E cells—will show you why their lower internal losses mean higher output. Lower leakages mean less heating, longer life, economical operation for G-E high-voltage rectifiers and the equipment they ably service.

COMPARE TEMPERATURE RISE—Because of their low forward resistance and low back leakage, they are cooler operating—don't overheat nearby parts—require less ventilation—have longer life.

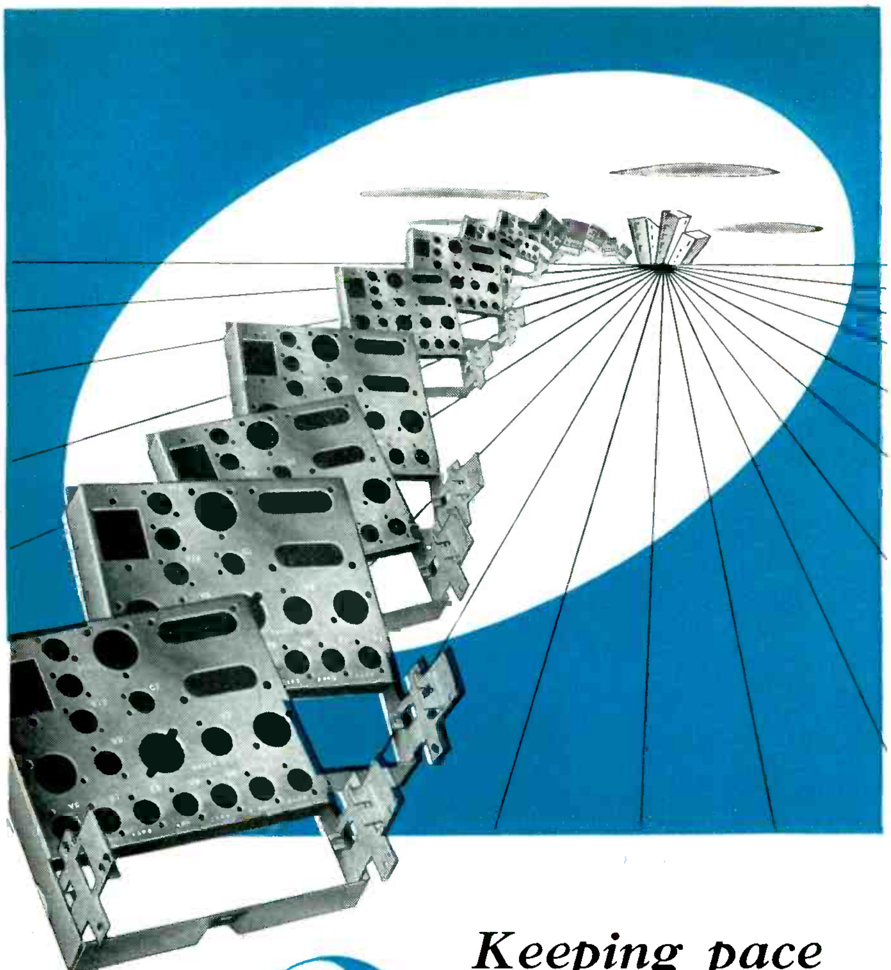
We want you to make these comparison tests. We want you to prove to yourself conclusively that G-E selenium high-voltage rectifiers are superior. Compare, and you'll decide to use them in your next job—to make the long-term high output of G-E stacks help keep your product out front.

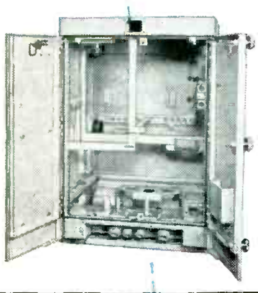
* * *

Write Section 461-15, *Apparatus Department, General Electric Company, Schenectady 5, New York* for a copy of GEA-5524 which gives details on comparative testing. Or, arrange for test details and sample units through the General Electric specialist at your local G-E office.

461-15

GENERAL ELECTRIC





and measurements, tv receiver tests and miscellaneous uses. The publication will be sold at one dollar per copy.

Antenna Catalog. The LaPointe Plascomold Corp., Windsor Locks, Conn. The 16-page 1951 catalog, including the complete line of Vee-D-X tv antennas and accessories, was recently issued. Along with technical, installation and ordering data on all antennas, the catalog contains general information of interest to the trade. Considerable space has been devoted to such products as the lightning arrester, the 3-way switch box, the Mighty-Match and Vee-D-X towers.

Self-Recording Accelerometers. Engineering Research Associates, Inc., 1902 W. Minnehaha Ave., St. Paul W4, Minn., has published a four-page folder on its self-recording accelerometers that feature a permanent-magnet recorder, exchangeable seismic element, convenient electrical playback and expanded visual display. The well-illustrated bulletin gives complete description and technical specifications.

Pressure Terminals and Connectors. The Thomas & Betts Co., Inc., Elizabeth 1, N. J. Sta-Kon bulletin No. 61 lists a wide line of pressure terminals and connectors for every type of application on all wire sizes from No. 26 through 250 mcm. A particularly useful feature is a section giving a complete listing of Armed Forces procurement numbers with corresponding catalog numbers. Complete dimensions of specific types are given in simplified tabular arrangement.

Soft-Soldering Technique. Multicore Sales Corp., 164 Duane St., New York 13, N. Y., has available reprints of an article on soft-soldering technique. Ideal for an employee training manual, the text is written in simple language and accompanied by diagrams. The history, content and construction of solders is discussed with the uses and purposes of each. The joinings necessary for various metals, and the occurrence and

avoidance of dry joints are described. Fluxes and the way they work are explained.

Recording Equipment. Cook Research Laboratories, 1457 Diversey Parkway, Chicago 14, Ill. Bulletin R-8 contains a series of project digests describing in detail a line of recording equipment that has been developed which may prove helpful to laboratories and related services in avoiding unnecessary expense and duplication in the development of similar equipment. The well-illustrated booklet gives project titles, statements of problems and summaries of results. Price sheets are included.

Components Catalog. Stackpole Carbon Co., St. Marys, Pa. The new 42-page RC-8 catalog lists, besides the standard lines, a number of items that are cataloged for the first time. Included are several single, dual-shaft and special-purpose volume controls, new 3-ampere slide switches, and Ceramag nonmetallic cores in "U," "E," width control and segmented deflection yoke types for modern tv uses. Complete mechanical and electrical specifications simplify component selection and the catalog contains a great deal of helpful engineering data.

Electronics Parts Catalog. A. W. Franklin Mfg. Corp., 43–20 34th St., Long Island City 1, N. Y. A 20-page catalog gives detailed specifications on a wide variety of acorn, c-r tube, ceramic, laminated, miniature, molded, octal and wafer-type sockets. Terminal strips, connectors, plugs and pen-board assemblies are also described. A revolutionary miniature tube socket suitable for automatic mass production dip soldering of circuit components is illustrated. Four pages of illustrations and descriptions are also provided on a circuit stamping process. Applications of this process are shown for loop antennas, amplifier circuits, cable assemblies and tv tuners.

Dynamic Microphone. Electro-Voice, Inc., Buchanan, Michigan. Bulletin 160 illustrates and de-

TWO NEW OSCILLATORS EVERY LABORATORY NEEDS

THE MARKA-SWEEP MODEL VIDEO

The Marka-Sweep Model Video is an electronically swept video sweep oscillator covering frequencies up to 20 mc. Crystal positioned marks of pip type are provided at 1, 2, 5, 10, 15 and 20 mc. By use of external signal generator a variable frequency pip type marker is available. Output maximum is 0.3 volt from a 72 ohm internal impedance.

Sweep Ranges: 50 kc to 10 mc and 50 kc to 20 mc.

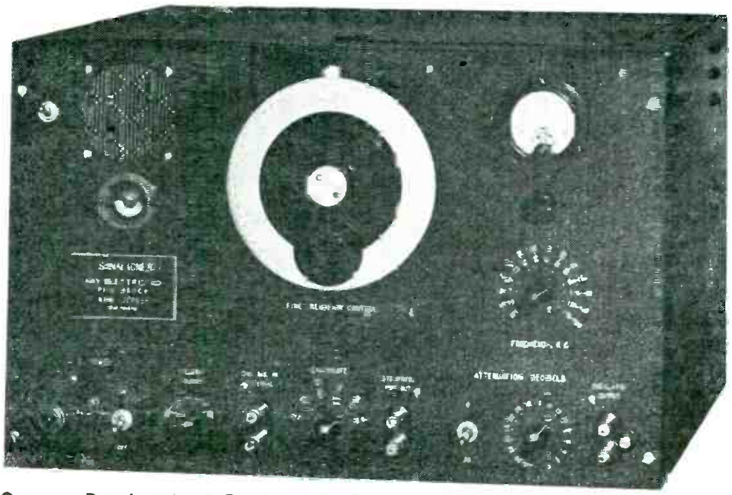
Crystal positioned pip type Marks connected directly to oscilloscope.

Variable frequency pip Mark directly to oscilloscope by use of external signal generator. Separate attenuators on pip markers and video output.

Sawtooth sweep for sweeping video output and deflecting oscilloscope horizontal.

Produces Zero Level Baseline on oscilloscope.

Price: $495.00 F.O.B. Factory



THE SONALIGNER

The Sonaligner is a very stable and accurate oscillator in the supersonic range suitable for use in determining the pass band of narrow band supersonic filters and other accurate work in this range.

Outputs Developed at Fundamental Frequency—No beat oscillators.

Frequency Range: 1 kc to 200 kc in 13 Bands. Output: Maximum of 2 volts from 600 ohms. Includes Output Level Meter and Calibrated Attenuator. Crystal Check Points Accurate to 0.01% included—May be externally calibrated—Marks every 2, 10, 50, 200 kcs—Timing "comb" may be used for accurate alignment of Radar range circuits.

Accuracy: 0.1% Closer at Check Points.

Price: $695.00 F.O.B. Factory

Prices 10% Higher outside of U. S. A. and Canada. Send for 1951 Catalog.

KAY

KAY ELECTRIC COMPANY

25 Maple Avenue

Phone CAldwell 6-4000

Pine Brook, New Jersey

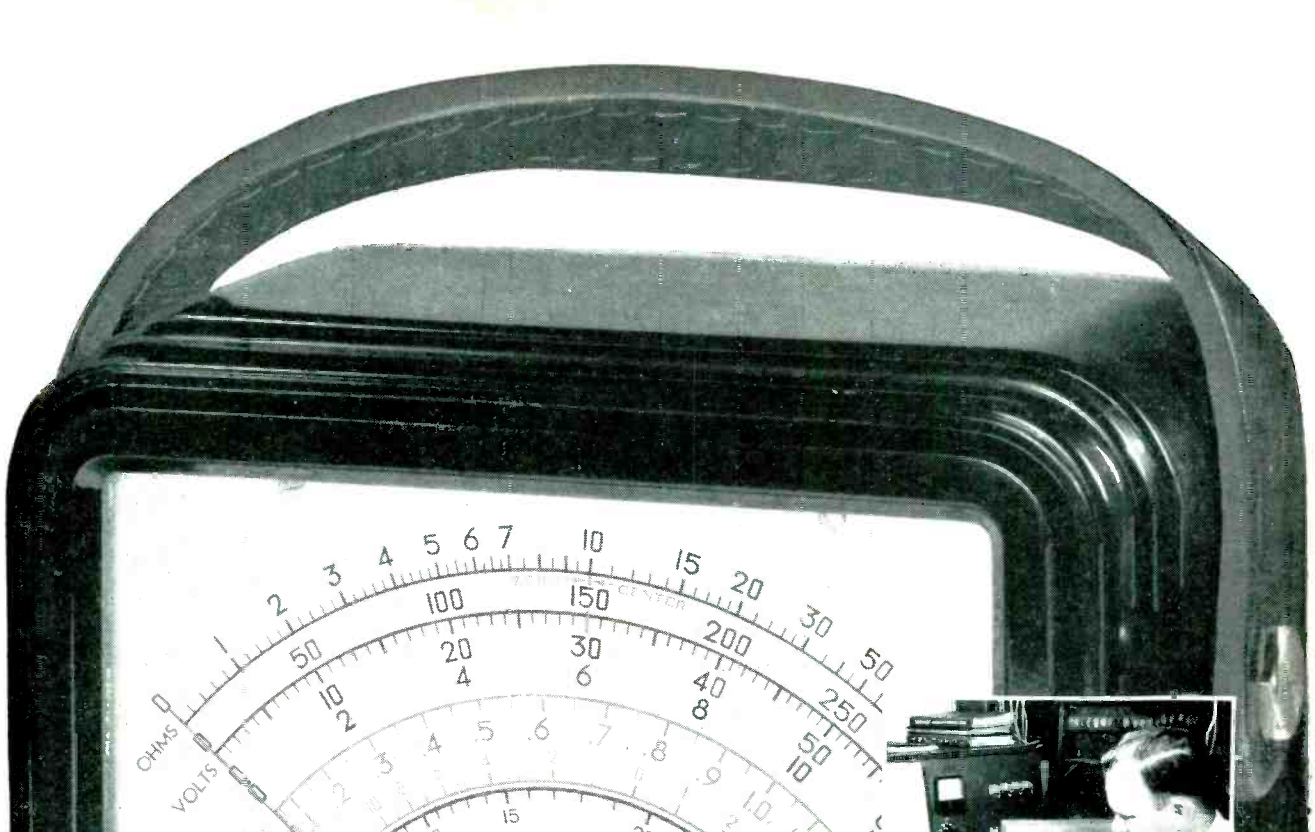
scribes the model 636 Slimair dynamic microphone. Photos show the modern slim-trim design of the unit and how easily it can be used on a stand or boom, vertically or tilted, or in the hand. It also shows how the Acoustalloy diaphragm and the pop-proof head insure smooth response and make the mike extra rugged for indoor and outdoor use, in all climates. Complete specifications and data are given.

Subminiature Capacitors. Fansteel Metallurgical Corp., 2200 Sheridan Road, North Chicago, Ill. A series of subminiature tantalum capacitors, notable for stability over wide ranges of time and temperature, is announced in bulletin 6.531. The polarized electrolytics described occupy less than 1/10 cubic inch excluding connection leads, and consist of a porous tantalum anode permanently sealed into a fine silver cathode that also serves as the container. Nine standard capacitors are listed, ranging from 30 μf at 6 volts d-c to 3.5 μf at 75 volts d-c.

Quartz Crystal Units. Reeves-Hoffman Corp., Cherry and North Streets, Carlisle, Pa. An 8-page folder illustrates and describes a complete line of quartz crystal units. Frequency ranges, dimensional diagrams, circuits, a typical frequency-temperature characteristic and ordering information are included.

Low-Power Klystron Supply. The Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif. Volume 2, No. 4 of the Journal is chiefly devoted to the model 715A bench-type power supply for operating low-power klystrons. The unit described provides a regulated beam supply adjustable from -250 to -400 volts d-c at currents up to 50 ma; a regulated reflector supply adjustable from -10 to -900 volts d-c; square-wave modulation on the reflector supply at a nominal repetition frequency of 1,000 cps; and a 6.3-volt a-c filament supply. Illustration, complete description and specifications are included.

Ceramic Disc Capacitors. Cornell-Dubilier Electric Corp., South Plainfield, N. J. Four single-page



Harry M. Neben, *Chief, Electrical*
AMPHENOL *Testing Laboratory*

RECOMMENDS

Simpson Model 303
VACUUM TUBE VOLT-OHMMETER

Says Harry M. Neben: "I understand the 303 was developed to be of particular use to television service men for aligning sets in the field—so it's designed to perform a lot of test functions and is compact and easy to carry around. These same features make it quite a valuable laboratory and production tool here at Amphenol."

In the photo, Mr. Neben is using the Simpson 303 in conjunction with an Amphenol test fixture to measure insulation resistance between one wire and all other wires of a cable assembly.

SPECIFICATIONS

DC VOLTAGE: Ranges 1.2, 12, 60, 300, 1200 (30,000 with Accessory High Voltage Probe).
Input Resistance 10 megohms for all ranges.
DC Probe with one megohm isolating resistor.
Polarity reversing switch.
OHMS: Ranges 1000 (10 ohms center).
100,000 (1000 ohms center).
1 megohm (10,000 ohms center).
10 megohms (100,000 ohms center).
1000 megohms (10 megohms center).
AC VOLTAGE: Ranges 1.2 12, 60, 300, 1200.
Impedance (with cable) approx. 200 mmf. shunted by 275,000 ohms.
AF VOLTAGE: Ranges 1.2, 12, 60.
Frequency Response Flat 25 to 100,000 cycles.
DECIBELS: Ranges −20 to +3, −10 to −23, +4 to + 37, +18 to +51, +30 to +63.
Zero Power Level 1 M. W., 600 ohms.

GALVANOMETER: Zero center for FM discriminator alignment and other galvanometer applications.
R. F. VOLTAGE: (Signal tracing with Accessory High Frequency Crystal Probe).
Range 20 volts maximum.
Frequency Flat 20 KC to 100 M.C.
LINE VOLTAGE: 105-125 V. 50-60 Cycles.
SIZE: 5¼"x7"x3⅛" (bakelite case). Weight: 4 lbs. Shipping Wt.: 6½ lbs.
STILL AT THE SAME NET PRICE: Model 303, including DCV Probe, ACV—Ohms probe and Ground Lead with Operator's Manual—**$58.75**
Accessory High Frequency Probe, **$7.50**
Accessory High Voltage Probe, **$9.95**
Also available with roll top case, Model 303RT—**$66.70**

Available through your Parts Jobbers

Simpson ELECTRIC COMPANY

5200 W. Kinzie St., Chicago 44, Illinois Phone: COlumbus 1-1221
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bulletins describe a series of miniature ceramic disc capacitors for bypass and coupling in tv, f-m, uhf and vhf in compact, miniaturized equipment. The five basic types described are: type 2TM—¼ in. diameter, single capacitor units from 500 to 1,000 $\mu\mu f$ at 500 volts d-c working; type 6TM—19/32 in. diameter, single capacitor units from 50 to 5,000 $\mu\mu f$ at 500 volts d-c working; type 8TM—¾ in. diameter, with a capacitance rating of 10,000 $\mu\mu f$ (8TM5S1C) at 500 volts d-c working; type 6TM—19/32 in. diameter dual capacitor units (from 2×100 to $2 \times 2,500$ $\mu\mu f$) and type 8TM—¾ in. diameter dual capacitor units, (from $2 \times 3,000$ to $2 \times 10,000$ $\mu\mu f$) all rated at 500 volts d-c working.

Supersensitive Galvanometer. Midwestern Geophysical Laboratory, 2803 W. 40th, Tulsa, Okla. A single-page bulletin gives an illustrated description of the model 1-06-SS galvanometer that has a sensitivity of 0.005 ma per in. at 12-in. focal distance (100-cps elements), a normal balance of 0.003 in. per G, and a special balance of 0.001 in. per G at the same distance. The unit described is available in three frequencies and characteristics of each are listed. The instrument in question was especially developed for use in recording signals direct from source without amplification.

Miniature Tap Switches. Tech Laboratories, Inc., Bergen & Edsall Boulevards, Palisades Park, N. J. Bulletin 29 covers the type 2B miniature tap switches that have already found many applications in defense work and can be furnished to JAN specifications. Included are a mechanical diagram, photos of the unit and complete technical specifications.

Strip Chart Potentiometers. Minneapolis-Honeywell Regulator Co., Brown Instruments Division, Wayne and Windrim Ave., Philadelphia 44, Pa. Multirecord ElectroniK strip chart control potentiometers furnished in both contact and proportional control types, and equipped with either a single or double set-point index, are de-

scribed and illustrated in specification sheet No. 189. Method of operation, general specifications, control forms and dimensional diagrams are included.

Servo Amplifier System. Minneapolis-Honeywell Regulator Co., Brown Instruments Division, Wayne and Windrim Ave., Philadelphia 44, Pa. A four-page pamphlet illustrates and gives technical details on the operation and application of a servo amplifier system especially adaptable to the detection and correction of error signals and operation of null-balance systems. The system described consists of a converter, amplifier and two-phase fractional horse-power motor.

Power Supplies Catalog. Furst Electronics, 12 S. Jefferson St., Chicago 6, Ill. The latest edition of the company's condensed catalog illustrates, in addition to a line of regulated power supplies, the new model 120 wide-band d-c amplifier as well as the model 115-R wow meter. Tables show model numbers, maximum output power for each, output voltages and currents, approximate output impedances, maximum ripple voltages (rms) and sizes.

Flow-Detector Amplifier. Rochester Electronics Co., Inc., Box 227, Penfield, N. Y. A single-sheet bulletin tells of the flow-detector amplifier (a low-priced instrument for detecting discrete particles falling onto a probe element) that was originally designed to detect drops of liquid, but can be used with smaller or larger masses of liquids and solids. The instrument's mode of operation and technical specifications are given.

Rheostat Bulletin. Rex Rheostat Co., 3 Foxhurst Road, P. O. Box 232, Baldwin, L. I., N. Y., has issued a bulletin on its vitreous enameled round type and tubular slide-contact rheostats. The new round type described features a rigid spring-hinged contact arm that assures unchangeable constant contact pressure; and is available in 7 sizes—50, 75, 100, 150, 225, 300 and 500 watts.

(continued from page 148)

three-quarters as large as the Microwave Laboratory in which the university is constructing a new-type atom smasher, the electron linear accelerator, under another ONR contract.

MIT announces Communications Course

A SPECIAL course in modern communications during the 1951 Summer Session from June 18 to July 6 at MIT will consist of lectures and laboratory experiments on selected topics in this new development, in both theory and application. The course is designed for research engineers concerned with the problems of transmission, presentation and assimilation of information. It should be of help to those interested in statistical methods and techniques for signal detection. Those concerned with human organizations will also find it stimulating, since consideration of the reactions and behavior of human beings in communication systems is a part of the communication problem.

Lectures daily from 9 to 12 will be followed by discussion periods from 2 to 3 and laboratory work from 3 to 5, the latter in the Research Laboratory of Electronics or the Acoustics Laboratory. Tuition for the three-week program is $175; no academic credit will be offered.

Since enrollment will be limited, early registration is advisable. Preference will be given to electrical and communication engineers and psychologists having a professional interest in the course, and to qualified students who wish to specialize in this subject. Requests for application forms and further information should be sent to Professor Walter H. Gale, Director of the Summer Session, Room 3-107, Massachusetts Institute of Technology, Cambridge 39, Mass.

Guided Missiles Plant Opened

A PRODUCTION plant for guided missiles operating at supersonic speed has been opened in San Diego by

Consolidated Vultee Aircraft Corp. under a contract with the Navy's Bureau of Ordnance.

Initial production will be on a supersonic antiaircraft missile. Hiring of 1,500 persons, who will work in a 200,000-sq-ft plant, started March 1. The company expects to reach its first production goals within a few months.

All details concerning the new San Diego plant, even to its generally known location, are being withheld insofar as a description of the work is concerned. Previously announced activities by Convair in the field of guided missiles, however, include these developments:

The Convair Lark was developed for the Navy between 1947 and 1949. It is a needle-nosed, double-finned experimental antiaircraft missile intended for shipboard use, powered with liquid rocket fuel and remotely guided.

Last summer Convair had under development a revolutionary long-range surface-to-surface missile for the Navy.

Work in developing a ramjet engine capable of propelling missiles at twice the speed of sound was carried on last year at the company's Daingerfield, Texas, missile research center.

BUSINESS NEWS

The Insuline Corp. of America has taken possession of a new 50,000-sq-ft factory in Long Island City, N. Y., to increase production of radio, tv and general electronic components.

Corning Glass Works, Corning, N. Y., has begun construction of a new 170,000-sq-ft plant in Danville, Ky., to provide additional facilities for the manufacture of glass bulbs and tubing. When in operation the plant will initially employ approximately 550 people.

National Electronic Mfg. Corp., producers of antennas and accessories, recently moved from Astoria, L. I., to new and larger quarters at 4202 Vernon Blvd., Long Island City, N. Y.

Sylvania Electric Products Inc. recently purchased a new factory

site at Woburn, Mass., where it will produce electronic tubes and equipment for national defense. The new factory, with 100,000 feet of floor space, will employ about 600 people and cost in the neighborhood of a million dollars.

CENTRAL TRANSFORMER CO., Chicago, Ill., was recently formed by M. R. Whitman, formerly chief engineer of Thordarson Electric, and L. G. Shore, formerly in charge of Geiger counter production at Radiation Counter Laboratories. The new company will specialize in custom transformer design and manufacture.

WESTINGHOUSE ELECTRIC CORP. is building a headquarters plant and engineering laboratories for its new electronic tube division on a 100-acre tract four miles northwest of Elmira, N. Y.

THE KELLEY-KOETT MFG. CO., manufacturer of x-ray equipment, was recently consolidated with Tracerlab, Inc., Boston, Mass., to expand both firms' operations in the fields of radiology and nucleonics.

PERSONNEL

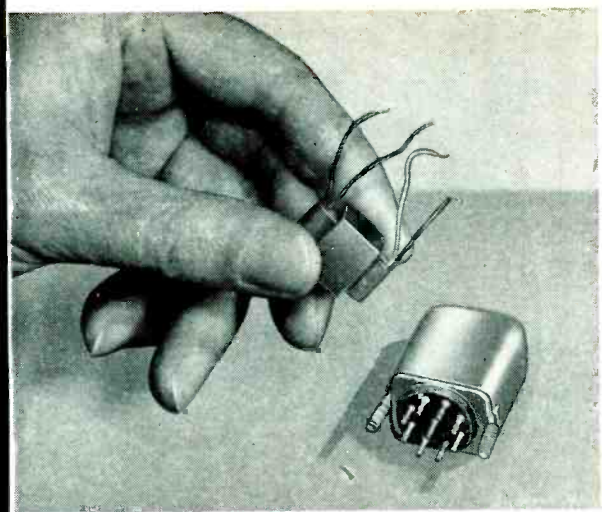
JOHN K. HILLIARD, chief engineer of Altec-Lansing Corp., is now on a two-month tour of western Europe, coordinating military design and production of Armed Services equipment and investigating commercial aspects of new European developments in microphones and loudspeakers. He is scheduled to return May 15.

JOHN RHOADES, since 1946 on the engineering staff of the Hoffman Radio Corp., Los Angeles, Calif., has been advanced to chief engineer of the company's Special Apparatus Division.

THOMAS A. FARRELL, JR., education director and service engineer, Soundscriber Corp. of New Haven, Conn., has been appointed general service manager for the company.

F. J. COOKE, formerly chief engineer of the Electronic Tube Laboratory of Remington Rand, has

Miniature Transformers and Coils to your Specifications!



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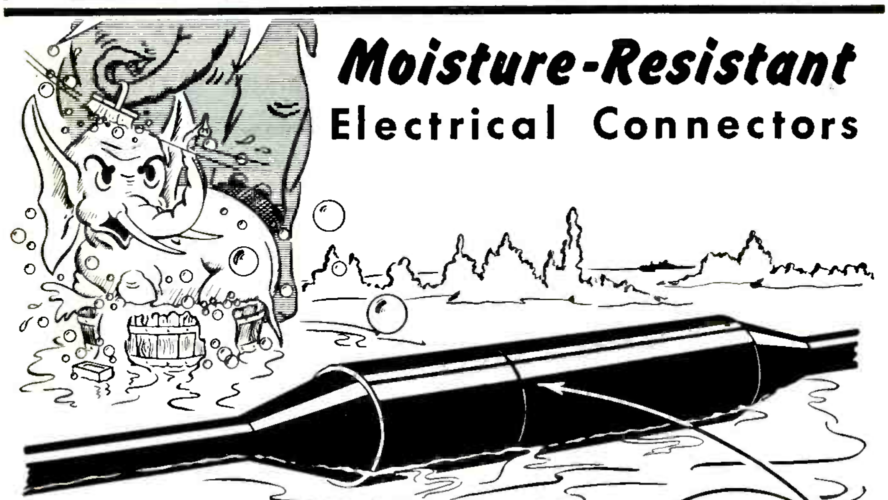
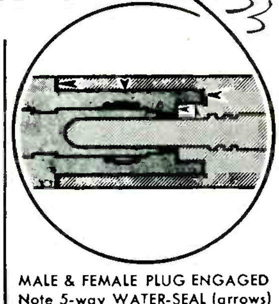


No question about it . . . JOY plugs and sockets are today's outstanding electrical connector value! Molded as one-piece Neoprene units and factory vulcanized to cords, they won't crack or shatter under hard blows—are surprisingly immune to climatic changes—and are trim, safe and easy to handle. Whenever advantageous, JOY Connectors are equipped with the famous MINES "Water-Sealing" face. Cut-away illustration in circle shows how close fitting segments on mating Male and Female plugs positively "*Seal-out*" dirt and moisture by enclosing contacts in a resilient rubber housing. Ask for a complete description on this and other advantages that only JOY Connectors provide.



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joined the manufacturing executive staff of Reeves Soundcraft Corp., New York, N. Y.

RUSSELL A. WHITEMAN has resigned his position with Tuttle and Kift, Inc., Chicago, to join the engineering staff of Eugene Mittelmann, consulting engineer, Chicago, Ill. He will be in charge of research and development in the applied electronics field.

LOUIS G. PACENT, president of the Pacent Engineering Corp., was recently awarded the Marconi Memorial Medal of Achievement by the Veteran Wireless Operators Association, for pioneer work in radio and communication.

NORMAN L. WINTER, until 1949 executive director of the Research and Development Board's committee on electronics, was recently named director of special electronic sales for Sperry Gyroscope Co., Great Neck, N. Y.

N. L. Winter

W. B. Bergen

WILLIAM B. BERGEN, with The Glenn L. Martin Co., Baltimore, Md., since 1937, was recently elected vice-president—chief engineer of the company. He had held the title of chief engineer since October 1949.

SHELDON E. YOUNG, formerly assistant chief engineer of The Barry Corp., Watertown, Mass., has been promoted to manager of field engineering service. In this capacity he will cooperate with designers and project engineers in the analysis and solution of shock and vibration problems.

A. V. ASTIN, formerly chief of the Electronics and Ordnance Division of the National Bureau of Standards, has been appointed associate director of the NBS.

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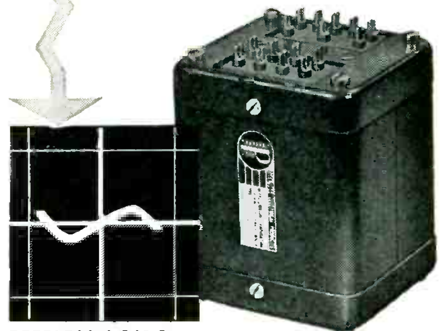

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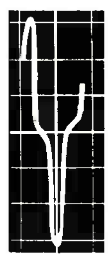
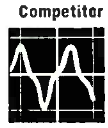


Competitor No. 1



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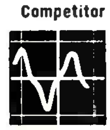

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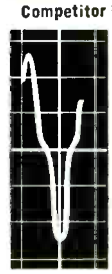

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Since the 1949 Audio Fair, comparative square wave tests on transformers shown all over the country have demonstrated Peerless superiority . . . Now Peerless emphasizes another very important property of transformers as shown by the "exciting current test."

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NEW BOOKS
(Continued from page 150)

clude quantum mechanics or solid-state physics. This review will be largely concerned with Part I for the reason that this portion of the book is likely to be of greatest interest to most readers of ELECTRONICS. Parts II and III, entitled "Descriptive Theory of Semiconductors" and "Quantum-Mechanical Foundations", will again be mentioned.

Conduction in Metals

To understand the action of the transistor, it is necessary first to distinguish between electrical conduction in metals and in semiconductors. The distinction is, in a way, arbitrary since the gradation between a pure metal and a perfect insulator is almost continuous. As it happens, semiconductors such as the highly purified germanium used in transistors occupy a rather unique position in this scale, making it instructive to compare their electrical characteristics with those of a pure metal.

In metals the general nature of conduction is visualized by aid of the electron gas concept. Here the valence electrons—those belonging to the outermost shell of the atom—are free to move about. We say that a conduction electron in a piece of metal is not to be identified with any particular atom, and that a field produces a drift in these electrons which is observed as an electric current. It is characteristic of metals that conductivity decreases with increasing temperature because of lattice vibration.

Conduction in Semiconductors

In a semiconductor such as germanium, the valence electrons are not normally free to move about but form electron-pair bonds. A few of these may be broken by heat or light, but at low temperatures most of the few charges available for carrying current come from ionization of chemical impurities or from imperfections in the lattice. As the temperature is increased, the number of free charges increases, with resultant increase in conductivity. At higher temperatures, the effects of lattice vibration become predominant so that, as in metal, conductivity decreases with increasing temperature over a considerable range. At still higher temperatures, conductivity again increases due to the excitation of carriers from the valence band.

As Dr. Shockley points out, it is basic to the theory of semiconductors that current conduction is accomplished by two distinctly different processes. One of these is conduction by electrons, the other by "holes". These processes may be described in terms of energy bands and Brillouin zones. Fortunately, a fairly satisfactory description can be given on the basis of the energy band scheme alone; the idea of Brillouin zones need not be introduced in a qualitative description.

Quantum Numbers of Electrons

According to modern theory, the energy of the conduction electrons in a metal is described by quantum numbers, and it follows from the exclusion principle that no two electrons may have the same set of quantum numbers. At absolute zero, every quantum number up to a certain maximum will be represented by an electron somewhere in the body; no electron will have energy represented by a higher quantum number. Figure 1A is intended to show this scheme; energy is represented as increasing upward. The line F is the Fermi level, which is the upper limit of electron energies at absolute zero; χ represents the energy which an electron must possess in

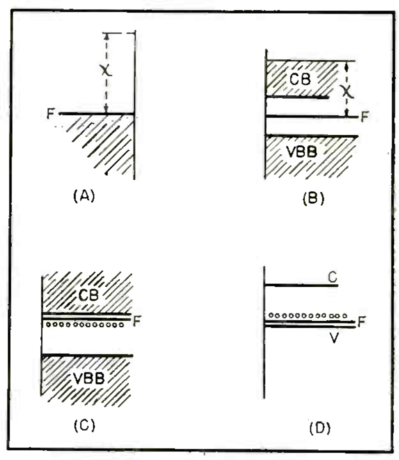


FIG. 1—Energy level diagrams for (A) a metal, (B) an intrinsic semiconductor, (C) an n-type semiconductor and (D), a p-type semiconductor

addition to F to escape from the body, and is commonly called the work function. At temperatures greater than zero, electrons may acquire energies such that their position in the diagram will be above F; it follows that a corresponding number of vacancies will occur below F. These elementary principles are fully discussed in modern texts on physics and on electron tubes. The scheme for metals should be kept in mind when considering the flow of electric charge across a metal-semiconductor boundary.

Energy Bands of Semiconductors

In a semiconductor there are several bands representing energy states. Figure 1B shows the uppermost bands of an intrinsic semiconductor. The lower band, marked *VBB*, is the valence bond band; it represents the energies of the valence electrons which bind the atomic nuclei together. In germanium, most commonly used for transistors, and in silicon, each atom has four valence electrons. These electrons form electron-pair bonds in such a way that the diamond lattice shown in Fig. 2 is formed. At low temperature, these bonds are quite stable with only a few disrupted by thermal agitation.

The upper band of Fig. 1B, labeled CB, is the conduction band. Normally, this band is practically empty; the few electrons present usually come from the ionization of an impurity atom or they may be excited to that level by disruption of the valence bond. The range of energies between the top of the

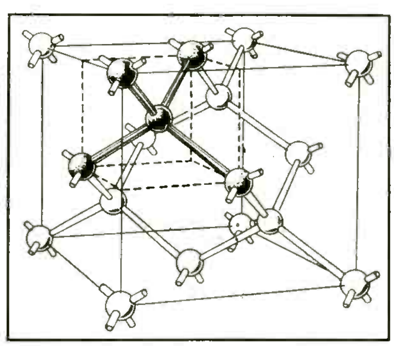


FIG. 2—The diamond structure, showing how each atom forms four bonds with its nearest neighbors. Each bond is represented by a rod which may be considered as a pair of valence electrons (Courtesy D. Van Nostrand Company, Inc.)

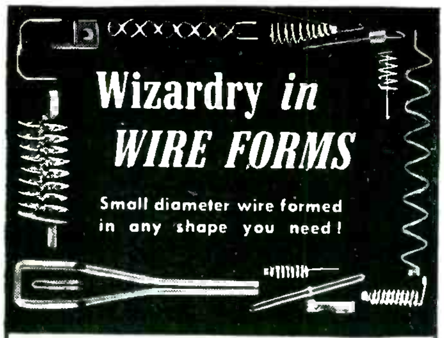
valence bond band and the bottom of the conduction band is called the *forbidden* zone because electrons do not occur in the semiconductor with energies between the extremes mentioned.

n-type Semiconductors

The Fermi level may occur midway between the conduction and valence bond bands under certain idealized conditions. More commonly, most of the electrons in the conduction band will come from the ionization of "donor" atoms. As the ionizing energy of these atoms is a rather small fraction of an electron volt, the energy level of the ion is not far below the bottom of the conduction band. In this case the Fermi level will lie somewhere between the energy position of the ion and the bottom of the conduction band. A semiconductor in which electrons are present in the conduction band as the result of the ionization of donor atoms shown in Fig. 1C is called an n-type semiconductor, the designation n arising from the fact that current is conducted by negative carriers. It is also convenient to remember that in an n-type rectifier the current is greater when the semiconductor is negative.

p-type Semiconductors

In a p-type semiconductor, represented by Fig. 1D, one considers the conduction band to be entirely devoid of electrons under ordinary conditions; current is carried by holes having energies near the upper part of the valence bond band. The word hole is used to designate the absence of an electron from its normal position in the lattice. This absence of an electron behaves as a positive charge, hence the designation p. Unlike an ion in a solid, a hole is free to drift in a semiconductor; when a field is applied it moves in the direction of decreasing potential just as an electron moves in the direction of increasing potential. Some holes are furnished when thermal or light energy causes a breaking of the valence bonds, but under ordinary conditions most of the holes in a p-type semiconductor occur as the result of the formation of negative ions by impurity atoms. These impurity



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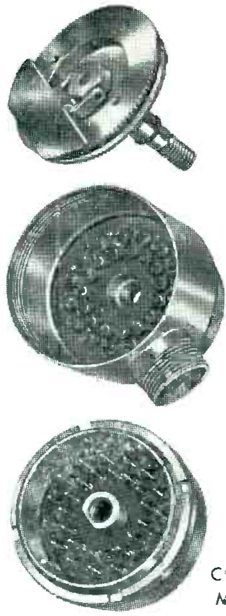

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atoms, which may be lattice defects, are called "acceptors" for the reason that they accept electrons which then become bound, leaving the hole free to move.

Carrier Injection in Semiconductors

If a piece of semiconductor such as germanium or silicon is connected by broad-area contacts to a pair of wires which are connected to a battery, current will flow through the semiconductor. As previously mentioned, the current will be carried by electrons in an n-type semiconductor or by holes in p-type material. With n-type material one readily imagines electrons flowing from the metal at the negative terminal into the semiconductor and, at an equal rate, electrons flowing into the wire at the positive terminal. For the p-type semiconductor, one may think of the positive terminal accepting electrons from the valence bond band so that holes flow across to the negative terminal, at which point electrons flow out of the metal to fill the holes reaching it. Such a picture is a gross over-simplification of actual conditions, especially when small-area contacts are used and surface effects are considered.

Proof of Hole Theory

Figure 3, from Dr. Shockley's book, illustrates an experiment which he and J. R. Haynes performed which confirmed predictions made upon theoretical reasoning and provided certain quantitative data concerning the movement of holes in n-type germanium. Figure 3A represents the experimental ar-

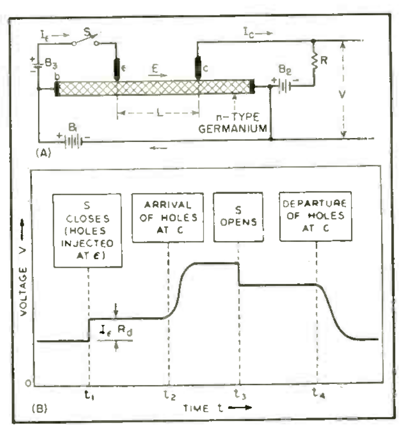

FIG. 3—Experiment to investigate the behavior of holes injected into n-type germanium (Courtesy D. Van Nostrand Company, Inc.)

rangement, while Fig. 3B shows the voltage V (measured between the points indicated in the circuit) as related to the time of closing and opening switch S. The cross-hatched element is a rod of n-type germanium having broad-area contacts at the ends; holes are injected into the germanium by the point contact ϵ (for emitter) and collected at a similar contact c.

Before the switch is closed, V is the battery voltage B_2 minus the drop RI_c, where I_c is an electron current in the semiconductor. When the switch is closed at time t_1, a current I_ϵ flows in the emitter circuit so that, regardless of the type of material from which the rod is made, there is a change in current through the resistor R. However, when the rod is an n-type semiconductor the current through R begins to increase at a later time t_2 and reaches a new value. From this it is clear that, when the switch is closed, holes are emitted into the germanium which drift down the rod to the collector under the influence of the field provided by battery B_1. When they arrive at the collector they increase the current in the collector circuit. When the switch is opened the process is reversed. The key to the explanation is best given in Dr. Shockley's own words: "In a sample having carriers of one type only, electrons for example, it is impossible to alter the density of carriers by trying to inject or extract carriers of the same type. The reason is . . . that such changes would be accompanied by an unbalanced space charge in the sample and such an unbalance is self-annihilating and does not occur." The fact that carriers of opposite type can be injected into a semiconductor with consequent alteration in the apparent conductivity at another point on the semiconductor constitutes the necessary and sufficient condition for transistor action to be a reality.

Surface States of Electrons

The term "surface states" frequently crops out in almost any discussion of semiconductor theory. In the few pages devoted to this topic, Dr. Shockley presents an

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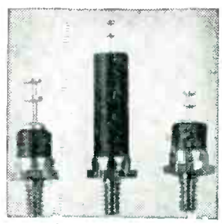

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Type-A Transistors

Transistors may be of more than one general type. That known as the type A is shown schematically in Fig. 4. It may employ either *n*- or *p*-type material; the battery polarities indicated are for the *n*-type material and would be reversed for the *p*-type transistor. The filamentary and *p-n-p* transistors will be mentioned later.

The similarity between the transistor of Fig. 4 and the experimental set-up for observing the effects of hole injection into *n*-type germanium shown in Fig. 3 is at once evident. When the emitter current I_ϵ is varied the collector current I_c also varies. That the collector current can vary more than the emitter current is not, however, obvious from what has so far been

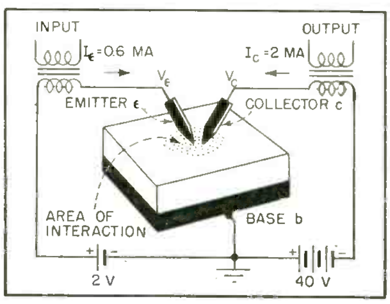

FIG. 4—Type-A transistor with typical operating conditions (Courtesy D. Van Nostrand Company, Inc.)

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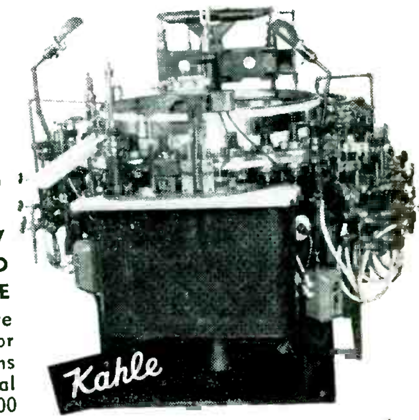

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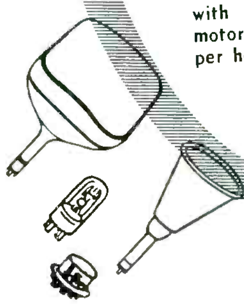

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noted. One defines the current amplification as

$$\alpha = -(\delta I_c/\delta I_e),\ V_c = \text{constant.}$$

An average value of α might be 2.5; values several times this amount are sometimes encountered. The reason for such high values is to be found in a number of factors.

Factors Affecting Amplification

First, the current in the collector circuit is increased by the magnitude of the hole current reaching the collector point. Second, the potential in the region of the point tends to be altered by the holes which act like positive charges so that a further increase in electron current from the collector results. This increase in electron current is, of course, limited to that which restores the normal space charge. As a rough approximation, if all holes injected by the emitter reach the collector, and if one hole balances the charge of one electron, the current gain as above defined should be two. There are, however, other factors to be considered.

By measurements of the Hall coefficient and resistivity, as well as by interpretation of data obtained from experiments like Fig. 3, it has been shown that the mobility of holes in germanium is only about half that of conduction electrons. If this ratio holds in the strong field existing in the space-charge region near the collector, the holes exert their influence twice as long, so that two electrons are emitted for every hole. Thus if b is the ratio of electron mobility (or velocity) to hole mobility, the current gain α is $1 + b$. For weak fields, as in the rod of Fig. 3, b is about 2, so that from these deductions α could be only about 3. That α can have much higher values may be taken as indication that some further action must take place such, for example, as the trapping of holes in trapping centers. "If a concentration of centers which has the property of binding holes tightly could be produced directly in front of the collector, then the holes would tend to accumulate there with a resultant increase in space charge."

Dr. Shockley discusses briefly his theory of the "p-n hook" as a prob-

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able means of current multiplication, the hook being a thin region of weakly p-type material formed between the n-type body of the crystal and an n-type region adjacent to the collector.

In view of the mechanism of current multiplication, whatever it may be, the factor $(1 + b)$ is apt to be of minor significance in most cases. The symbol α_i is used for the intrinsic current gain taking place at the collector and, for the device, the current gain α will be $\alpha_i\,\beta\gamma$. The factor β is the fraction of holes leaving the emitter which arrive at the collector. Since some holes are lost by recombination with electrons, β is somewhat less than unity and drops to low values for wide separation between emitter and collector points. The factor γ is the fraction of emitter current carried by holes; it will also be somewhat less than unity for the reason that a part of the emitter current may be due to electrons entering the emitter from the conduction band of the semiconductor.

Equivalent Circuit

In Part I of his book, Dr. Shockley devotes about 13 pages to the equivalent circuit and noise. One naturally wishes that these sections could have been somewhat expanded, but the fact that these topics have already been well covered in the literature by some of his associates is reason enough for brevity.

Figure 5 shows three equivalent circuits for the transistor and the relationships among the parameters. Attention must here be called to the fact that a transistor is a current-operated device and as such may be considered the dual of the triode. We write the functional relationships in the form

$$v_\epsilon = f_1(I_\epsilon, I_c)$$
$$v_c = f_2(I_\epsilon, I_c)$$

The subscripts refer to the emitter and collector. The small a-c voltages v_ϵ and v_c produced by small a-c currents i_ϵ and i_c are then

$$v_\epsilon = \frac{\delta f_1}{\delta I_\epsilon} i_\epsilon + \frac{\delta f_1}{\delta I_c} i_c = r_{11}\, i_\epsilon + r_{12}\, i_c$$

$$v_c = \frac{\delta f_2}{\delta I_\epsilon} i_\epsilon + \frac{\delta f_2}{\delta I_c} i_c = r_{21}\, i_\epsilon + r_{22}\, i_c$$

The r's are the slopes of the char-

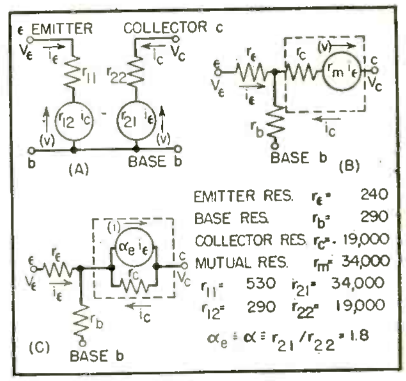

FIG. 5—Equivalent circuits for the transistor and average equivalent circuit parameters in ohms. For computation of performance, the network may be arranged as in (B) or (C), the elements in the boxes being the required constant-voltage or constant-current generators (Courtesy D. Van Nostrand Company, Inc.)

acteristic curves of the transistor units under consideration.

Transistor Noise Figures

The noise of the transistor has a frequency spectrum associated with contact or current noise. "The noise power per cycle varies inversely with frequency so that the noise per octave is the same for all octaves, at least over the frequency range for which the equivalent circuit parameters are independent of frequency." The equivalent circuit is that of Fig. 5A but with $v_{n\epsilon}$, the noise generator voltage at the emitter, substituted for v_ϵ and with v_{nc}, the noise generator voltage at the collector, substituted for v_c. Typical values are $v_{n\epsilon} = 1$ microvolt and $v_{nc} = 100$ microvolts, these being the rms noise voltages in a 1-cps band at 1,000 cps. Since the noise power varies as $1/f$, the values of $v_{n\epsilon}$ and v_{nc} at another frequency f are $(1{,}000/f)^{\frac{1}{2}}$ times their values at 1,000 cps.

A typical noise figure is 55 db for the 1,000 to 10,000 cps band which is, of course, poorer than that of a triode. Comparison is not so unfavorable at considerably higher frequencies; for example, the typical transistor would have a noise figure of about 30 db at 1 mc. Dr. Shockley indicates that "there appears to be no basic physical principle which will prevent lowering the noise in transistors greatly." While results of recent tests at the Bell Telephone Labora-

tories are not known to this reviewer, those at the Physics Laboratories of Sylvania Electric Products Inc. are in agreement with Dr. Shockley's predictions.

Other Transistors

As previously mentioned, the type-A transistor is not the only variety of transistor, although it is the only kind so far adapted to reasonably reproducible manufacture. The filamentary transistor and the *p-n-p* transistor are of special interest as tools for the investigation of semiconductor phenomenon. One kind of crystal photodiode is sometimes called a phototransistor since its operation is quite analogous to that of the type-A transistor, hole injection in the former being accomplished by light. Dr. Shockley makes only brief mention of this most useful and interesting device, presumably because its operation is easily understood when the action of the type-A transistor and the creation of hole-electron pairs by means of photons has been explained.

In the book, discussion of the filamentary transistor precedes that of the type-A transistor because it is more basic; the order has been reversed in this review because the latter is more familiar to most readers.

Filamentary Transistors

The filamentary transistor is made by mounting a thin slab of single-crystal germanium on an insulating block and cutting it out as shown in Fig. 6. Broad-area contacts are made at the ends and an emitter point positioned as shown. The high impedance of the

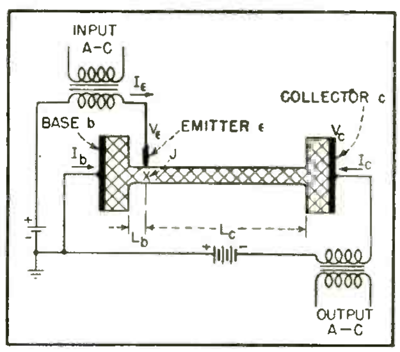

FIG. 6—Filamentary transistor (Courtesy D. Van Nostrand Company, Inc.)

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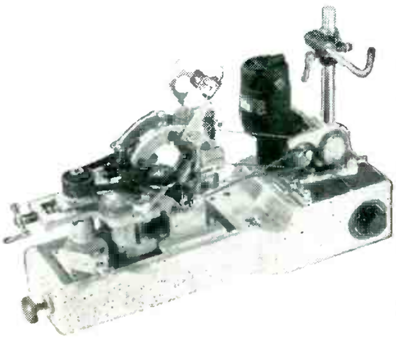

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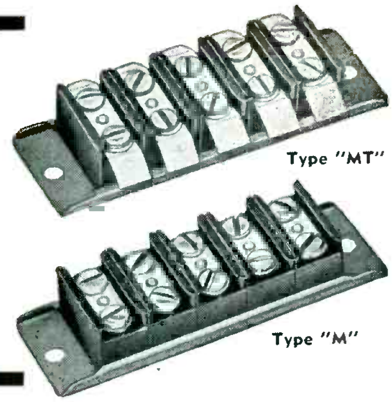

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type-A transistor point-contact collector is absent in the filamentary type, although this is in part compensated by the length and the small cross-section of the filament. By placing the emitter well to the right of the broad-area base connection, any holes emitted at the base will have been lost by recombination near the base and the emitter is thus able to produce a current amplification. Since the collector is also a broad-area contact, the current gain is not high as in the type-A transistor, but will be very close to $(1 + b)$ where b is the ratio of electron to hole mobility.

The discussion of positive feedback in transistors which Dr. Shockley gives at this part of the book is brief and much to the point; it is highly recommended reading for anyone who proposes to work with transistors, for the reason that they are so easily ruined if adequate provision is not made to prevent abnormal currents.

Type p-n-p Transistors

The *p-n-p* transistor has no point contacts in the usual sense; it "has the expositional advantage that a detailed mental picture can be formed of the distribution of all the atoms involved." In Fig. 7 the *p-n-p* transistor is shown diagramatically. A single crystal of germanium is used, having a narrow *n*-type zone in the middle, the end portions being *p*-type. As shown in Fig. 7E, there are more acceptor impurities in the end sections so that conduction is primarily by holes; in the center section there are more donor impurities, hence conduction is primarily by electrons. The extremely thin region where the germanium changes from one conductivity type to the other is called a *p-n* junction. In the figure there are two such junctions indicated by the dashed lines J_e and J_c.

As shown schematically in Fig. 7G, there are conduction electrons present in the *n*-type center or base region N_b and holes in the end parts P_e and P_c when no voltage is applied. When voltages are applied as in Fig. 7B, holes flow from P_e into N_b and, if N_b is very thin, the holes flow on into P_c where they add to the current in the collector

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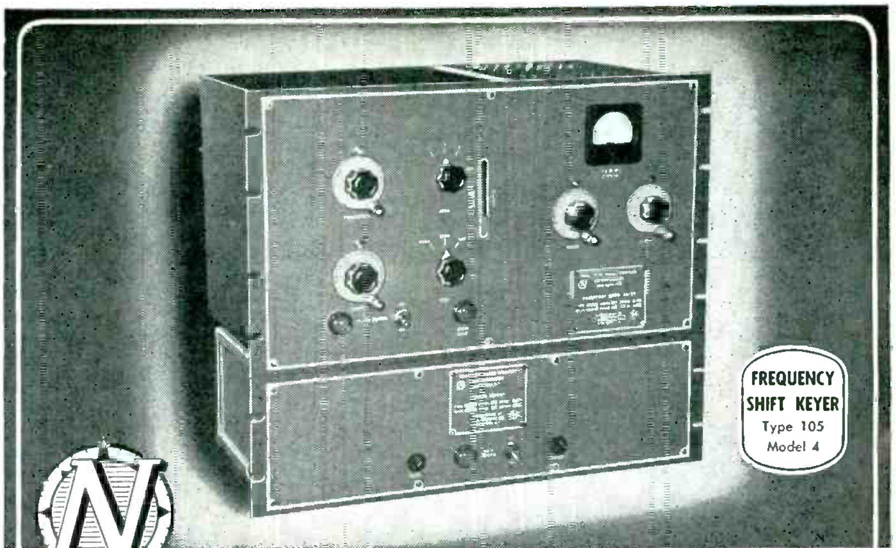

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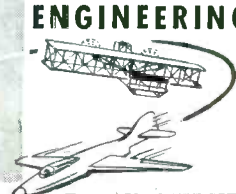

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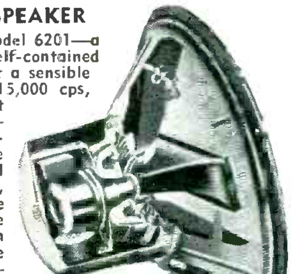

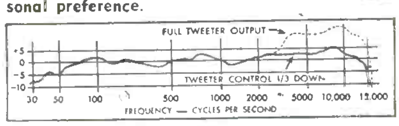

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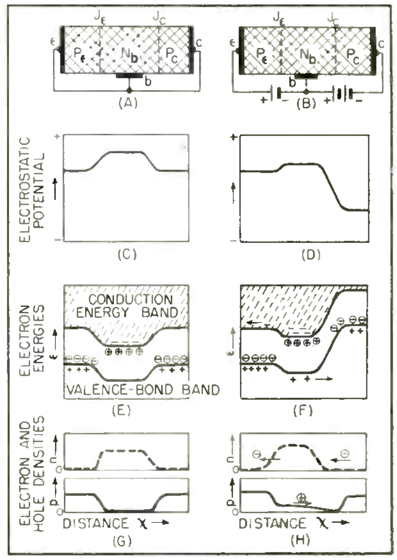

FIG. 7—The p-n-p transistor, showing potential, energy and charge density relations for zero current in (C), (E) and (G), and with current flowing in (D), (F) and (H) (Courtesy D. Van Nostrand Company, Inc.)

circuit. If a small a-c voltage is inserted in the base circuit (between N_b and the point where the two batteries are connected) the voltage across J is varied so that it produces a variation in hole current across this junction. This, in turn, varies the current in the collector circuit. The factors β and γ previously mentioned apply to the *p-n-p* transistor as in the type A transistor, and $\alpha = \beta\gamma$. The value of α for such a transistor is obviously less than unity, but power gain can still result. Since electrons do not readily flow from P_c into N_b, the dynamic resistance r_c of the collector circuit is high when P_c is negative with respect to N_b. Conversely, the dynamic resistance r_ϵ is low because the emitter section P_ϵ is biased positive with respect to N_b and a small change in voltage across J_ϵ can produce a considerable change in hole flow. The power gain is approximately $\alpha^2 \, r_c/r_\epsilon$.

Descriptive Theory of Semiconductors

While a general idea of transistor action and semiconductor phenomena in general can be understood without recourse to the concepts of theoretical physics, the difficulty in reasonably interpreting the experimental data is considerable. Without an understanding of the principles of quantum mechanics, one

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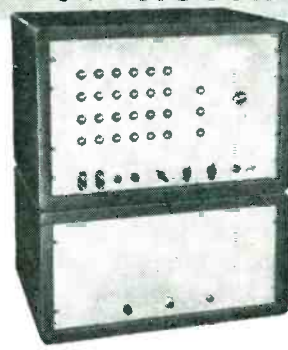

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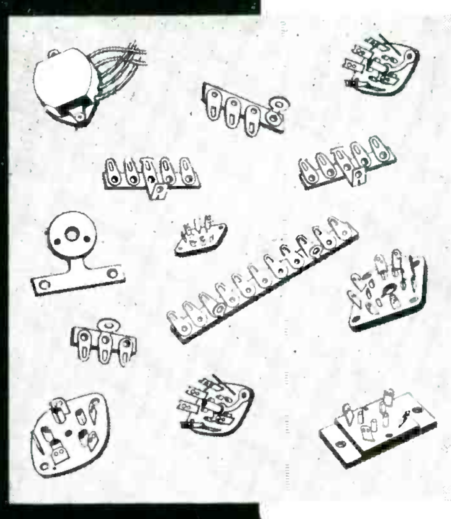

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NEW BOOKS (continued)

could not hope to rationalize, for example, hole injection or the movement of electrons in a lattice.

Although one may have become familiar with some of the more basic implications of the theory, such as the principles of least action and the Pauli exclusion principle, it is often difficult to acquire a genuine feeling for some of the more abstract, but equally important, aspects of quantum theory. For example, most texts begin the discussion of wave mechanics by simply writing out Schroedinger's equation and leaving the student completely in dark as to the significance of ψ, stating merely that it is an unknown wave function. It is a pleasure to note here the manner in which Dr. Shockley proceeds to attach meaning to what, in many treatments of the subject, is most apt to remain but little more than an "unknown wave function". Mechanical analogies are used in the early discussion of the wave equation in such a manner that the concepts can be carried directly over to wave motion within the crystal.

The Bloch functions, as proper solutions to the wave equations in a periodic system such as a crystal lattice, are introduced in an early part of the section. Explication of the Brillouin zones and periodicity of the functions complete the basic foundations for the complete picture of the nature of hole and electron flow and the theory of conduction and the Hall effect. The last fifty pages of Part II are devoted directly to applications of the theory to transistor electronics.

Theoretical Section of Book

Part III, entitled "Quantum Mechanical Foundations", is highly theoretical and to discuss its content in any detail would be outside the scope of this review. Apart from its specialized nature, however, it will be found very helpful in connection with the study of Part II. For example, in Part II the Bloch wave functions are simply set down as the eigenfunctions of the general wave equation as applying to a particular set of boundary conditions. For one who dislikes accepting solutions on faith, it is quite consoling to find

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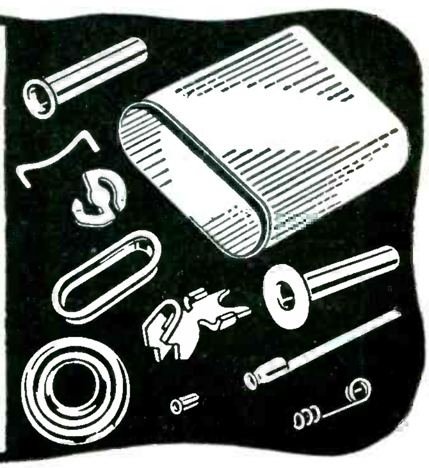

them derived in Part III. The simple atom-transmission line analog should be an excellent means of gaining an insight into the rigorous derivation of solid-state functions.

Conclusion

Technical and scientific books written by one who has not taught a course for some years on the subject of the book often fail miserably in logical presentation. In view of the newness of much of the material in Dr. Shockley's book, the degree of clarity he has achieved is noteworthy. The problems given at the ends of several of the chapters, plus frequent reference to older books and the periodical literature, provide additional means to insure that the more difficult parts can be understood.—G. D. O'NEILL, *Head, Solid State Section, Physics Laboratories, Sylvania Electric Products Inc., Bayside, N. Y.*

THUMBNAIL REVIEWS

ALTERNATING CURRENT CIRCUITS. By R. M. Kerchner and G. F. Corcoran. John Wiley & Sons, New York, 1951, third edition, 598 pages, $5.50. Junior class textbook for engineering colleges, revised to include elementary four-terminal communication networks, an additional method of wave analysis, design of tuned coupled circuits, and three-origin vector diagrams of polyphase circuits. Problems have been rather completely revised, new problems added, and minor changes made throughout text for clarification of principles.

RADIATION MONITORING IN ATOMIC DEFENSE. By D. E. Gray and J. H. Martens. D. Van Nostrand Co., New York, 1951, 122 pages, $2.00. Background information on radiation hazards, based on data obtained from the Federal Civil Defense Administration and the Atomic Energy Commission, and semitechnical information on the basic construction, characteristics and uses of specific radiation detecting devices, along with instructions for operation and maintenance. Directed principally to the geigerman and others whose duties include responsibility for radiation safety of people in an emergency involving atomic energy hazards. Covers Geiger counter survey meters, ionization chamber survey meters, proportional alpha counters, pocket chambers, film badge dosimeters, and the AEC emergency monitoring kit.

ARINC SYNCHRO SYSTEM MANUAL. Available in limited quantities from Aeronautical Radio Inc., 1523 L Street N.W., Washington 5, D. C., 1950, 59 pages, $3.00. Presents a review of simple synchro systems, the theory of a set of recommended standards, and includes charts for design, testing and maintenance of a complete synchro system of instrumentation. Especially useful is the chart listing connection codes for synchro units produced by different manufacturers. A special section is devoted to a discussion of aircraft systems using synchros.

BACKTALK

(continued from page 152)

chestra, which gave two chamber music concerts daily at the Philadelphia Radio Show of the same year. The performers were members of the Philadelphia Orchestra. Even this early attempt could hardly claim to be the first one as it was antedated by Theremin's concert at the Carnegie Hall, New York City, during the early part of 1931. The same period witnessed numerous similar concerts in Europe, featuring ensembles of electronic solo musical instruments developed by Martenot and Bertrand in France and by Mager, Lertes and Helberger, and Trautwein in Germany. Incidentally, Trautwein's electronic solo instrument, the "Trautonium", had the distinction of having special music written for it by Paul Hindemith, the well-known modern composer.

That the crank-operated solo instruments of the type described by Meachem were not commercially successful was probably due to the fact that they are not suitable for the execution of rapid musical passages. They were quickly superseded by solo instruments in which the selection of pitch is accomplished by keyboard control, as in the writer's Emicon, manufactured by Pratt, Read & Co. in Deep River, Conn. in 1932-33, or by displacement of a finger on a string, as in the Trautonium, manufactured by the Telefunken Company of Berlin, Germany in about the same period. Both of these early attempts were commercial failures, due to a variety of reasons. In the first place, the resistance of musicians, both professional and amateur, against an instrument requiring a completely non-conventional, although relatively simple, playing technique, was considerable. In the second place, the selling price of the instruments twenty years ago, when the quantity production of electronic devices was still in its infancy, was too high to permit reaching a sufficiently broad segment of the public. Finally, the development, manufacture and distribution of a practical and commercial electronic instrument of this type requires an unusual combination of electronic and musical talent which was impossible to find within the

same organization twenty years ago. However, it may well be that, apart from the present emergency, a similar venture may have better prospects for success at the present time.

NICHOLAS LANGER
New York, N. Y.

Author Replies

DEAR SIRS:

THANK YOU FOR your invitation to reply to the comments of Nicholas Langer on my article "Electronic Music for Four" published in the February issue of ELECTRONICS.

I am grateful to Langer for his contribution of historical background. Not long ago I was hunting for such information, and although acquainted with Theremin's and Péchadre's patent, I found little else pertaining to instruments using continuously tuned oscillators.

If we assume it to be true, as Langer points out, that what I have lightly referred to as "the present state of the art" is actually similar to efforts of twenty years ago, then we must ask why there has been so little advance in these twenty years. The answer appears to be that efforts to establish "crank-controlled" devices as serious musical instruments met early discouragement, which caused interest to shift over to the keyboard type of control. The resulting electronic organ was quite successful and captured almost all the subsequent development effort. If this shift of interest had not occurred, the field would surely have been covered more thoroughly. Perhaps it is because it did occur that the Patent Office has found it possible to allow my application, Patent No. 2,544,466, which includes as one of its claims, "An electronic musical instrument comprising a plurality of self-oscillating electronic sources of electric waves, rotary manual means for independent frequency variation of each of said sources over a continuous range of at least one octave, means for independent amplitude variation of each of said sources, means for independent interruption of each of said sources,

means for combining the electric waves of said sources, and an electromechanical transducer for converting the sum of said waves into sound, whereby a plurality of players, respectively controlling said sources, may produce polyphonic music". Incidentally the patents referred to by Langer do not show an ensemble type of instrument.

It seems to me that the most significant thing I have happened to come across in this matter is a surprisingly encouraging response by various samples of the public. The wobble organ started as a joke—a rather horrible novelty—and produced happy enthusiasm. People have asked where they might obtain one. They have made serious comments on such things as the "sympathetic" quality of the vibrato and blending. They have speculated on uses in hospitals and rehabilitation centers, and in musical education. This observed phenomenon is what has led me to carry the wobble organ up to the stage of an ELECTRONICS article.

Let's not be too serious about it. Let's never mention it in the same breath with the symphony or the pipe organ or the string quartet. Nevertheless, here it is for what can be made of it. Maybe the development of twenty years ago should be resumed.

L. A. MEACHAM
Bell Telephone Laboratories
Murray Hill Laboratory
Murray Hill, New Jersey

Electronics Quiz

THIS month's quiz was furnished by Emil M. Anderson of Detroit, Michigan. For his contribution, Anderson will receive our check for five dollars, as will all contributors whose problems are published.

This Month's Problem

Assume a superheterodyne receiver with a signal input to the converter of frequency f, and a local oscillator input of frequency (5/4)f. Then, in accordance with established principles of converter action, its output will contain the two input frequencies f and (5/4)f, and the sum and difference frequencies (9/4)f and ¼f. The intermediate frequency amplifier is, as usual, tuned to pass only the

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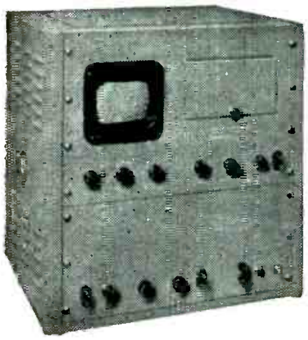

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difference frequency.

Now suppose that, instead of the local oscillator, we substitute a modulator. This modulator accepts the signal input of frequency f and modulates it with a voltage of frequency ¼f, taken from a point at or near the output of the intermediate frequency amplifier. In accordance with principles of modulator action, its output will contain the two input frequencies f and ¼f, two side-band frequencies (¾)f and (5/4)f, and higher harmonics which may be bypassed and neglected. Note that the side-band frequency (5/4)f is the same as the local oscillator frequency in the original receiver. The other side-band frequency (¾)f entering the converter would produce beat frequencies with the signal frequency, of which only the difference frequency ¼f would be accepted by the intermediate frequency amplifier.

General Case

Extending the reasoning now to the general case for any ratio n of signal frequency to intermediate frequency, the output of the modulator contains the frequencies

$$f + \frac{f}{n} \text{ and } f - \frac{f}{n}$$

Considering the first of these two terms in the converter action, we obtain the following expressions for the sum and difference frequencies in its output:

$$(1)\ \left(f + \frac{f}{n}\right) + f = 2f + \frac{f}{n}$$

(rejected by i-f amplifier)

$$(2)\ \left(f + \frac{f}{n}\right) - f = \frac{f}{n}$$

(passed by i-f amplifier)

Considering the other modulator output frequency, we obtain for the sum and difference frequencies in the converter output:

$$(3)\ f + \left(f - \frac{f}{n}\right) = 2f - \frac{f}{n}$$

(rejected by i-f amplifier)

$$(4)\ f - \left(f - \frac{f}{n}\right) = \frac{f}{n}$$

(passed by i-f amplifier)

Thus it would appear that we can construct a superheterodyne receiver with a modulator operating as described instead of a local

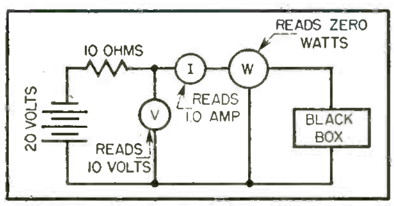
oscillator. The modulator would automatically provide the correct relationship of frequencies to make best use of the intermediate frequency amplifier characteristic and thereby do away with the tracking problems inherent in the tuning of an adjustable type of local oscillator.

What is the fallacy in this reasoning?

Last Month's Solution

THE PROBLEM published last month was:

Consider the circuit diagram shown. The battery supplies 20 volts d-c with no internal resistance. The voltmeter, ammeter and wattmeter are average or rms indicating, and for this problem they



require no power to operate. The apparent power dissipation in the black now is 10 watts according to the voltmeter and ammeter, but the zero wattmeter indication is a contradiction of this. What is in the little "black box?"

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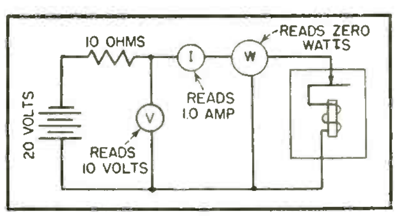

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$I = 2.0$ amperes $V = 0$ volts
When contact is open
$I = 0.0$ amperes $V = 20$ volts
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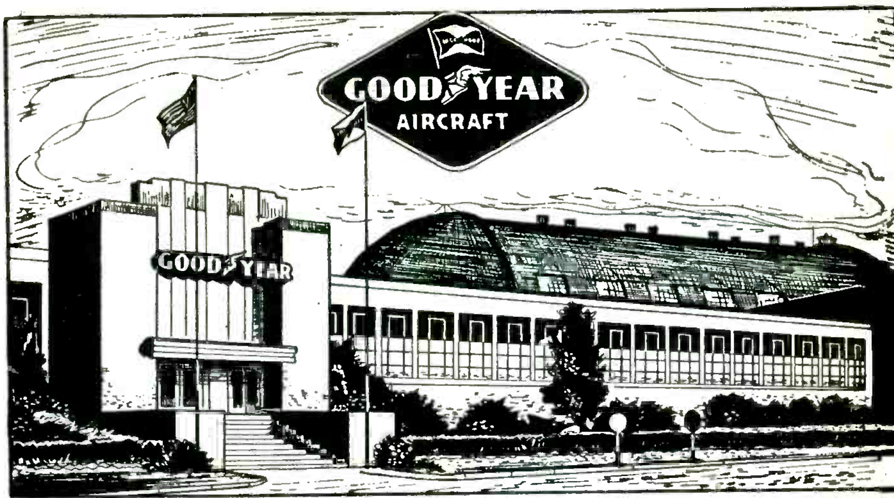

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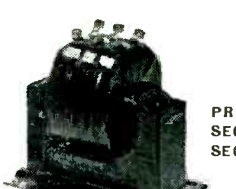

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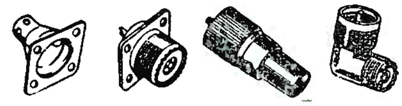

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UG-19	UG-27A	UG-83	UG-106	MX-195	UG-260
UG-21	UG-29	UG-85	UG-108	UG-197	UG-264
UG-21B	UG-30	UG-86	UG-109	UG-201	UG-274
UG-22	UG-33	UG-87	UG-167	UG-206	UG-275
UG-22B	UG-34	UG-88	UG-171		UG-290
					UG-306

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500	5/16"	15K	SS	100K	1/2"
500	1/2"	15K	1/2"	150K	1/2"
500	5/8"	20K	SS	200K	3/8"
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RG-24/U	125	240	RG-55/U	53.5	65
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RG-26/U	48	75	RG-58/U*	53.5	60
RG-27/U	48	290	RG-59/U*	73	70
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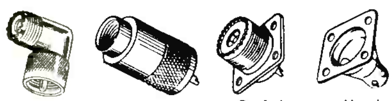
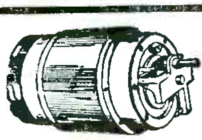


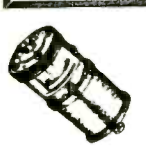
83-1AC	$0.42	UG-13/U	.63	UG-85/U	.88
83-1F	1.30	UG-19/U	.73	UG-87/U	.79
83-1J	.80	UG-21/U	.67	UG104/U	.85
83-1R	.40	UG-23/U	1.10	UG-167/U	2.00
83-1SPN	.50	UG-24/U	.67	UG-171/U	1.33
83-1T	1.12	UG-25/U	.60	UG-175/U	.15
83-22AP	1.10	UG-27/U	.68	UG-176/U	.15
83-168	.15	UG-29/U	.83	UG-197/U	1.33
83-185	.15	UG-33/U	14.80	UG-206/U	.63
UG-7/AP	2.14	UG-34/U	16.00	UC-255/U	1.22
UG-12U	.63	UG-58/U	.63	UG-264/U	1.74
				UG-281/U	.60

DIFFERENTIAL

115 V., 60 Cyc.
#C78249
3⅜" dia. x 5⅜" long
$3.95 ea.



Used between two #C78248's as dampener. Can be converted to 3600 RPM Motor in 10 minutes. Conversion sheet supplied. (Converted) $4.50
Mounting Brackets — (Bakelite) for selsyns, and differentials shown above ....35¢ pair



2J1G1 SELSYNS

BRAND NEW
400 Cycle
Can be used on 60 cycle
$1.90

JONES BARRIER STRIPS

Type	Price	Type	Price	Type	Price
2-140Y	$0.13	4-141W	$0.30	9-141Y	$0.64
3-140¾W	.19	5-141	.26	10-141	.50
6-140	.25	5-141¾W	.37	17-141Y	1.17
10-140¾W	.53	7-141	.36	2-142	.15
2-141	.13	7-141¾W	.49	3-142	.21
3-141¾W	.24	8-141¾W	.58	2-150	.39
3-141W	.24	9-141W	.64	3-150	.54

UNIVERSAL JOINT

3/16" hole x 3/8" O.D.
1 1/8" long
Steel or Aluminum
50¢

EQUIPMENT

LAVOIE Micro Wave Freq. Meter. Model 105. 300 to 600 Mcs. .... $ 58.50
JACKSON Audio Oscillator. Model 655 .... 95.00
FERRIS Standard Signal Generator. Model 47-A. 40 Mcs. 79.95
G. R. Standard Signal Generator. Model GR-P-330. 15-30,000 Kcs. Less Coils) 45.00
RCA Advanced Voltohmyst, 10X Multiplier. Regular & 30 KV Probes. Type WV-75A 85.00
BC-221-E Freq. Meter with 110V Power Supply 73.95
TS-343/U Sig. Gen. Measurements Corp.—Model 78B 39.95
BC-1016 Recorder 395.00
ASB-4 6 Units 50.00
BC-191-N (BC-375) Tubes—Tuning Unit 22.50
CLOUGH-BRENGLE—Model 230 Capacity Bridge Etc. 45.00

TYPE "J" POTENTIOMETERS

Ohms	Shaft	Ohms	Shaft
200	1/2"	5K	5/8"
300	5/8"	10K	S.S.
400	3/8"	15K	3/8"
500	S.S.	30K	S.S.
1,000	S.S.	50K	3/8"
1,500	S.S.	80K	S.S.
2,000	S.S.		
2,500	S.S.	100K	7/16"
3,000	S.S.	250K	S.S.
4K	3/8"	1 meg.	S.S.

$1.00 Each

GEAR ASSORTMENT

100 small assorted gears. Most are stainless steel or brass. Experimenters dream! .... Only $6.50

VERNIER DIAL or DRUM (From BC-221)

DIAL—2⅝" dia. 0-100 in 360°. Black with silver marks. Has thumblock. DRUM—0-50 in 180°. Black with silver marks .... either, 85¢

BLOWER & MOTOR

Blower #1½. motor 27½ V.D.C., 1/100 H.P., 8,500 R.P.M. Continuous duty. Has mounting brackets. Navy Inspected $3.50

ALLEN SET SCREWS

4-40 x 1/8 — 8-32 x 1/8 — 8-32 x 5/16
4-40 x 3/16 — 8-32 x 3/8
ALL SIZES .... $1.50 per 100

NEEDLE BEARINGS

B108 1/2" wide — 5/8" — 13/16" — 30¢

Wrapped—BALL BEARINGS—New

Mfg	ID	OD	Width	Price
Fafnir 33K5	3/16"	1/2"	5/32"	$0.25
N.D. 5202C13M	1/2"	1 3/8"	1/8"	1.00
Fafnir 7308W	1 37/64"	3 9/16"	5/16"	2.00
Fafnir 545	2 1/16"	2 5/8"	15/32"	1.00
TIMKEN	4 5/16"	6 1/4"	29/32"	4.25

CAPACITORS

POSTAGE STAMP MICAS

MMF	MMF	MMF	MMF	MMF	MFD	MFD
8.2	40	90	240	510	.0011	.0051
10	43	100	250	560	.0012	.006
15	47	110	300	580	.0013	.0062
20	51	120	330	600	.00136	.0065
22	56	125	350	620	.0015	.0068
24	60	130	370	680	001625	.007
25	62	150	390	800	.002	.0075
26	68	160	400	820	.0026	.008
30	75	175	430	910	.0027	.0082
35	82	180	470	MFD	.003	.01
39	85	220	500	.001	.0033	

Price Schedule
8.2 MMF to .001 MFD .... 5¢
.0011 MFD to .001625 MFD .... 7¢
.002 MFD to .0082 MFD .... 12¢
.01 MFD .... 22¢

SILVER MICAS

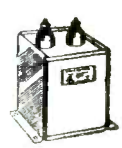
MMF	MMF	MMF	MMF	MMF	MMF	MFD
10	51	120	270	470	875	.00282
18	60	125	325	488	MFD	.002826
22	62	150	330	500	.001	.003
23	66	180	360	510	.001625	.0033
24	68	200	370	525	.0022	.0039
30	75	208	390	560	.0023	.005
39	82	225	400	660	.0024	.0051
40	100	240	410	680	.0028	.0056
50	110		430	700		.006
	115		466	750		.0082

Price Schedule
10 MMF to .001 MFD .... 10¢
.001625MFD to .0024 MFD .... 20¢
.00282 MFD to .0082 MFD .... 50¢

OIL FILLED

MFD.	V.D.C.	Price	MFD.	V.D.C.	Price
.125	35,000	$34.95	.02	2,000	$0.70
.125	27,000	28.95	6	1,500	2.25
.5	25,000	34.95	2	1,500	1.75
.05	16,000	2.95	1	1,500	1.50
.03	16,000	1.95	12	1,000	2.45
.1	12,000	1.95	6	1,000	1.79
.15-.15	8,000	2.45	4	1,000	1.39
.02	8,000	1.69	3	1,000	.80
.05	7,500	1.50	2	1,000	.65
.03	7.500	1.40	1.02	1,000	.59
.1-.1	7,000	1.69	1	1,000	.59
.02-.03	7,000	1.35	7	800	1.59
1	6,000	5.25	8-8	600	2.25
.03-.03	6,000	1.35	8	600	1.60
.03	6,000	1.25	7	600	1.45
.01-.03	6,000	1.35	5	600	1.20
2	5,000	4.65	4	600	.98
.25	5,000	2.25	4x3	600	1.95
3	4,000	4.50	2	600	.45
2	4,000	3.95	1	600	.39
3x.2	4,000	2.35	.5	600	.35
.1	4,000	1.55	8	500	1.45
.06	4,000	1.35	4	500	.89
2	3,000	3.65	4	300	.59
.25	3,000	1.50	4	200	.39
.1	3,000	1.45			
4	2,500	4.25			
8	2,000	4.45			
6	2,000	4.25			
4	2,000	3.65			
3	2,000	3.50			
2	2,000	2.95			
1	2,000	1.95			
.5	2,000	1.60			
.3	2,000	1.35			
.25	2,000	1.05			
.1-.1	2,000	.95			

2 mfd
4,000
V.D.C.
G.E.
SPECIAL
$3.95



TIMING MOTOR — 8 RPM

115V., 60 cyc., E. Ingraham Co $1.95

WIRE WOUND PRECISION RESISTORS

2% OR BETTER

¼ Watt—30¢

2	10.84	13.52	62.54	301.8
2.5	11	13.89	79.81	366.6
3.5	11.25	14.98	105.8	414.3
5	11.74	15.8	123.8	705
6.68	12.32	16.37	125	2,193
10.48	13.02	32	147.5	59,148
			220.4	100.000

½ Watt—30¢

.250	13.15	260	4,000	8,000
.334	46	270	4,300	8,500
.502	52	298.3	4,451	14,825
.557	55.1	400	4,500	15,000
.627	75	723.1	5,000	15,750
.76	97.8	855	5,900	17,000
1.01	125	1,500	6,500	30,000
1.53	180	2,500	7,000	37,000
2.04	210	2,850	7,300	50,000
11.1	235	3,427	7,500	100,000

1 Watt—35¢

.5	15	3,000	9,000	55,000
1.01	270	3,300	10,000	65,000
2.58	420	7,000	12,000	70,000
3.39	1,000	8,250	23,000	84,000
5.21	2,000			

1 Watt—45¢

100,000	130,000	260,000	320,000	520,000
105,000	132,000	270,000	348,000	522,000
120,000	200,000	296,000	500,000	600,000
128,000				700,000

1 Megohm, 1 Watt, 1%—65¢: 5%—45¢

2 Watt—60¢

2,000 — 4,385 — 5,000 — 6.000

AN CONNECTORS

IMMEDIATE SERVICE
PHONE! WIRE! WRITE! YOUR NEEDS

BC 348—H, J, L, O, P, Q —write for prices

DELAY NETWORK—ALL 1400Ω

T 113—Approx. 1.2 micro sec. delay .... 95¢ each
T 114—Approx. 2.2 micro sec. delay ....
T 115 Similar to T 114 with tap brought out ....

CHOKES

30 Henry 80 ma.... $1.29 — 6 Henry 80 ma..... .79

3AG FUSES

AMP	Per 100	AMP	Per 100	AMP	Per 100
1/8	$4.00	3/4	$4.00	6	$3.00
1/4	4.00	1	3.00	10	3.00
3/8	4.00	1½	3.00	15	3.00
1/2	4.00	5	3.00	20	3.00

4AG FUSES

AMP	Per 100	AMP	Per 100	AMP	Per 100
1/8	$4.00	2	$2.00	10	$2.50
1/4	3.50	3	2.00	15	2.50
1/2	3.50	3.2	2.00	20	2.50
1	2.00	5	2.00	25	2.50

Fuse Holder—For 4AG Fuse .... 25¢

Brand New METERS—Guaranteed

0-1 Amp. R.F. 2½" $3.29 | 0-80 Amp. D.C. 2½". $2.25
0-300 V.D.C. 2½"... 3.50 | 0-7.5V. A. C. 3½"... 3.46

SOUND POWER HANDSET

Brand New!
Includes 6 ft. cord. No batteries or external power source used. $17.60 pr.

Sound Powered
Chest Set
RCA—With 24 Ft. Cord
$17.60 per pair

TIME DELAY RELAY

Raytheon CPX 24166 KS 10193-60 Sec. • 115 V., 60 cycle • Adj. 50-70 Seconds • 2½ second recycling time—spring return • Micro-switch contact, 10A • Holds ON as long as power is applied • Fully cased • ONLY $6.50

FILAMENT TRANSFORMER

Pri., 115V., 60 Cyc. — Sec. { 6 V. @ 35 A. or 12 V. @ 18 A. or 24 V. @ 9 A. } **$6.50**

PRECISION CAPACITOR—W.E.

D-161270. 1 mfd @ 200 VDC; −40° to +65°C $8.50

IN 34 Crystal Diode .... 79¢

CARBON MIKE—T-17, slightly used, guaranteed. Has 5 foot cord and PL68 .... 89¢

THROAT MIKE—MT 81-A—2 mikes in leather zipper case with 56" cord & PL68—Brand New .... 59¢

SPAGHETTI SLEEVING—assortment—99 feet $1.00

Minimum Orders $3 .... All orders f.o.b. PHILA, PA.

RELIANCE MERCHANDIZING CO.

Arch St. Cor. Croskey — Phila. 3, Pa. — *Telephone RIttenhouse 6-4927*

MOTOR GENERATORS DYNAMOTORS, INVERTERS, ETC.

2.5 KVA MG SET. Diehl Elec. Co. 120V DC to 120V AC, 60 cy. 1 Ph. Complete with Magnetic Controller, 2 Field Rheos and Full Set of Spare Parts including Spare Armatures for Generator and Motor. Full specs. on request. New. $285.00

2 KVA MG SET. O'Keefe and Merritt. 115V DC to 120V AC, 50 cy. Idles at 3 Ph. syncs motor on 208V, 50 cy. New. Export crated $165.00

1.25 KVA MG SET. Allis-Chalmers. 230 DC To 120 AC. 60 cy. 1 Ph. Fully enclosed, Splashproof Ball Bearings. centrifugal starter. **New** $150.00

Kit of Spare Parts........................ 25.00

MG. Set. Onan MG-075. Navy type PU/11. Input 115/230, 60 cy, 1 Ph. Output 115, 480 cy, 1 Ph. 5.3 amps and 26V DC at 3.8 amps. New...$198.50

MG Set. Onan MG-215H. Navy type PU/13. Input 115/230, 60 cy. 1 Ph. Output 115, 480 cy, 1 Ph. 1200W and 26V DC at 4 amps. New......$295.00

MG SET FOR NAVY TBS TRANSMITTER. Type CG-21302. 440V AC, 60 cy, 3 Ph, 1500 VA to 875 DC and 300V DV. New $69.50

DYNAMOTOR. Navy-Type CAJO-211444. 105/130V-DC to 13V DC at 40A or 26V DC at 20A. Radio filtered. Complete with Line Switch. New. $69.50

DYNAMOTOR. Elcor. 32V DC to 110V AC, 60 cy. 1 Ph, 2.04 Amps. New...................$24.50 Also available for 64 volts input. Same price.

DYNAMOTOR. Elcor. 32V DC to 110V AC, 60 cy. 1 Ph, 0.43 Amps. New.....................$17.50

DYNAMOTOR — Type PE94C. For use with SCR522 Transmitter-Receiver. Brand new in export cases $9.50

AMPLIDYNE—G. E. Model 5AM21JJ7. 4600 R.P.M. Motor Compound wound. 150 Watts. Input: 27V. DC. Output: 60V. DC Sig Corps. U. S. Army MG-27-B. New.......................$26.50

AMPLIDYNE—Edison type 5AM31NJ18A. Input: 27 volts 44 Amps., 8300 RPM. Output: 60V DC at 8.8 amps. 530 Watts. New.................$22.50

INVERTER—G.E. Model 5D-21NJ3A. Input: 24V. DC, Output: 115V. 400 cy. 485 Va. New...$49.50

INVERTER—Leland Elec. Co. Model PE206A. Input: 28V. DC, 38 Amps. Output, 80V., 800 cy, 485 VA. New $17.50

PE 218 INVERTER—G. E. J8169172. Input: 28V. DC, Output: 115, 400 cycles at 1.5 KVA...$50.00

GENEMOTOR—Carter 6V DC to 400 V DC at 375 mils. New $49.50

D. C. MOTOR—G. E. Model 5BA 50LJ2A 0.5 HP. Armature: 27V. at 8.3 Amps. Field: 60V. at 2.3 Amps. R.P.M. 400. New...................$22.50

400 Cycle Generator. Geophysical Inst. Co. Model 24-A. Delivers 15 kw single ph. or 25 kw—3 ph; reconnectable for 120 and 240 volts. Drive speed required—1714 RPM. ....**Price** $325.00

BC-348 RECEIVER PARTS

Dial Mechanism assemblies. 1st, 2nd, 3rd, 4th I.F. transformers. C.W. osc. and xtal filter trans. with xtals. All R.F. coils. Front panels. Shock mounts. Large quantity misc. hardware sub assemblies, etc. Write your requirements.

MISCELLANEOUS EQUIPMENT

TS-127/U Lavoie Freq. Meter—375 to 725 MC.
TS-47APR Test Set—40 to 500 MC.
213-A DuMont C.R. Modulation Monitor.
BC1203B APN-4 Test Set.
78B Boonton Sig. Gen.
6255A H.P. Interpolation Osc.
TS-102A/AP Test Set.
TS-23/APN Test Set.
TS-487/U Peak to Peak VTVM.
BC-221AE Freq. Meter.
LM-13 Freq. Meter.

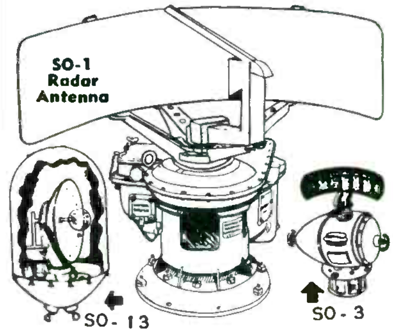
MICROWAVE RECEIVERS

AN/APR-1 Receivers and tuning units TN-1 (38 to 95 MC) TN-2 (76-300 MC) TN-3 (300-1000 MC).
AN/APR-4 Receivers and tuning units TN- 16 (38-95 MC) TN-17 (76-300 MC) TN-18 (300-1000 MC).
AN/APR-5A Receivers. 1000 to 6000 MC Range.

MODEL AN/APA-10 PANORAMIC ADAPTER

Designed for use with receiving equipment AN/ARR-7, AN/ARR-5, AN/APR-4, SCR-587 or any receiver with I.F. of 455kc. 5.2mc. or 30mc. With 21 tubes including 3" scope tube. Converted for operation on 115 V. 60 cycle source.
PRICE $245.00
AN/APA-10 80 Page Tech Manual...........$2.75

RADAR ANTENNAS



Type SO-1 (10 CM.) Complete assembly with reflector, waveguide nozzle, drive motor and synchros, etc. New in original cases................$279.50
Type SO-3 (3 CM.) Surface Search type complete with reflector, drive motor, synchro, etc., but less plumbing. New in original cases..........$189.50
Type SO-13 (10 CM.) Complete assembly with 24" dish with feedback dipole. Complete with synchros, drive motor, gearing, etc. New in original cases $149.50
Also in stock—spare reflectors, nozzles, probes, right angle bends for SO-1 antennas.

S. G. RADAR EQUIPMENT

Navy Yard Spares for

Model SG Radar

Consisting of the following

2—CRP-20ABM Rectifier Power Units for modulation generators.
2—CRP-20ABM Rectifier Power Units for Radar Receivers.
2—CRP-35AAH Modulation Generators.
2—CRP-46ABD-1 Radar Receivers (including R-906 Gain Controls for Range and Train Indicators).
2—CRP-60AAN Signal Monitors.
2—Complete Transmitter R.F. System coupling assemblies including—10087 magnets and Duplexing tube cavity assemblies.
1—Complete Power Control Chassis.
2—Complete Driver and modulator assembly including driver chassis with delay line, Modulator and Driver Rectifier Tube Assembly and Driver Rectifier Power Unit.
2—Complete sets equipment spare parts consisting of R.F. Assemblies, motors and accessories, switches, interlocks, fuses, fuse holders, fuse links, relays, contacts, crystals, thermostats, R.F. inductors, capacitors, sockets, test equipment, cables, resistors, etc., as listed in Navy Spare Parts List WX3885.

All above in new and unused condition packed in original metal spare parts boxes.

RADAR COMPONENTS

CRP-23AGC Load Dividers for use with S.G. Modernization Kits. New.
CBM-50AFO Navy type Radar Repeater Adapters. New and complete with 14 tubes, coax fittings, installation plans and wiring diagram.
Synchro Amplifiers. New.
Type CARD 23AEK Bearing Control Units. New.
Type T.D.Y., SO-1, SO-13, SO-3 Radar Antenna Assemblies. New.
Radar Crystals Raytheon 98.35 KC.
Type SO-11 Radar Modulator.
Type SO-1 Transmitter Receivers.

400 CYCLE TRANSFORMERS

AUTO. 400 cy. G.E. Cat No 80G184. **KVA** .945S—520P. Volts 460/345/230/115. New. $4.95

FILAMENT. 400/2600 cy. Input: 0/75/80/85/105/115/125V. Output: 5V3A/5V3A/5V3A/5V3A/5V6A/5V6A/6.3V6A/6.35A. New $2.95

THYRATHRON POWER. 400/1600 cy. Raytheon UX-8876, 400/1600 cy. Pri: 115, Sec: 50-0-50V at 1.5A, 6.3V at 1.2A. Test r.m.s. 1780. New..$2.75

PLATE WECO KS9560. 400/800 cy. Pri: 115V. Sec: 1350-0-1350 at .057A (2700 V Total). Elecstat shlded. Wt. 2.3 lbs. New...................$2.95

Plate. Thordarson #T46889. 1650 VA. Pri: 105-120V. 500 cy. 1 PH. Sec: 5600V. Center tapped. 1.5KV insulation. Brand new..............$49.50

SCOPE PL. & FIL. WECO 9556. 400/2400 cy Pri: 115. HV Wdg. 1125V at .008A. Fil. Wdgs. 6.4V4A/2.5V1.75A/6.4V.6A. Elecstat shlded. Wt. 1.4 lbs. New $2.75

FILAMENT. 400/2400 cps. WECO KS9558. Pri: 115V. Sec: 8.2V1.25A/6.35V1.5A Elecstat shlded. Wt. 0.5 lbs. New $1.95

PLATE & FIL. 400/2600 cy. Pri: 0/80/115V. Sec: #1=1200VDC at 1.5MA. Sec. #2=400VDC at 130MA. Fil. Secs: 6.4V4.3A/6.35VO.8A. (ins. 1500V)/5V2A/5V2A $4.95

RETARD. 400 cy. WECO KS9598. 4 Henry 100MA $1.75

60 CYCLE TRANSFORMERS

FILAMENT. Raytheon Hypersil Core, Pri: 115V. Sec: 6.3V22A/6.3V2.4A/6.3V2.25A/6.3VO.6A Ins. for 1700V $5.95
High Rectance Trans. G. E. type Y-3502A.—60 cy., Voltage 11200-135. Inductance H.V. Winding 135 Henries. Output: Peak Voltage 22.8KV. Cat. 8318065G1. New $89.50
High Voltage Trans. Westinghouse Pri: 115, 60 cy. Sec: 15,000 C.T., 60 MA. Good for Hi-Pot test set up $32.50

PULSE TRANSFORMERS

PULSE. WECO KS-9563. Supplies voltage peaks of 3500 from 807 tube. Tested at 2000 Pulses/sec and 5000V peak. Wdg. 1-2=18 ohms. Wdg. 1-3=72 ohms. L of Wdg. 1-3=.073-.082H at 100 cps.$5.00
PULSE. WECO KS-161310, 50 KC, to 4MC. 1¾" Dia. x 1⅞" high. 120 to 2350 ohms. New..$3.95

RAYTHEON VOLTAGE REGULATOR

Adj. input taps 95-130V., 60 cy. 1 Ph. Output: 115V., 60 Watts, ½ of 1% Reg. Wt. 20 lbs. 6⅛" H x 8¼" L x 4⅝" W. Overload protected. Sturdily constructed. Tropicalized. Special.........$14.75

HIGH VOLTAGE CAPACITORS

.25 MFD., 20KV	$26.50
.25 MFD., 15KV	22.50
.5 MFD., 25KV	34.50
1 MFD., 15KV	34.50
1 MFD., 7.5KV	12.50

SOUND POWERED PHONES

Western Electric No. D173312, Type O. Combination headset and chest microphone. Brand new including 20 ft. of rubber covered cable.......$17.50
Automatic Elec. Co. No. GL843AO. Similar to above but including Throat microphone in addition to chest microphone. Brand new with 20 ft. rubber covered cable $13.50
U. S. Instrument Co. Navy Type M. Dr. No. A-260 ALT. 1. Complete with 20' cable and navy plug. **Brand new** $17.50
W. E. type TS-10M Handset. New.........$16.50

PARABOLOIDS

Spun Magnesium dishes 17½" dia. 4" deep. Mounting brackets for elevation and azimuth control on rear. 1½ x 1⅝" opening in center for dipole. **Brand new, per pair.**..........................$8.75

SWEEP GENERATOR CAPACITOR

High speed ball bearings. Split stator silver plated coaxial type 5/10 mmfd. Brand new........$2.50

WESTERN ELECTRIC CRYSTAL UNITS

Type CR-1A/AR. Available in quantity—following frequencies—fundamentals.
5910—6350—6370—6470—6510—6610—6670—6690—6940—7270—7350—7380—7390—7480—7580—9720—Kilocycles.

$1.25 each

All prices indicated are F O B Bronxville, New York. Shipments will be made via Railway Express unless other instructions issued.

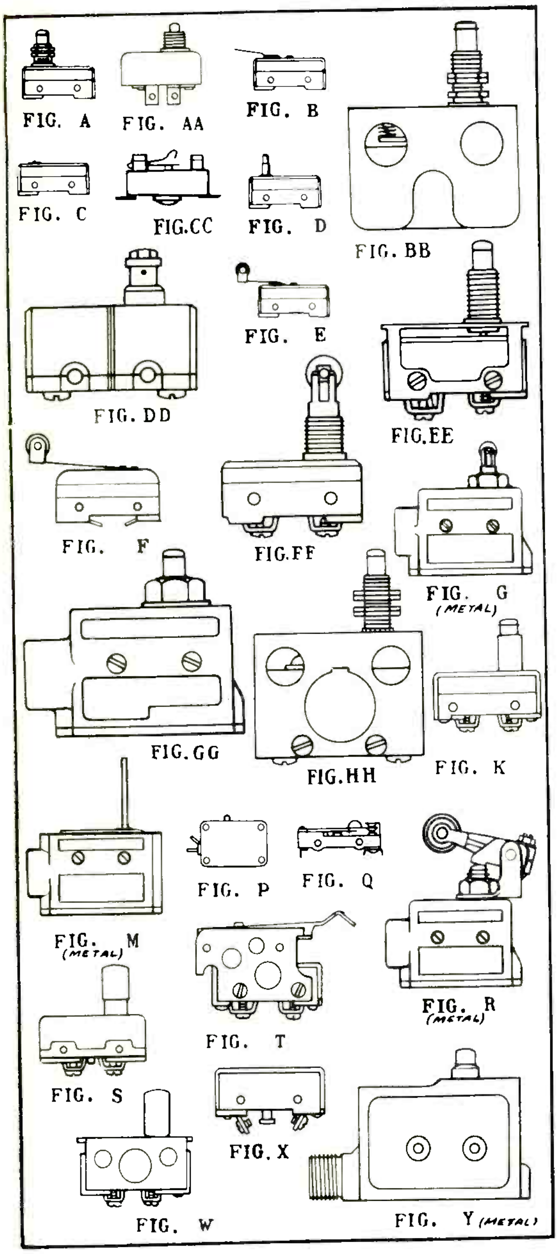
ELECTRONICRAFT
INC.

27 MILBURN ST. BRONXVILLE 8, N. Y.
PHONE: BRONXVILLE 2-0044

All merchandise guaranteed. Immediate delivery, subject to prior sale.

All Prices Subject to Change Without Notice

IMMEDIATE DELIVERY OF *Top Quality* MINIATURE SWITCHES



This list of brand new standard brand miniature switches represents only a few of many types in stock at Wells. Large quantities of most types are on hand for your immediate requirements. Write or wire for quotations on switches not listed.

Stock #	Mfr	Type #	Contact	Fig.	Price
41MC2	ACRO	2M03.1A	NO	P	.50
41MM2	MU	ACZ101BB	SPDT	W	.85
41MC6	MU	APB236	SPDT	A	1.15
41MC26	MU	APG210	NO	A	.80
41MC17	MICRO	B-1	NC	Y	1.45
41MC16	MICRO	B-1T	NC	OD	.90
41MC7	MICRO	B-14	NO	HH	1.70
41MD62	MICRO	B-R	SPDT	C	.70
41MD46	MICRO	B-RL18	SPDT	B	.95
41MD63	MICRO	B-RS36	SPDT	D	80
41MD23	MICRO	BD-RL32	SPDT	B	.95
41MLH	MICRO	BZRQ41	SPDT	W	85
41MD51	MICRO	BZ-R37	SPOT	C	.70
41MD2	MICRO	BZE7RQT2	SPDT	GG	1.70
41MD21	MICRO	BZ-7RST	SPDT	D	.80
41MD38	MICRO	BZE2RQ9TN1	SPDT	G	2.65
41MD6	MU	CUM 24155	NO	E	.80
41ML1	MU	D	NO	BB	1.50
41MC12	MICRO	D in case	NC	Y	1.45
41MD34	KLIXON	ES692070	NC	CC	.50
41MD65	MICRO	G-R26	NO	C	.60
41MD60	MICRO	G-RL	NO	B	80
41MC11	MICRO	G-RL 5	NO	B	80
41MD61	MICRO	G-RL35	NO	B	80
41MD41	MICRO	G-RL43	NO	B	80
41MD64	MICRO	G-RS	NO	D	55
41MD66	MICRO	G-RS36	NO	D	.60
41MC32	ACRO	HRO 7.1P2TSP1	NO	K	65
41MC19	ACRO	HRO 7.4P2T	NO	S	.60
41MD8	ACRO	HRRC 7.1A	NC	C	55
41MD27	ACRO	HRRO 7.1A	NO	C	.60
41MC31	MICRO	LN-11 H03	SPDT	M	1.70
41MC18	MU	MLB 321	SPDT	B	.95
41MD1	MU	MLR 643	NC	B	70
41MD55	PHAO	PS 2000	SPDT	C	85
41MC28	ACRO	RC71P2T	NC	A	70
41MD45	ACRO	RO1P2T	NO	A	.80
41MD22	ACRO	RO2M	NO	E	.80
41MD28	ACRO	RO2M12T	NO	E	80
41MC25	MICRO	R-RS	NC	D	.50
41MD47	MICRO	R-RS13	NC	D	.50
41MD9	MICRO	SW-186	NC	D	.50
41MC10	MICRO	WP3M5	NC	AA	.50
41MC4	MICRO	WP5M3	NC	AA	.50

Stock #	Mfr	Type #	Contact	Fig.	Price
41MD53	MICRO	WP5M5	NC	AA	.50
41MC27	MICRO	WZ2RST	NC	D	.55
41MD48	MICRO	WZ2RT	NC	C	.65
41MD33	MICRO	WZ3PW2	NC	F	.80
41MD16	MICRO	WZ7R	NC	C	.55
41MD43	MICRO	WZ7RQ1T	NC	A	.70
41MC15	MICRO	WZ7RQT2	NC	A	.70
41MD36	MICRO	WZ7RST	NC	D	.55
41MC24	MICRO	WZE7RQTN	NC	Y	1.45
41MC23	MICRO	WZE7RQTN	NC	R	3.75
41MD54	MICRO	WZR8X	NC	X	.80
41MC9	MICRO	WZR31	NC	C	.65
41MD57	MICRO	WZR31	NC	T	.70
41MD31	MICRO	WZRD	NC	C	.55
41MD19	MICRO	WZRL8	NC	B	.70
41ML3	MICRO	WZRQ41	NC	W	.65
41ML2	MICRO	WZV7RQ9T1	NC	G	2.25
41MC21	MICRO	X757	NC	C	.55
41MD37	ACRO	XC1A	NC	C	.55
41MC5	ACRO	XD45L	SPDT	B	.95
41MD4	MICRO	YZ	NO	C	75
41MD40	MICRO	YA2RLE4D13	NO	B	.70
41MD24	MICRO	YZ2YLTC1	SPDT	B	.95
41MC1	MICRO	YZ2YST	SPDT	D	.60
41MD13	MICRO	YZ3R3	NO	C	.60
41MD56	MICRO	YZ3RLTC2	NO	B	.80
41MC14	MICRO	YZ3RW2T	NO	F	.90
41MD49	MICRO	YZ7RQ9T6	NO	FF	.85
41MD32	MICRO	YZ7RST	NO	D	.60
41MC13	MICRO	YZ7RA6	NO	EE	1.00
41MD25	MICRO	YZRQ1	NO	A	80
41MC20	MICRO	YZRQ4	NO	S	.60
41MD59	MICRO	YZRQ41	NO	W	.75
41MD20	MICRO	YZ7RQT	NO	K	.65
41MD42	MICRO	YZRTX1	NO	X	.95
41MC22	MU	Z	NC	Y	1.45
41MD44	ACRD	Blue Stripe	SPDT	C	.70
41MD52	MU	Blue Dot	SPDT	E	.90
41MC8	MU	Red Dot	NC	C	.65
41MD18	MICRO	Open Type	SPDT	Q	.50
41MD39	MU	Green Dot	NO	B	.80
41MC29	MU	Green Dot	NO	D	55
41MD26	MAXSON	Preeision	SPDT	B	.95

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PARTS SHOW VISITORS:

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WIDE SELECTION OF ELECTRONIC COMPONENTS AT

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- Transformers • Chokes • Micro Switches, Toggles • Antennas
- Accessories • Electronic Assemblies • Dial Light Assemblies

WELLS SALES, INC. 833 W. CHICAGO AVE., DEPT. SL, CHICAGO 22, ILL.

SOLVE YOUR **RADAR** CALL PAUL J. PLISHNER **SONAR** SUPPLY PROBLEMS

3000 MC. BENCH TEST PLUMBING

SIGNAL GENERATOR. using 417A klystron, 2700-3300 mc. Output approx. 50 mw. 115 vac power supply. With tubes, new....$425
10 CM RF PACKAGE, using 2J22 magnetron, freq. range 3267-3333 mc, complete with power supply and pulser giving apx. 20 kv @ 30 A, 1 usec, 1000 PPS. Power output 265 kw. 7/8" rigid coax plumbing thruout. Uses 417A klystron mixer, 6Ac7 preamp. Pulser is 715 B HARD TUBE. Complete RF unit, pulser unit, receiver front end, new, with tubes. Requires 115v, 400 cy ac primary source $385
RECEIVER POWER SUPPLY for GL 446 type lighthouse tubes (2C40, etc.) 115 vac, 60 cycles. Panel mounting. Less tubes $32.50
10 CM DISH AND DIPOLE ASSY; apx. 30" parabola, with 360 deg. rotating mechanism, and approx. 10 deg. tilt mechanism. Operating from 24 vdc. With selsyn....$85
10 CM LOW POWER tunable load with circ. cover....$225
COAX. CRYSTAL MOUNT, type N connectors....$17.50
RT-39/APG-5 10 CM light house RF head c/o Xmtr.-Recvr-TR cavity, compl. rcvr & 30 MC IF strip using 6AK5. (2C40, 2C43, 1B27 lineup) w/Tubes.

721A TR BOX complete with tube and tuning plungers....$12.50
McNALLY KLYSTRON CAVITIES for 707B or 2K28. Three types available $4.00
F 29/SPR-2 FILTERS, Type "N" input and output....$12.50
WAVEGUIDE to 7/8" rigid coax "Doorknob" Adapter, Choke Flange, Silver Plated Broad Band....$32.50
WAVEGUIDE DIRECTIONAL COUPLER, 27 do, Navy type CABV 47AAN, with 4 in. slotted section....$32.50
SQ. FLANGE to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide type "N" output and sampling probe....$27.50
AN/APR5A 10 CM ANTENNA equipment consisting of two 10 cm waveguide sections, each polarized 45 degrees....$5.00 per set.
POWER SPLITTER: 726 Klystron input dual "N" output....$5.00
MAGNETRON COUPLING FOR TYPE 720 MAG. to 1½" x 3" Waveguide $35.00
10 CM WAVEMETER WE type B43549 Transmission type. Type N Fittings Veeder Root Micrometer dial, Gold Plated W/Calib Chart P/o Freq. Meter X66404-A. New....$99.50
AS14A/AP-10 CM Pick up Dipole with "N" Cables....$4.50
LHTR. LIGHTHOUSE ASSEMBLY Part of RT39 APG 5 & APG 15. Receiver and Trans Cavities w/assoc. Tr Cavity and Type N CPLG. To Recvr. Uses 2C40, 2C43, 1B27. Tunable APX 2400-2700 MCS. Silver Plated $49.50
BEACON LIGHTHOUSE CAVITY 10 cm with miniature 28 volt DC FM motor. Mfg. Bernard Rice....$47.50 ea.
MAGNETRON TO WAVEGUIDE Coupler with 721A Duplexer Cavity, gold plated $45.00

7/8" RIGID COAX.—3/8" I. C.

7/8" RIGID COAXIAL TUNING STUBS with vernier stub adjustment. Gold Plated $17.50
7/8" RIGID COAX ROTARY JOINT. Pressurized. Sperry #810613. Gold Plated $27.50
DIPOLE ASSEMBLY. Part of SCR-584....$25.00 ea.
ROTARY JOINT. Part of SCR-584....$35.00 ea.
RIGHT ANGLE BEND. with flexible coax output pickup loop $8.00
SHORT RIGHT ANGLE BEND. with pressurizing nipple....$3.00
RIGID COAX to flex coax connector....$3.50
STUB-SUPPORTED RIGID COAX, gold plated 5" lengths. Per length $5.00
RT. ANGLES for above....$2.50
RT. ANGLE BEND 15" L. CA....$3.50
FLEXIBLE SECTION. 15" L. Male to female....$4.25
MAGNETRON COUPLINGS to 7/8" rigid coax, with TR pickup loop, gold plated....$7.50
FLEX COAX SECT. Approx. 30 ft....$16.50
CG 54/U—4 foot flexible section ¼" IC pressurized....$15.00
7/8 RIGID COAX. Bead Supported....$1.20
SHORT RIGHT ANGLE BEND....$2.50

6000 Mc to 8500 Mc BENCH TEST PLUMBING

1½" x ¾" Waveguide

KLYSTRON MOUNT. DB356 complete with shield and tunable termination $125.00
FLAP ATTENUATOR. DB361 $45.00
VARIABLE STUB TUNER $90.00
WVGD. TO TYPE "N" ADAPTER $18.50
WAVEMETER TEE. DB352 $32.50
MAGIC TEE $80.00
DIRECTIONAL COUPLER, two hole 25DB coupling, type "N" output $25.00
PRECISION CRYSTAL MOUNT. Equipped with tuning slugs and tunable termination $125.00
TUNABLE TERMINATION. Precision adjust $70.00
LOW POWER LOAD....$35.00

4000 to 6000 Mcs BENCH TEST PLUMBING

2" x 1" Waveguide

FLAP ATTENUATOR ..$48.00
VARIABLE STUB TUNER AND LOW POWER TERMINATION $48.00
WAVEMETER TEE $48.00
ADAPTERS:
Choke to choke....$18.00
Cover to cover....$14.00
Choke to cover....$16.00
WAVEGUIDE TO TYPE "N" ADAPTER $45.00
DIRECTIONAL COUPLER. Two hole type "N" output $48.00
KLYSTRON MOUNT. Equipped with tunable termination and micrometer adjust. Klystron antenna tuning $110.00
CRYSTAL MOUNT. Equipped with tunable termination and micrometer adjust crystal tuning $125.00
TUNABLE TERMINATION. Precision adjust $90.00

23,000 to 27,000 Mc BENCH TEST PLUMBING

½" to ¼" Waveguide

LOW POWER LOAD....$20.00
SHUNT TEE $35.00
WAVEGUIDE LENGTHS. 2" to 6" long, gold plated with circular flanges and coupling nuts ....$2.25 per inch
APS-34 ROTATING JOINT $49.50
RIGHT ANGLE BEND E or H Plane, specify combination of couplings desired $12.00
45° BEND E or H Plane. Choke to cover....$12.00
MITRED ELBOW, cover to cover $4.00
TR-ATR-SECTION. Choke to cover $4.00
FLEXIBLE SECTION 1" choke to choke $5.00
"S" CURVE CHOKE to cover $4.50
ADAPTER. round to square cover $5.00
FEEDBACK to Parabola Horn with pressurized window..$27.50
90° TWIST $10.00
"K" BAND DIRECTIONAL COUPLER ....$49.50 ea.

APS-2
APS-3
APS-4
APS-6
APS-6A
APS-10
APQ-13
APS-15
APS-31
CPN-8
CEXH
FD MK 4
MARK 10
SA
SC
SD
SE
SF
SG
SI
SK
SL
SM
SN
SO
SQ
SW
SCR 518
SCR 520
SCR 533
SCR 545
SCR 663

MAGNETRONS

Tubes
2J27
2J31
2J21 A
2J22
2J26
2J32
2J37
2J38
2J39
2J40
2J49
2J34
2J61
2J62
3J31
5J30
714AY
718DY
720BY
720CY
725-A
730-A
728
700
706

KLYSTRONS
723A
707B
417A
2K41

TEST SETS
TS 12
TS 33
TS 35
TS 36
TS 45/APM 3
TS 62 3CM
TS 108

SCR 584

PARTS AVAILABLE
BC1056A
BC1058A
BC1086B
RA71A
BC1090A
BC1090B
BC1096A
BC188B
BC105BB
BC1094A
BC1088A

SONAR SYSTEMS
QBF
QBG
QC
QCJ
QCL
QCO
QCS
QCU
WEA

8500—9600 Mc Bench Test Plumbing

1" x 1½" Waveguide

3 CM SIGNAL GENERATOR and thermistor bridge, using 723AB oscillator, calibrated variable attenuator, direct reading power meter; reg. 115 vac 60 cy power supply. Complete with tubes $425
3 CM SLOTTED LINE, with probe, and including accessories, i.e. low power load, adapters, etc. TS 12/Unit 2....$385
AN/APS-15A "X" Band compl. RF head and mod. inch 725-A mag and magnet, two 723A/B klystrons (local osc. & beacon) 1B24, TR, rcvr ampl. duplexer, HV supply blower, pulse xfmr. Peak Pwr Out: 45 KW apx. input: 115, 400 cy. Modulator pulse duration .5-2 microsec., apx. 13KV. PK. Pulse, with all tubes incl. 715B, 829B, BKR 73, two 72's. Complete pkg....$375
COMPLETE 3 CM. RADAR SYSTEM, 40 KW peak transmitter, pulse modulator, receiver, using 723AB, power supply operating from 115V 800 Cycle, antenna system. Complete radar set neatly packaged in less than 16 cubic feet. Less receiving Type Tubes, but including all other, in used but excellent condition—$350.00 This price for laboratories, schools, and experimental purposes only.

MAKE SURE YOU SEE OUR SPECIAL AD NEXT MONTH

2J42 PULSE MODULATOR. 14 Kw max. rating, 7kw min. Plate voltage pulsed 5.5 kv, 6.5 amp. .001 duty cycle, 2.5 usec pulse length max, filament 6.3 v, .5 amp. Includes magnetron mtg. and blower. Requires 3C45 and 2-3B24....$75
3 CM SECTOR SCANNING ANTENNA, 18" dish, cutler feed dipole. 24 vdc drive motor....$75
APS-3 RADAR. new and complete, using 725A magnetron....$950
TS 36 X BAND POWER METER 1½" x 5/8" waveguide; thermistor bridge with indicating meter, complete....$175
TS 33 X BAND COAX FREQ. METER with resonance indicating meter crystal mount, type N fitting....$225

WAVEMETER. 8500 to 9400 Mcs., with calibration. Micrometer adjust head. Reaction type $85.00
90 DEGREES ELBOWS. E or H plane. 2½" radius....$12.50
90 DEGREE TWIST. 6" long $8.00
BULKHEAD FEED-THRU ASSEMBLY $15.00
PRESSURE GAUGE SECTION 15 lb. gauge and press nipple $10.00
PRESSURE GAUGE. 15 lbs. $2.50
DUAL OSCILLATOR-BEACON MOUNT. P/O APS10 Radar for mounting two 723A/B klystron with crystal mts. matching slugs, shields $42.50
DUAL OSCILLATOR. MOUNT. (Back to back) with crystal mount, tunable termination attenuating slugs $18.50
DIRECTIONAL COUPLER UG-40/U Take off 20 DB $17.50
ROTARY JOINT Choke to Choke $10.00
2K25/723 AB RECEIVER local oscillator Klystron Mount, complete with crystal mount. Iris coupling and choke coupling to TR $22.50
TR-ATR DUPLEXER section for above $8.50
CU 105/APS 31 Directional Coupler 25 DB....$25.00
723AB MIXER—Beacon dual Osc. Mnt. w/xtal holder $12.00
TR-ATR SECT APS 15 for 1B24 w/724 ATR cavity w/1B24 & 724 Tubes. Complete...$21.00
STABILIZER CAVITY with bellows $21.50
3 CM 180° BEND, with pressurizing nipple ....ea. $6.00
3 CM 90° BEND. 14" long 90° twist with pressurizing nipple ....ea. $6.00
3 CM. "S" CURVE 18" long ea. $5.50
3 CM. "S" CURVE 6" long ea. $3.50
3 CM. RIGHT ANGLE BENDS. "E" plane 18" long cover to cover ....ea. $6.50
3 CM. CUTLER FEED DIPOLE. 11" from parabola mount to feed back....ea. $8.50
3 CM. DIRECTIONAL COUPLER. One way waveguide output ....ea. $15.00
CIRCULAR CHOKE FLANGES solid brass 55c
SQ. FLANGES. Flat Brass ea. 55c
APS-10 TR/ATR DUPLEXER section with additional iris flange $10.00

"X" BAND PREAMPLIFIER. consisting of 2-723 A/B local oscillator-beacon feeding waveguide and TR-ATR Duplex sect. incl. 60 pic. IF amp....$47.50
15 DEG BEND 10" choke to cover $4.50
5 FT. SECTIONS choke to cover. Silver plated....$14.50
18" FLEXIBLE SECTION $17.50
TR CAVITY for 724 A TR Tube $3.50
724 TR Tube (41 TR 1)..$2.50
SWR MEAS. SECTION, & L with 2 type "N" output probes MTD full wave apart. Bell size guide. Silver plated $10.00
ROTARY JOINT with slotted section and type "N" output pickup $17.50
WAVEGUIDE SECTION 12" long choke to cover 45 deg. twist & 2½" radius. 90 deg. bend $4.50
TWIST 90 deg. 5" choke to cover w/press nipple....$6.50
WAVEGUIDE SECTIONS 2½ ft. long silver plated with choke flange $5.75
ROTARY JOINT choke to choke with deck mounting....$17.50
3 CM. MITRED ELBOW "E" plane unplated $12.00
1¼" x 5/8" WAVEGUIDE TUNABLE TERMINATION Precision adjust $65.00
LOW POWER TERMINATION $25.00
MAGIC TEE $45.00
90 DEGREE ELBOWS, E or H plane $12.50
WAVEGUIDE LENGTHS. Cut to size and supplied with 1 choke, 1 cover, per length $2.00 per ft.
BI DIR-COUPLER WG output calibrated —25 db nominal $17.50
FLEX SECTIONS. 12" Rubber Coated $14.50
MITRED ELBOW H Plane UG51-UG52 ....$12.00
6" ST. SECT. choke to choke $3.50
APQ 13 Constant Z Rotat Jnt. $22.50
CG 98B/APQ 13 12" Flex. Sect. 1¼" x 5/8" OD....$10.00
WAVE GD. RUN 1¼" x 5/8" Gd. consists of 4 ft sect. w/RT angle bend on one end, 2" 45 deg bend on other end....$8.00
X BAND WAVE GD. 1¼" x 5/8" O.D. 1/16" wall aluminum Per ft. 75c
SLUG. TUNER ATTENUATOR W.E. guide. Gold Plated..$6.50

WAVEGUIDE

½" x ¼" ID....$1.00 per foot
1" x ½" OD....$1.50 per foot
5/8" x 1¼" OD....$1.65 per foot
5/8" x 1¼" OD Aluminum....75 per foot
1½" x 3" OD....$3.00 per foot
2½" x 3" OD....$3.50 per foot
1" x ½" OD Flexible....$4.00 per foot
7/8" rigid coax ¼" IC....$1.20 per foot
(Available in 10FT to 15 ft. lengths or smaller)....$8.50 each

All merch. guar. Mail orders promptly filled. All prices, F.O.B. N.Y.C. Send M.O. or Chk. Only shipping chgs. sent C.O.D. Rated concerns send P.O.

MIN. ORDER $3.00 **COMMUNICATIONS EQUIPMENT CO.** MIN. ORDER $3.00

131 Liberty St., New York, N. Y. Dept. E5 P. J. PLISHNER **Phone: Main 4-8373**

UPRIGHTS

Mfd.	Volt	Type	Cat. No.	Price
.0025	1500	2TT	D164209	30¢
.03	600	2ST	RO3	25¢
2.0515	600	2TT		45¢
.05	400	2BT	616M	25¢
.05	600	2BT	C51481918-20	28¢
.05	600	2BT	7700BR	28¢
3x.05	300	3BT	NJOCA195	30¢
3x.05	300	3BT	CA195	30¢
.125-.05	400	2TT	CMR481380-10	25¢
.1	600	2BT	616M-14842	35¢
.1	600	2BT	R11-616MB	35¢
.1	400	2BT	418CB	30¢
.1	600	2BT	7701BR	35¢
.1	600	2BT	CP69B1AF104K	35¢
.1	400	2BT	XMRBW4-.1	30¢
.1	600	2BT	C69B1AF104	35¢
2x.1	600	2BT	P9711	39¢
3x.1	400	3BT	CA255	39¢
3x.1	400	3TT	ROBC	39¢
3x.1	400	3BT		39¢
3x.1	600	3TT	C168B5EF104V	42¢
3x.1	600	3BT	7710BR	42¢
3x.1	600	3BT	CD516	42¢
2x125	400	2TT		
.25	800	2WTT		69¢
.4	600	2BT	M-7725BR	30¢
.25	600	2BT	C168B1EF251K	30¢
.5	600	2BT	SO1	32¢
.5	600	2BT	PO8	32¢
.5	400	2TT	416T	30¢
.5	600	2BT	616MB	32¢
2x.5	250	2TT	A-8B515	30¢
2x.5	400	3BT	418MCB	35¢
2x.875	400	2BT	CWS-P-72076-503	39¢
1	400	2TT	305-1605S	35¢
1	600	2BT	616MCB	38¢
1	600	2BT	YAB6100	38¢
1	250	2TT	CBV48553-15	30¢
1	100	1BT	104M59	25¢
1	600	2BT	616MCB	38¢
1	400	2BT	418MCB	35¢
1.75	50	2TT	CRV48661	45¢

Oil Condensers
Famous Makes
Brand New

Mfd.	Volt	Price
5	50	45¢
650	80	$1.95
5	150AC	1.45
15	220AC	2.00
5.5	400	.50
1	500	.40
1	600	.45
6	600	.98
7	600	1.05
20	600	2.10
.5	750AC	1.69
.5	1K	.69
2x.5	1K	.70
1	1K	.75
1.5	1K	.75
2	1K	.99
4	1K	.98
3x.1	1.2K	1.35
.0016	1.5K	1.25
.25	1.5K	1.05
1	1.5K	.89
1.5	1.5K	.95
2	1.5K	1.05
6	1.5K	2.25
2x.1	2K	1.15
1	2K	.98
2	2K	2.25
3	2.2K	2.45
.5	2.5K	1.35
1.5	2.5K	1.35
.1	2.5K	1.20
1	3K	1.45
.15	4K	2.95
.1.1	4.8K	2.95
.4	5K	2.95
.015	6K	2.25
.1	6K	2.79
.15.15	6K	3.95
1.5	6K	9.75
.1.1	7K	2.49
.1	7.5K	2.95
1	7.5K	12.95
.15.15	8K	4.95
.1	10K	14.95

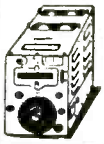
ELECTROLYTICS
Prong Mount
D. Y. Type
A.C. Cond.

13-15	220-1.20
20-24	110-1.00
26-30	220-1.35
43-65	110-1.25
43-48	110-1.25
50-75	110-1.25
53-60	220-1.50
61-69	320-1.60
64-72	110-1.25
72-87	110-1.25
75-84	110-1.25
88-106	110-1.50
107-129	110-1.65
130-157	110-1.75
130-150	70-1.50
130-180	110-1.85
158-191	110-1.85
161-180	110-1.75
189-210	110-1.95
200-220	110-1.95
270-300	110-2.10
324-360	110-2.40
378-420	175-3.00
432-480	110-2.75
485-540	110-2.85

Many Others

PHOTO PRINT-DRYERS

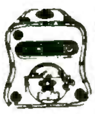
Consists of microme element insulated from open frame 9¾"x10" 110V 60 cy ....75¢



Xmfrs VFO Drivers 40 Watts Output 274N (ARC5)

4-5.3 Mc $5.95
5.3-7 MC $5.95
7-9.1 MC $13.95
Used Good Cond.

GIBSON GIRL



The Emergency Radio Transmitter. Sends S O S signals automatically on 500KC. 150-mile range. No batteries required. Has hand-driven hand - driven generator, tubes, wire. New. It's only $4.25

BC 604 DM Transmitter FM 20-28 MC 11 & 15 Mtr. Can be operated on 10 Mtr. 10 Channel push button control w/tubes meter. Less xtals. Good used. w/dyn. Sold as is... $15.95

CONDENSER TUNING UNITS FOR BC 191 or 375

Write up in OCT QST for Conv to vhf freq meter

TU 7— 4500 to 6200 KC
TU 8— 6200 to 7700 KC
TU 9— 7700 to 10000 KC
TU 26— 200 to 500 KC

Price $2.49 ea.

TUNING UNITS FOR BC 223 XMITTR

TU17A 2000-3000Kc....$2.75
TU18 3000-4500Kc.... 2.25
TU25 3500-5200Kc.... 2.25

ANTENNA MAST

Are you in a dead spot? If you can't get a good T. V. Picture. Here is a Sig. Corp. Ant. mast 30' high of rugged plywood construction to solve your problem. It telescopes into 3 ten ft. sect. for easy stowage. Easy to Mnt. Comp. with stakes & rods. Ea. $19.95.

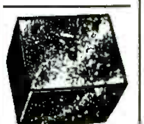
CRYSTALS Low Frequency

FT-241. A holder ½" pin spacing, for ham and general use. Xtal controlled Signal Generators, marked in army Mc harmonic frequencies—Directions for deriving fundamental frequencies enclosed. Listed below by fundamental frequency, fractions omitted.

370	424	472	505	537	447
372	425	473	506	390	448
374	426	474	507	391	450
375	427	475	508	392	451
376	429	476	509	393	453
377	430	477	511	394	454
379	431	479	512	395	455
380	433	480	513	396	456
381	434	481	514	397	457
383	435	483	515	398	463
384	436	484	516	400	465
385	437	485	518	401	498
386	438	486	519	402	500
387	440	487	520	403	501
388	441	488	522	404	538
412	442	490	523	405	540
413	443	491	525	406	each
414	444	492	526	407	$1.49
415	445	493	527	408	
416	458	494	529	409	
418	459	495	530	411	
419	461	496	531	each	
420	462	497	533	69¢	
422	469	503	534		
423	470	504	536		

EE89A Telephone Repeater
Used to extend range of field telephones. Simplex Teleg. and 20 cycle ringing possible over lines equipped with unit. Supplied w/ 305 tube. Phone supplied. (Featherweight $9.59

COLLINS ART. 13 FREQ MULT UNIT
2-18 Mc for two 1625 Tubes. Comp. Assy less Tubes & Coils w/ ckt dia. Price **$8.95**



400 MA 12 HY Choke
90 ohms Herm. sealed. Special $3.75

CHOKE SWINGING
9/60Hy .400/.05 Amp. 10000V ins. Mfg. Super. Elect. $5.95

BATHTUBS

Mfd.	Volt	Type	Cat No.	Price
.01	600	2ST		25¢
.02	600			
.1	400	2ST	HC 3755	30¢
.02	1600	2ST	BA31227-E	45¢
.03	1000	2ST	W3-94	45¢
.06-.1	1500	2TTins	305-1526S	50¢
3x.05	600	3ST	CP50BSOFSO3V	30¢
.05	600	2TT	CSF-481391-10	30¢
.05	600	2ST	DYR 6005	30¢
2x.05	600	3ST	CGF483151B-10	40¢
2x.05	600	3ST	DYR 60055	40¢
.1	600	2ST	A-8B-373	25¢
.1	600	2TT	630T	25¢
.10	600	1ST	NDN	25¢
.1	1000	2ST	CAW48197-B10	30¢
2x.1	400	2BT	1574	25¢
2x.1	400	2TT	1572	25¢
2x.1	600	3ST		30¢
2x.1	400	2TT	CBY48678	25¢
2x.1	600	3BT	305-1133	30¢
2x.1	600	2BT	CSF48680-A20	25¢
2x.1	200	2ST	CP-204D P11	20¢
2x.1	600	3ST	CQU48313-B10	30¢
2x.1	600	2ST	CGF48712B-10	30¢
2x.1	600	3ST	DYR6011	30¢
2x.1	600	2ST	CQU-48712-B10	30¢
2x.1	600	3BT	305-1133	30¢
2x.1	600	3ST	2XDMRW6-1	30¢
2x.1	600	3ST	CP50B4EF101UX	30¢
2x.1	600	3BT	305-1133	30¢
2x.1	600	3BT	305-1133	30¢
3x.1	600	3TT	7890481-P1	35¢
3x.1	600	3ST	CQU48713-B10	35¢
3x.1	600	3TT	305-1683S	35¢
3x.1	600	3BT	22F462	35¢
3x.1	600	3TT	3XDRTMW6-.1	35¢
3x.1	400	3BT	CAW48709	30¢
3x.1	600	3ST	A-18933-1	35¢
.13	600	2TT	630MT	25¢
.25	400	2TT	430T	30¢
2x.25	400	2ST	7253775	40¢
2x.25	100	2TT	K-7101880	25¢
3x.25	400	3BT	CAW-481372	35¢
.5	120	2TT	C226806-2	20¢
.5	600	2TT	305-1154	25¢
.5	400	1TT		23¢
.5	200	2ST	XDMR2-.5	20¢
.5	600	2ST	DYR6050G	25¢
.5	400	2ST	14862	25¢
.5	600	2BT	CSF48704-A20	25¢
.5	400	2TT	RO5	23¢
.5	400	2ST	48205A	23¢
.5	200	2ST	8A31231-C2	20¢
.5	400	2TT	1573	23¢
3x.5	100	3ST	B-215563-5	25¢
2x.5	250	2TT	A8B-515	30¢
2x.5	400	2ST	Z1065A	30¢
2x.5	300	3TT	541B	25¢
2x.5	400	2BT	1575	30¢
3x.5	400	3BT	CBY48703	30¢
.7	200	1TT	7157	30¢
1	200	1ST	55907	25¢
1	600	2ST		35¢
1	600	2BT	305-1391	35¢
1	400	2ST	A-8B-361	35¢
1	600	2TT	305-1507SNDO	35¢
1	600	Test 2ST	NDPS	30¢
1	400	2ST	A-8B-1104	30¢
1	600	2ST	W5-13	35¢
2x1	200	4ST	W226671-1	35¢
2x1	200	4ST	W-226671-2	35¢
2.5	100	2ST	K7101881-P1	35¢
4	50	2ST	678687-5	25¢
8	500	2ST	55844	79¢
30	150	2ST	D11206	1.15
25		2BT		
5-20		3TT	5417	
.025	600	2ST	NCN	35¢
2x.1	400	3TT	P8887	25¢
2x.1	600	3TT	CP51B4EF104V	30¢
2x.1	600	3BT	CP52B4EF104V	30¢
2x.1	400	3ST	NKPS	25¢
3x.1	600	3TT	CMR-48849-A	35¢
3x.1	400	3ST	CP50BSEE104V	30¢
3x.1	400	3ST	CP505BEE104X	30¢
3x.1	600	3BT	CSF48709-A20	35¢
.1	400	2TT	CD-1066-11V	23¢
.1	600	2BT	NKP	25¢
.5	600	1TT	7283	30¢
6	400	2TT	CE64B060Q	1.00

ARC/5 BATHTUBS

Mfd.	Volt	Type	Cat No.	Price
3x.05	300	3TT	5414	08¢
.05-.01-.05	300	3TT	5415	08¢
3	300	1TT	7582	05¢
3x.22	300	3TT	692643 NAO	20¢

HF-185 — 120 watt Modulation Transformer — a sused in the Army BC-191 and RC-375 Xmtrs. Designed for class B modulating a single 211 with push-pull 211's—9000 ohm plate to plate load impedance into a 7000 ohm load. With this transformer and 211's you can build yourself a good economical modulator for an 804, 814 or similar final. $1.49 each

872 FIL XFRMR
Pri: 115-125V 60cy Sec: 2x2.5/20A $6.95

CHIME XFRMR
Pri. 110V 60 cy Sec: 24V/1A $1.25

POWER XFRMR
Pri: 110V 60 cy Sec: 4V/16A 2.5V/1.75A Ideal for 2x2 & 826 Tubes ....$1.[illegible]

AMPLIFIER
AM-32/PRSI less batt w/carry case for Mine Detector AN-PRSI. Price ea. $5.95

CONDENSERS

XMTG. Micas Tapped Holes

Mfd.	Price
2500 V Test	
.00001	$0.25
.000025	.25
.00003	.25
.00005	.25
.000075	.25
.0001	.25
.00015	.25
.00025	.25
.0003	.25
.0004	.25
.0005	.30
.00075	.30
.00085	.30
.001	.30
.0015	.30
.0016	.30
.0017	.30
.002	.50
.0023	.50
.003	.50
.004	.65
.005	.65
.006	.65
.0063	.65
.0069	.65
.007	.65
.0075	.65
.0076	.65
.008	.65
.01	.75
.015	.75
.02	.75
.015	.75
.027	.75
.03	.75
5000 V Test	
.0015	.95
.002	.95

XQ Solder Lugs 2500 V Test

.01	.75
.015	.75
.02	.80
.04	.80
.001	.60
.0015	.60
.002	.60
.0022	.60
.0023	.60
.0024	.60
.0025	.60
.0027	.60
.003	.60
.004	.60
.005	.60
.0056	.60
.006	.60
.0063	.60
.0075	.75
.0076	.75
.008	.75
.0085	.75
.0005	.45
.0005	.45
.00015	.45

T.U. For BC 746 Includes 2 Xtals Poly Coil & RF Coil Sec QST Jan 48 For Convert to Bantam 1 Watt XMTTR. Price $1.29

Photo Material Ethyl Phthalate (East Kod) Apprx. 1 Qt. Bottle.... $3.95

Detonit Surface Cleaning Solution Photomat lithomat Apx.1 Qt... $3.95

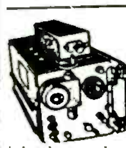
Transparente # 146 For Transparentizing Drawings & Tracings Apx. 1 Qt. $3.95

VITREOUS RESISTORS & OTHERS

Ohms	Size	Type	Price
5M	2x⅝D	Lugs	20¢
12	2x11/16D	Lugs	18¢
2500	2x⅝	Lugs Var.	20¢
5M	2x½	Lugs	20¢
100	1¾x⅜	Lugs	15¢
3150	2x⅝	Lugs	20¢
1000	2x½	Leads	20¢
500	4½x⅞	Lugs	30¢
7500	4x⅞	Lugs	30¢
10	2½x⅝		35¢
3000	3x⅝	Lugs	25¢
12000	3x¾	Lugs	25¢
10	6½x1⅛	Lugs	45¢
5CT	6½x¾	Lugs	40¢
5000	2x1/16	Lugs	20¢

MOUNTINGS

MT-5/ARR2
MT-7/ARR2
MT-171A/U
FT-265A
FT-340
MT-167/U
FT-308A
FT-282A
MT-80/ARC5
FT-141
MT-85/ARC5
MT-78/ARC5
MT-62/ARC5
FT-225A
FT-229A
FT-232A
FT-234A



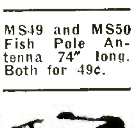
Aircraft Receiver #429 for Mobile or Aircraft Covers from 201 Kc interchange plug in tuning units includes one Tuning Unit. Less Tubes. Rec. Only a few left. $3.95 ea.

JUNCTION BOXES

Pilots control box for RL7 inter-phone equip...$1.29
Junction box J23/ARC4 50¢
Tuning control BC496A for ARC5 ....$1.00
Push button control C-30 /ARC5 ....$1.95
Junction box J-17A/ ARC5 ....$2.49
Junction box TM-AA-160 75¢
Interphone box BC 606 G for SCR 538.........$1.00
Junction box J-22B/ARC5 $1.25
Loading coil TN-6/ARC5 $2.29
Impedance adapter ..75¢
Switch box assy SA/41/ APA-2B $1.00

Code Practice Key
MNTD on bakelite base 1¼ x 4¾ x 3" Adjustable, Tungsten Contacts ...... $1.20 ea.
Key Less Bakelite base...79¢

MS49 and MS50 Fish Pole Antenna 74" long. Both for 49¢.



RL9 or RL7
Interphone Amplifier Convert to High Fidelity Phone Amp. or Spch. Amp. Comp. w/12A6. 12SL7, 2 Choker 1XFRMR. DYN. for 24 operation, etc. $2.29

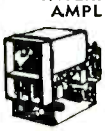
Loading Coil C114
Same as WE No. 632 but in waterproof case to counter balance cap. in line gives clearer signal. Army used W/ W110 & W130 wire .....85c ea.

ARC-5
Mod. XFMP P-P 807 to P-P or PAR 807's #9446 $1.65

SHOCK MOUNTS

No. 1 Square
No. 2 Square & Diamond
No. 4 Square & Diamond
No. 6 Square
No. 8 Square & Holder
No. 12 Square & Holder
No. 15 Square & Holder
No. 20 Square & Holder
No. 33 Square
No. 35 Square & Holder
No. 10 Square & Holder
No. 25 Square & Holder
No. 45 Holder
No. 55 Holder
Write for More Data

BC 605 INTERPHONE AMPLIFIER



Easily converted to an ideal intercommuications set for office— home — or factory. Complete w/conversion diagram for 110 V operation.
Brand New........$4.49
Used $3.95

T. U. for BCAR230 or 430
3.2—4MC
5—6.2MC
1.2—1.5MC
1—1.2MC
Price 95c ea.
4—5MC W/ 4495KC XTAL $1.69

1% PRECISION RESISTORS

.6	7500
1.01	8500
5.	10,000
5.05	10,000
10.1	10,000
18.	12,000
43.5	12,000
50	17,000
75	17,300
82	20,000
120	25,000
125	30,000
128	33,000
150	40,000
128	55,000
250	57,000
300	75,000
430	84,000

30¢ each

468	100,000
800	120,000
920	120,000
1100	150,000
4300	220K
5000	

40¢ ea.

1 Meg. 75¢ ea.
10 Meg. $2.10 ea.

HEADSETS & MIKES

HS23 Used Good 8000 Imp. $2.49
HS33 Used Good 600 Imp. $2.49
HS30B Replace Elements. 60c each
Rubber Earplugs for HS30..... 10 for 25c
Matching XFRMR C110 Less Cords 59c
T45 Lip Mikes.............98c
T30 Throat Mikes...........85c
CD508T30 Ext. Cords w/Switch
Sw141 Complete..........$1.25
Gas Mask Mike Elements....49c
Cords 3 Cond. Color coded approx. 42" ....15 ea.
Hdband HBI 25c
Hdband HB30...............25c

Thermo Couple RF Meter GE DW 52 4 Amp 2% accy Expanded Scale 2.19" dia. List Price $19.95. Our Price $3.95

SELSYN TESTER

Magnesyn Instrument Field Tester AAF 43G23330 Spec. 40772 To test individual mag. Ind. & Xmitters. for isolating Faults in magnesyn systems. Brand new. $99.00

All merch. guar. Mail orders promptly filled. All prices F.O.B. N. Y. C. Send MO or Chk. Only shipping chgs. sent C.O.D. Rated concerns send P.O.

MIN. ORDER $3.00 **COMMUNICATIONS EQUIPMENT CO.** MIN. ORDER $3.00

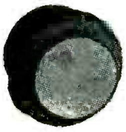
131 Liberty St., New York, N. Y. Dept. E-5 Chas. Rosen Phone: Digby 9-4124

SYNCHROS • AMPLIFIERS • ALNICO MOTORS • SHUNT MOTORS • BLOWERS • RATE GENERATORS • SUB-FRACTIONAL HORSEPOWER AC MOTORS • SELSYN UNITS • TORQUE UNITS • AMPLIDYNES • INVERTERS • ELECTRONIC SERVO SYSTEMS • TACHOMETER GENERATORS • AUTOMATIC PILOT COMPONENTS • DC MOTORS • SINE-COSINE GENERATORS • U. S. NAVY SYNCHROS • AUTOSYNS • SERVO MOTORS • DYNAMOTORS

IMMEDIATE DELIVERY — Servo-Tek — FULLY GUARANTEED

ANTENNA TILT INDICATOR

D-C Selsyn type tilt indicator. G.E. 8DJ29AAK. 24 volt. Stock #SA-296. **Price $3.75 each.**

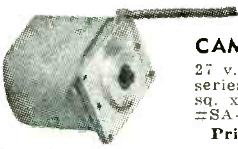


Gyro and Housing Mirror Assembly. For K-14A sighting head. Gyro stabilized mirror assembly. Stock #SA-294. **Price $6.75 each.**

BODINE NSHG-12 MOTOR

Constant speed

27 v. D-C Governor controlled 3600 rpm. 1/30th hp. Stock #SA-39. **Price $17.50 each.**



REVERE CAMERA MOTOR

27 v. D-C. Split field series. Approx. 2½" sq. x 2½" lg. Stock #SA-315. **Price $6.75 each.**

SYNCHRONOUS MOTOR

W.E. S-1283228. For 2 phase 240 cycle operation. 55 volts.

Stock #SA-317. **Price $9.75 each.**

DC MOTOR

High speed 27 v motor with high inertia flywheel. Ideal for gyro demonstrations.

Stock #SA*S-313

Price $9.75 each.

SWEEP GENERATOR CAPACITOR

Hi-speed bearings. Split-stator. Silver-plated coaxial type. 5-10 mmf.

Stock #SA-167 **Price $2.75 each**

MINIATURE DC SELSYN INDICATOR

G.E. miniature indicator. 24 v. d-c operation with G.E. Position Transmitter or with Ohmite 360° type potentiometer. Has iron plug for zero dial adjustment. Stock #SA-268. **Price $14.50 each.**

RECORDER

Brown Instrument Co. "Electronik Recorder" 12 in. chart. One rev. per 10 min. Center O. 200 micro volts DC for full chart. Use as recording galvanometer, or modify for use with strain gauges, etc. Charts included. Operates from 110 volts 60 cycle line. Unit supplied complete with amplifier and tubes. Stock #SA-261.

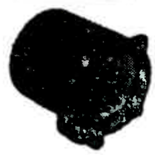
Price $199.50 each

400 Cycle Generator

G. E. 5ASB31JJ3, 400 cycles out at 115 volts 7.2 amps. Ideal for lab. 6" lg. x 6" diam. 8000 rpm. Stock #SA-292. **Price $79.50 ea.**

PRECISION AUTOSYN

Pioneer Type AY-150 Control Autosyn. Precision type. 26 v. 400 cycle. Stock #SA-297. **Special low price $14.50 each.**



A-5 Autopilot Indicator

Autosyn Type Pilot Indicator for A-5 Autopilot. 26 v. 400 cycles. Stock #SA-299. **Price $12.50 each.**

¾ HP DC MOTOR

Electric Specialty Co. HCA315T. 24 volts DC. 3800 rpm. Stock #SA-321. **Special Price $24.50 each.**

ARMA 5A MOTOR

10 Watt Servo Motor—2 phase 115 v. 60 cycles. 3½" lg. x 3½" diam. 1" shaft ext. 0.250 diam. one end, other ext. ½" lg. 0.250 diam. Stock #SA-231. Limited quantity. **Price $49.50 each.**

400 CYCLE AIRCRAFT ACTUATORS

Manufactured by AirResearch. 115 volt 400 cycle operation. 2½" linear travel. Stat. load 200 lbs. Ten. 75-100 lbs. Comp. 75-100 lbs. Stock #SA-326. **Price $21.50 each.**

WINCO DYNAMOTOR

Model 41S6. 13 v D-C in. @ 13 A. Output 250 v @ 0.60 A and 300v @ .225 A. Stock #SA-323.

Price $9.50 ea.

MAGNETIC AMPLIFIER ASSEMBLY

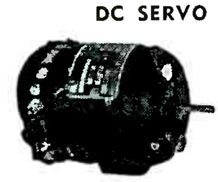
Sperry 661824. Saturable reactor type output transformer. Designed to supply one phase of 400 cycle servo motor. Stock #SA-266. Price $6.75 each.

Autosyn Indicator

I-82F Compass Indicator. 0-360°-5 in. dial. 26 v 400 cy. 8-12 v. 60 cy. Ideal position indicator. Stock #SA-284.

Price $6.50 each

DC SERVO MOTOR



Elinco Type B-64. 1/165 hp at 3100 rpm. Field volts 27.5 Max. armature voltage 80. Ideal for thyratron servo control Stock #SA-211. **Price $16.50 each**

Pioneer Servo Motors

Type 10047-2A. 2ϕ 400 cycle low inertia. 26 v fixed phase. 45 v. max. variable phase. Stock #SA-90. **Price $12.50 each.**

PIONEER CK-17

400 cycles 2 phase, 26 v fixed phase. 45 v. max. variable base. Built in gear reduction. Output shaft speed approx. 4 rpm.

Stock #SA-287. **Price $16.50.**

LOAD & BALANCE COMPUTER

C-54B Aircraft load computer. Totals load and locates center of gravity. Voltage divider type computer. Ideal for classroom. Stock #SA-334. **Price $49.50 each.**

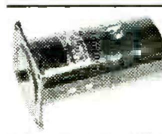
INVERTER

Pioneer 12130-4-B Input 28 VDC at 14 amps. Output 120 v. 400 cy. Single Phase at 1.15 amps. (140 VA.) Voltage and frequency regulated. Made 1949. Stock #SA-304. **Price $89.50 each.**

MICROPOSITIONER

Barber Colman AYLZ-2183. Polarized dc relay. Double coil differential current sensitive. Alnico PM polarized field. 24 v. Contacts 0.5 amps 28 v. Use for remote positioning, synchronizing, control, etc. Sens. 1.25 ma. diff. Use to 100 cy. Stock #SA-290.

Price $12.50 each.



JA1 MOTOR (D-C)

Electric Specialty. ¼ hp. 24 v. D-C. (Wing flap motor.) Stock #SA-325. **Price $19.50 ea.**

SYNCHROS

Navy Types

1G, 1F, 1CT, 5G, 5F, 5CT, 5DG, 5HCT, 5SF, 5HSF, 5SDG, 6DG, 6G, 6DG, 7G, etc.

Prices on Request

Servo-Tek products co.
4 Godwin Ave. Paterson, N. J.

WRITE FOR LISTING
Prices F.O.B. Paterson
Phone ARmory 4-3366

SPECIALISTS IN FRACTIONAL HORSE POWER MOTOR SPEED CONTROL

1000 KC crystal BT cut $3.95
3" scope shield 1.29
2 speed dial drive for ¼" shaft ratios 5:1 1 to 1 .39
ATC 100 mmfd air trimmer screwdriver shaft .... .29
Centralab 850 S 50MMF 5KV BUTTON COND. ... .39
500 watt 12.5 ohm power rheostat 3.49

R·H·S
SPECIALS OF THE MONTH

6v, 12v vibrators any type .... $ .98
Rotary switch Mycalex, 2 deck SP3T .... .39
1 mfd 5000v oil condenser 2.98
2 mfd 3000v oil condenser 3.25
3 mfd 4000v oil condenser 3.95
24 mfd 1500v DC 3KV flash. Excellent for speed lamp 3.95

TUBES!! BRAND NEW! STANDARD BRANDS! NO SECONDS! COMPARE! TUBES!!

OA3/VR75	$1.69
OB3/VR90	1.29
OC3/VR105	1.49
OD3/VR150	1.29
1B22	3.45
1B23	12.50
1B24	6.95
1B26	3.95
1B27	24.50
1B29	2.75
1B32	8.95
1B36	24.96
1B38	32.50
1N21 Xtal	1.25
1N21A Xtal	2.25
1N21B Xtal	3.25
1N22 Xtal.	1.35
1N23 Xtal.	2.25
1N23A Xtal	3.25
1N23B Xtal	4.95
1N27	1.69
1N34	1.40
1N34A	1.40
1P23	3.95
1P24	1.79
1P36	2.95
1S21	6.95
2AP1	8.95
2AP5	6.95
2C21/RK33	.69
2C22/7193	.49
2C26A	.49
2C34/RK34	.89
2C39	24.50
2C40	4.95
2C43	14.95
2C44	1.49
2C46	7.50
2C51	5.75
2D21	1.79
2E22	1.95
2E24	4.89
2E26	3.69
2E30	2.29
2J21A	9.95
2J22	8.45
2J26	29.50
2J27	29.50
2J30	39.50
2J31	39.50
2J32	39.50
2J33	39.50
2J34	39.50
2J36	97.50
2J37	12.75
2J38	12.75
2J39	39.50
2J40	39.50
2J46	39.50
2J48	29.50
2J49	39.50
2J50	22.50
2J54B	39.50
2J55	97.50
2J61	49.50
2J62	49.50
2K25/723AB	24.95
2K28	39.50
2K29	24.50
3AP1	9.95
3B22/ELIC	2.95
3B23/RK22	4.85
3B24	5.95
3B24W	7.95
3B25	4.65
3B26	3.95
3B27	3.95
3B28	8.95
3BP1	8.95
3C22	64.50
3C23	$ 9.95
3C24/24G	2.25
3C30	2.95
3C31/C1B	3.49
3C45	12.75
3CP1	2.25
3CP1-S1	2.95
3DP1	4.95
3DP1A	6.95
3DP1-S2A	8.95
3D21A	1.98
3E29	14.95
3EP1	5.95
3FP7	3.95
3GP1	4.75
3HP7	3.95
4-65A	14.21
4-125A	26.95
4-250A	29.95
4AP10	4.95
4B22/EL5B	9.95
4B24/EL3C	7.95
4B25/6CF	8.95
4B26/2000	8.95
4B28	4.95
4B32	9.95
4C27/CV92	49.50
4C35	29.50
4D22	12.95
4D32	14.95
4E27/257B	17.95
5AP1	3.69
5AP4	3.69
5BP1	5.95
5BP4	5.95
5CP1	4.95
5CP7	4.95
5C22	49.55
5D21	24.50
5FP7	1.95
5GP1	4.95
5JP1	24.45
5JP4	24.45
5J23	12.95
5J29	12.95
5J30	49.50
5J32	99.50
5LP1	13.95
5NP1	5.95
6AS6	3.69
6C21	22.50
6F4	5.95
6J4	5.95
7BP7	8.95
9GP7	14.95
9JP1	14.95
9LP1	19.95
9LP7	14.95
10BP4	18.95
7DP4	17.95
10	.49
12DP7	16.95
12GP7	16.95
12HP7	16.95
12LP4	22.50
15E	1.19
15R	.89
16AP4	42.50
16CP4	42.50
19T8	1.29
23D4	.45
28D7	.98
30 Special	.59
35TG	4.95
45 Special	.39
53A	5.95
75TL	6.95
100R	.89
100TH	9.95
121A	2.98
203A	8.95
204A	$69.50
211	.69
212E	49.50
215A	.19
217C	8.95
227A/5C27	5.95
249C	3.95
250R	12.95
250TH	21.50
250TL	21.50
274A	5.50
274B	2.65
276A	9.95
293A	2.98
294A	5.75
300B	9.95
304TH	27.50
304TL	29.95
305A	34.95
307A/RK75	5.95
310A	8.95
316A	.65
323A/B	24.50
327A/5C37	4.95
328A	13.95
331A	12.95
350A	8.95
350B	2.95
368AS	7.95
371A	1.49
371B	.98
388A	2.75
393A	6.95
394A	4.95
417A	12.95
434A	4.95
446A	4.95
446B	1.79
450TH	47.50
450TL	44.50
527	12.75
559	1.39
562	97.50
575A	13.95
701A	5.95
702A	3.95
703A	7.95
704A	1.05
705A	.89
706BY	39.50
706CY	39.50
706FY	42.50
706GY	42.50
707B	17.95
708A	4.95
709A	3.95
710A/8011	1.75
713A	1.45
714AY	6.95
715A	7.95
715B	12.95
715C	24.50
717A	1.69
721A	2.59
722A	2.95
723A	9.95
723A/B	14.95
724B	3.89
725A	7.95
726A	6.95
726B	29.50
726C	49.50
730A	12.95
750TL	79.50
800	1.95
801A	.49
802	4.49
803	4.49
804	9.95
805	4.49
806	29.95
807	1.98
808	4.49
809	$ 2.45
810	9.95
811	2.95
812	2.95
812H	6.90
813	8.95
814	3.95
815	2.95
816	1.19
826	.98
828	12.75
829	12.95
829B	14.95
830B	3.95
832	5.95
832A	8.95
833A	37.50
836A	3.95
837	1.69
838	2.95
841	.45
843	.39
845	4.95
849	29.50
851	69.50
852	29.50
860	6.95
861	29.50
864	.39
865	1.45
866A	1.39
866JR	1.29
869B	39.50
872A	2.49
874	1.49
876	.59
878	2.25
881	1.49
885	1.49
902	8.95
905	3.59
908	7.95
918	1.69
919	2.79
922	.98
923	1.05
927	1.59
930	1.05
931A	4.95
954	.39
955	.45
956	.45
957	.45
958	.45
959	.65
991/NE16	.39
1603	3.25
1613	1.25
1614	1.95
1616	.98
1619	.29
1622	1.98
1624	1.98
1625	.45
1626	.35
1629	.25
1630	.98
1631	1.29
1632	.79
1633	.75
1634	.75
1636	3.25
1638	.65
1644	.98
1654	2.39
1665	1.45
1851	1.89
1960	.79
1961	4.99
2050	1.25
2051	.65
8005	5.95
8011	1.75
8012	$ 3.95
8013	2.95
8014	29.95
8020	1.29
8025	5.95
9001	2.25
9002	1.49
9003	1.49
9004	.45
9005	2.35
9006	.29
C1JA	9.95
C5B	9.95
C6A	7.95
C6J	6.95
C100D	1.49
CK502AX	2.95
CK503AX	2.95
CK505AX	2.25
CK506AX	2.25
CK507AX	2.25
CK512AX	2.25
CK517AX	8.45
CK1005	.89
CK1006	.95
E1148	.35
EF50	.69
F123A	8.75
F127A	22.50
F128A	89.50
F606	37.60
F660	79.50
FG17	3.95
FG27A	8.75
FG32	7.95
FG57	14.95
FG81A	3.95
FG105	8.95
FG172	29.50
FG146	8.95
FG434A	4.95
FG451	.89
FG502A	1.85
GL562	97.50
GL592	14.95
HF125	14.95
HF300	19.95
HY114B	.79
HY115	.79
HY615	.29
KC4	37.50
KU610	6.95
ML101	69.50
REL21	3.25
RK20	9.95
RK25	4.49
RK33	.69
RK34	.89
RK48A	4.49
RK59	1.49
RK60/1641	.98
RK65	24.50
RK72	.59
RK73	.59
RX21A	2.95
RX120	8.95
V70D	6.95
VR78	.69
VR91	1.49
VR92	.98
VT127A	3.95
VT158	14.95
VU29	2.95
VU111	1.49
WL468	12.95
WL530	12.75
WL531	12.75
WL532	2.95
WL578	1.29
WL616	37.50
WL619	18.95
WL677	34.50
WL681	22.50

OA2, OA4G, OB2, OZ4, O1A, 1A3, 1A4P, 1A5GT, 1A6, 1A7GT, 1AB5, 1B3/8016, 1B4, 1B5/25S, 1B7GT, 1C5GT, 1C6, 1C7G, 1D5GP, 1D7G, 1D8GT, 1E5GT, 1E7G, 1F4, 1F5G, 1G4GT, 1G6GT, 1H4G, 1H5GT, 1H6GT, 1J6GT, 1L4, 1LA4, 1LA6, 1LB4, 1LC5, 1LC6, 1LD5, 1LE3, 1LG5, 1LH4, 1LN5, 1N5GT, 1P5GT, 1Q5GT, 1R4, 1R5, 1S4, 1S5, 1T4, 1T5GT, 1U4, 1V, 2A3, 2A4G, 2A5, 2A6, 2A7, 2B7, 2V3G, 2X2, 2X2A, 3A4, 3A5, 3A8, 3B7/1291, 3D6/1299, 3LF4, 3Q4, 3Q5GT, 3S4, 3V4, 5R4GY, 5T4, 5U4G, 5V4G, 5W4, 5X4G, 5Y3GT, 5Y4G, 5Z3

DUE TO CURRENT NATIONAL EMERGENCY AND THE CRITICAL RECEIVING TUBE SHORTAGE, TUBES WILL BE SHIPPED AT PREVAILING PRICES. WE WILL QUOTE ON LARGE OR SMALL QUANTITIES.

5Z4, 6A3, 6A4LA, 6A6, 6A7, 6A8, 6AB7, 6AC5GT, 6AC7, 6AD7G, 6AE6G, 6AF6G, 6AG5, 6AG7, 6AH6, 6AJ5, 6AK5, 6AK6, 6AL5, 6AQ5, 6AQ6, 6AR5, 6AT6, 6AU6, 6AV6, 6B4G, 6B6G, 6B7, 6B8G, 6BA6, 6BE6, 6BF6, 6BG6G, 6BH6, 6BJ6, 6C4, 6C5, 6C6, 6C8G, 6D6, 6D8G, 6E5, 6F5, 6F6, 6F6GT, 6F7, 6F8G, 6G6G, 6H6, 6H6GT, 6J5, 6J5GT, 6J6, 6J7, 6J7GT, 6K5GT, 6K6GT, 6K7, 6K8, 6L5G, 6L6, 6L6G, 6L6GA, 6L7, 6L7G, 6N7, 6Q7, 6R7, 6S7G, 6S8GT, 6SA7, 6SC7, 6SD7GT, 6SF5, 6SF5GT, 6SF7, 6SG7, 6SH7, 6SJ7, 6SK7, 6SL7GT

DUE TO CURRENT NATIONAL EMERGENCY AND THE CRITICAL RECEIVING TUBE SHORTAGE, TUBES WILL BE SHIPPED AT PREVAILING PRICES. WE WILL QUOTE ON LARGE OR SMALL QUANTITIES.

6SN7GT, 6SQ7, 6SR7GT, 6SS7, 6ST7, 6SU7GTY, 6SV7, 6T7G, 6T8, 6U5G, 6U6GT, 6U7G, 6V6, 6V6GT, 6W4, 6W7G, 6X4, 6X5GT, 6Y6G, 6Y7G, 6Z7G, 6ZY5G, 7A4/XXL, 7A5, 7A6, 7A7, 7A8, 7AG7, 7B4, 7B5, 7B6, 7B7, 7C4, 7C5, 7C6, 7C7, 7E5, 7E6, 7E7, 7F7, 7H7, 7K7, 7L7, 7N7, 7Q7, 7R7, 7S7, 7V7, 7W7, 7X7, 7Y4, 7Z4, 12A, 12A6, 12A7, 12A8GT, 12AH7GT, 12AL5, 12AT6, 12AT7, 12AU6, 12AU7, 12AV6, 12BA6, 12BE6, 12C8, 12F5GT, 12H6, 12J5GT, 12J7GT, 12K7GT, 12K8, 12Q7, 12SA7GT, 12SC7, 12SF5, 12SF7, 12SG7, 12SH7

DUE TO CURRENT NATIONAL EMERGENCY AND THE CRITICAL RECEIVING TUBE SHORTAGE, TUBES WILL BE SHIPPED AT PREVAILING PRICES. WE WILL QUOTE ON LARGE OR SMALL QUANTITIES.

12SJ7, 12SK7, 12SL7, 12SN7, 12SQ7, 12SR7, 12Z3, 14A4, 14A7, 14B6, 14F7, 14F8, 14H7, 14J7, 14N7, 14Q7, 14R7, 19, 24A, 25L6GT, 25Z5, 25Z6GT, 26, 27, 28D7, 30, 31, 32, 32L7GT, 33, 34, 35/51, 35A5, 35B5, 35C5, 35L6GT, 35W4, 35Y4, 35Z3, 35Z4, 35Z5, 36, 37, 38, 39/44, 41, 42, 43, 45, 45Z3, 45Z5, 46, 47, 48, 49, 50A5, 50B5, 50C5, 50L6GT, 50Y6, 53, 56, 57, 58, 59, 70L7, 71A, 75, 76, 77, 78, 80, 82, 83, 83V, 84/6Z4, 85, 89Y, 117L7/M7, 117N7, 117P7, 117Z3, 117Z6

DUE TO CURRENT NATIONAL EMERGENCY AND THE CRITICAL RECEIVING TUBE SHORTAGE, TUBES WILL BE SHIPPED AT PREVAILING PRICES. WE WILL QUOTE ON LARGE OR SMALL QUANTITIES.

FULL-WAVE SELENIUM RECTIFIER STACKS
Voltage and Current Ratings Based on 35° C. Ambient, Self-Cooled

Max. A.C. Input Volts RMS	Max. D.C. Volts Output	Cell Size in Inches		Max. D.C. Amps. Output Continuous	Order by This Number	Price
SINGLE PHASE BRIDGE						
0-18	0-14.5	1¾"	x1¾"	1.3	18B4D1S1	$ 2.95
"	"	2-3/16"	x2-3/16"	2.4	18B4E1S1	3.95
"	"	3⅜"	x3⅜"	6.6	18B4F1S1	5.45
"	"	4½"	x5"	13.0	18B4K1S1	9.50
"	"	5"	x6"	17.5	18B4J1S1	12.45
"	"	4½"	x5"	26.0	18B4K1S2	18.65
"	"	4½"	x5"	39.0	18B4K1S3	25.95
"	"	4½"	x5"	52.0	18B4J1S3	31.50
"	"	4½"	x5"	70.0	18B4J1S4	37.50
0-40	0-34	1¾"	x1¾"	0.60	40B4D1S1	3.45
"	"	2-3/16"	x2-3/16"	1.2	40B4EW1S1	4.45
"	"	3⅜"	x3⅜"	3.2	40B4FW1S1	5.75
"	"	4½"	x5"	6.0	40B4K1S1	10.50
"	"	5"	x6"	9.0	40B4JW1S1	13.95
"	"	4½"	x5"	12.0	40B4K1S2	19.89
"	"	5"	x6"	18.0	40B4JW1S2	23.75
"	"	4½"	x5"	25.0	40B4J1S3	33.95
"	"	4½"	x5"	34.0	40B4J1S4	36.45
"	"	5"	x6"	36.0	40B4JW1S4	41.95
0-120	0-100	1¾"	x1¾"	0.60	40B4D3S1	8.45
"	"	2-3/16"	x2-3/16"	1.2	40B4EW3S1	11.55
"	"	3⅜"	x3⅜"	3.2	40B4FW3S1	17.95
"	"	4½"	x5"	6.0	40B1K3S1	25.95
"	"	5"	x6"	9.0	40B4JW3S1	34.25
CENTER-TAP						
10-0-10	0-8	1¾"	x1¾"	1.2	20C2D1S1	$ 2.25
"	"	2-3/16"	x2-3/16"	2.4	20C2EW1S1	2.95
"	"	3⅜"	x3⅜"	6.4	20C2FW1S1	4.55
"	"	4½"	x5"	12.0	20C2K1S1	5.89
"	"	5"	x6"	16.0	20C2J1S1	8.45
"	"	4½"	x5"	24.0	20C2K1S2	11.69
"	"	4½"	x5"	36.0	20C2K1S3	15.25
"	"	4½"	x5"	48.0	20C2J1S3	18.10
"	"	4½"	x5"	64.0	20C2J1S4	21.49
"	"	4½"	x5"	80.0	20C2J1S5	26.50
"	"	4½"	x5"	81.0	20C2KW1S7	29.95
"	"	5"	x6"	96.0	20C2J1S6	34.95
"	"	4½"	x5"	128.0	20C2J1S8	45.50
3 PHASE BRIDGE						
0-120	0-150	1¾"	x1¾"	0.90	40B6D3S1	$14.95
"	"	2-3/16"	x2-3/16"	1.8	40B6EW3S1	16.65
"	"	3⅜"	x3⅜"	4.75	40B6FW3S1	24.95
"	"	4½"	x5"	9.0	40B6K3S1	42.50
"	"	5"	x6"	12.5	40B6J3S1	46.89
0-240	0-300	1¾"	x1¾"	0.90	40B6D6S1	$27.95
"	"	2-3/16"	x2-3/16"	1.8	40B6EW6S1	31.50
"	"	3⅜"	x3⅜"	4.75	40B6FW6S1	47.75
"	"	4½"	x5"	9.0	40B6K6S1	85.95
"	"	5"	x6"	12.5	40B6J6S1	97.25

Note: All Current Ratings Can Be Increased 2 to 2½ Times Normal Ratings by Fan Cooling.
When Moisture and Fungus Proof Is Desired Add Letter "M" to Last Number of Code

TRANSFORMERS—115V 60 CY
HI-VOLTAGE INSULATION

2700v @ 2 MA; 6.3v @ .6A; 2.5v @ 1.75A .. $ 4.45
2500v @ 15 MA 3.49
1540v @ 5 MA; 340-0-340 @ 300 MA 4.35
925v @ 10 MA; 525-0-525v @ 60 MA; 2X5v @ 3A; 6.3v @ 3.6A; 6.3v @ 2A; 6.3v @ 1A 4.85
500-0-500v @ 175 MA 4.55
425-0-425v @ 75 MA; 6.3v @ 1.5A; 5v @ 3A 3.65
415-0-415v @ 60 MA; 5v CT @ 2A; 115/230 Dual Pri 4.25
400-315-0-100-315v @ 200 MA; 2x6.3v @ 9A; 5v @ 3A; 2.5v @ 2A 5.35
500-385-0-385v @ 200 MA; 3x6.3v @ 6A; 5v @ 3A; 2.5v @ 2A 4.75
375-0-375 @ 175 MA, 5v @ 3A, 6.3v @ 5A, 78 v @ 1A 3.79
350-0-350v @ 35 MA 2.49
325-0-325v @ 12 MA; 255-0-255v @ 240 MA. 4.25
300-0-300v @ 65 MA; 6.3v @ 2.5A; 6.3v @ 1A; 2x5v @ 2A 3.25
80-0-80v @ 225 MA; 5v @ 2A; 5v @ 4A 2.97
0-17.4 21.6 25.8v @ 400 MA; 6.4v @ .5A; 2.6v CT @ 2.5A Pri 115 230 .... 3.85
12.6v CT @ 10A; 11v CT @ 6.5A 6.35
3x10.3v CT @ 7A .. $6.95 6.3v @ 1A .... .98
6.5v @ 12A; 6.3v @ 2A; 115v @ .1A 3.50
6.5v @ 8A; 6.5v @ 6A; 2.5v @ 1.75A 4.17
6.3v @ 1A; 2.5v @ 2A .. $2.29 4-0-4v @ 1A .87
6.3v CT @ 3.5A; 2x2.5v CT @ 3A 2.97
5v CT @ 20A; 10 KV INS 8.95
.6v @ 15A RMS 1.47

TRANSFORMERS—220v 60 Cyc

512.5-0-512.5 @ 427 MA .... $ 5.35
3x5v @ 6A; 4v @ .25A 2.95
3x6.3v CT @ 3A; 6.3v CT @ 1.6A 2.95
10v CT @ 6.5A; 6.3v CT @ 2.5A; 6.3v CT @ 1.8A 220/440 Pri 3.95
Step Up/Down 110/220, 500 watt 10.95

EQUIPMENT SPECIALS

ATR Inverter 12v DC in 110v AC Out 125 w Int. 100 w Cont.	New	$14.95
AN/CRW-2 UHF Receiver Less Tubes	New	5.95
BC433 Receiver	Good	24.94
BC456 Modulator	Good	1.98
BC434A Control Box/BC433	Used	1.95
BC459 Transmitter	Good	10.95
BC778 Gibson Girl	Good	3.95
BC950A-121 Xmitter 100-156 MC	New	69.50
BC1016 Tape Recorder	New	459.50
BC1206B Beacon Receiver, Less Tubes	Good	3.95
CF1 Navy Unit w/200KC Crystal	New	14.95
DM 19 Dynamotor 12v DC in 500v 200 MA Cont. Output	Good	6.95
MN26C Compass Receiver	Good	24.95
M110 Dynamic Chest Mike	New	3.95
PE94 Dynamotor SCR522	Good	1.98
PE97A Vibrator Power Supply	New	6.95
PE103 Dynamotor	Like New	29.95
R89 ARN5 Receiver Less Tubes, Covers	Good	14.95
SCR518 Altimeter Complete	New	97.50
T17 Carbon Mike	Used	1.59

FILTER CHOKES HI V INS

.025 HY @ 1.36A $1.98
2 HY @ 175 MA 1.49
3 HY @ 50 MA .39
5 HY @ 1A 13.95
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HY 350 MA Dual 2.39
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10 HY @ 55 MA .89
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10 HY @ 250 MA $3.15
10/20 HY @ 85 MA 1.49
13 HY @ 130 MA 1.55
15 HY @ 25 MA .59
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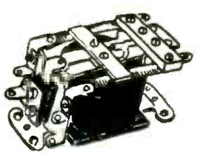
Over 200,000 RELAYS in our Vast Stock—Guaranteed—*HERE'S A FEW*

ALLIED RELAYS

			Each
BO6D40	77VDC, DPDT, 2380 ohm.	#R356	$2.25
BO6A55	55VAC, (or12VDC), DPDT	#R211	1.69
BO6D35	24VDC, DPDT, 240 ohm	#RO4	1.75
BO635	24VDC, DPDT, 240 ohm	#RO4B	1.69
BO13D35	24VDC, SPST, double make, 240 ohm	#RO6	1.25
DO9D28	6VDC, 3PDT, 14 ohm,	#R225	2.25
BO9D35	24VDC, 3PDT, 230 ohm	#R357	2.25
BJX-4Z	12 or 24VDC, SP DBLE break, 240 ohm C.T.	#R226	.89
55837	24VDC, Double make, 250 ohm	#R108	1.50
BO1535	24VDC, Double make, & Break 240 ohm	#R238	1.30
BO1332	12VDC, 80 ohm, Coil & Frame only (no contacts)	#RC358	.40
BOYX3	1VDC, SPST, n.o., 1 1/2 ohm	#R359	1.50
BOY13D	20VDC Double make 1, break 1, 550 ohm	#R360	1.95

DIFFERENTIAL 803476 DUAL 8000 ohm 2.5 ma. coils. Armature pivoted betweenETAOIN ETAOINN normally open. SPDT 5A. contacts Hi-speed. Suitable for P. P., bridge or balanced circuits where differential action is required #R362..........$4.95

ANTENNA SWITCHING



ADVANCE Type 400. 110 VAC, DPDT, large ceramic base, 15A contacts #R355..$4.75 ea.
LEACH 1077-BF WM1. 24VDC, DPDT, 250 ohm, ceramic insul. #R361 ......$2.50 ea.
G. E. 37843 12VDC, DPDT & SPST n. c., ceramic insul. 50 ohms, 10A. contacts #R57 $1.95 ea.
ADVANCE 4001B 75VDC, DPDT & SPST, ceramic insul., 2500 ohms, 15A. contacts #R227..3.95 ea.
G. E. CR 2791D107F3, 24VDC, DPDT, ceramic insul., 100 ohms, 5A. contacts #R229 5.95 ea.

A. C. RELAYS

A. B. T. C1070, 110V 60cyc., Coin release mechanism #R362 ....$.69 ea.
ADVANCE Type 400, 110V 60cyc., DPDT, Large ceramic base, 15A. contacts #R355......$4.75 ea.
GUARDIAN 12-24 VAC, Make 2, Break 1, 5A. contacts #R273 ....$1.10 ea.
GUARDIAN 12-24 VAC, SPST n. o., 5A. contacts #R274 ....$.98 ea.
ALLIED BO6A55, 55 VAC, DPDT, 10A, contacts #R211 ....$1.69 ea.
12VAC DPST. n. o., 5A contacts, #R275 ..$.98 ea.

POWER POTENTIOMETERS

Ohms	Watts	Type	Each
0.87*	150	pot	$3.95
7.5	150	pot	3.95
12	50	pot	1.98
25	25	pot	1.25
25	25	rheo†	1.25
25	50	pot	1.98
50	50	pot	2.49
50	75	pot	3.25
60*	25	pot	1.25
80	50	rheo†	1.98
185	25	rheo†	1.25
250	25	rheo†	1.25
370	25	rheo†	1.25

*Screwdriver shaft †with off position

9006 Jan Tubes—Bulk . . $.35 each

ROTARY SWITCH

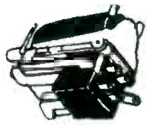
40 circuit, 2 position, bakelite insul. 10 decks, 4 ckts/deck, non-shorting Mallory #S24 ....$2.75 ea.

400 CYCLE INVERTER

Leland PE218 22.5V 92A in: 115 VAC 400 cyc. 1500 VA 0.9P.F. out: 8000 RPM ....$29.50 ea.

SAVE 50% AT U.g.

MINIATURE RELAYS



AMER. TOTALIZATOR A8045, 24VDC, DPDT, 300 ohm #R351 ......$1.25 ea.
CLARE — A21577, 24VDC, DPST, 250 ohm #R352 $1.15 ea.
LEACH P2 (Pair on Board) Ea Relay, 6 VDC, SPDT, 125 ohm #R353 $1.25 pr.
GUARDIAN—24VDC, SPST n.o., 300 ohm, ceramic insul., Anti-capacity contacts #R106.....$.59 ea.
ALLIED—55837 24VDC, Double make, 250 ohms #R108 ....$1.50 ea.
G. E. 55837 Same as #R108 #R108G....$1.00 ea.
RBM 55837 Same as #R108 #R108R.....$1.25 ea.
CLARE—A13415, 12VDC, DPST n.o., 120 ohms #R246 ....$1.25 ea.
ARC-7252, 24VDC, DPST n.o., 300 ohm, ceramic insul., Anti-capacity contacts #R354....$1.25 ea.
CLARE—R35226, 24VDC, 4PST n.o., 300 ohm #R135 ....$1.35 ea.

MISCELLANEOUS RELAYS

G. E. CR2791B106J3, 12VDC, 3PDT, 180 ohms, 3A contacts #R237 ....$1.25 ea.
G.M. 12792-1 18-24 VDC, 3PDT, 100 ohms, 10A. contacts #R240 ....$1.75 ea.
LEACH 2069 (G.E. M7472260) 12-24VDC, 3PDT, 130 ohms, 15A. contacts #R241..........$1.50 ea.
AMPERITE TIME DELAY 24NO2 24VAC or DC, SPST, n.o. 5A contacts, 2 sec. delay at 24V; can operate from 110 V with 1250 ohm resistor or larger for longer delay #R316..........$.98 ea.
G. E. CR2791-B100J4 4-6VDC 3PDT, 12 ohm, 3A contacts #R361 ....$1.25 ea.
G. E. CR2791-G100K4 24VDC, 4PST n.o., 300 ohm, 10A contacts #R362 ....$1.95 ea.

SENSITIVE PLATE CIRCUIT

POTTER & BRUMFIELD—2500 ohm, 9ma., SPDT #R364 ....$1.25 ea.
CLARE—A12342, 3600 ohm, 7ma., DPDT & DPST n.o. #R363 ....$3.95 ea.
DUMONT—5000 ohm, 5ma., SPST n.o. 10A contacts #R230 ....$.98 ea.
G. E CR2791B109P36 10,000 ohm, 9 ma, double make and break, 5A. contacts #R231......$.98 ea.

H-F TIE POST

Low-Loss Yellow Bakelite Insulation, pictured actual size (40-40 Thread)
$7.50/C $10.00/M

HI-VOLTAGE GLASS TO METAL SEALS (FEEDTHRU)

¼" Hole ⅞" Overall #841
3/16" Hole 1 ¼" Overall #341
3/16" Hole 1 ⅛" Overall #356
8.00/c 70.00/M Any Size

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Hermetically sealed glass ferrule types
1 megohm 10 long 1 ¼" diam .....$1.98 ea.
10 megohm 5 ½" long 1 ¼" diam.. 2.40 ea.
15 megohm 10" long 1 ¼" diam..... 3.98 ea.

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1K, 4K, 60K, 100K, 500K. All 1 watt $10.00/C

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APC's	Crystals	Resistors
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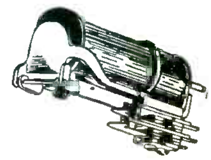
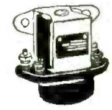
TELEPHONE RELAYS

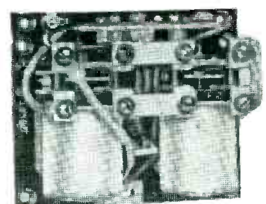


AUTOMATIC — 1300 ohm, 9ma., SPST n.o. #R103 $1.25 ea.
STROMBERG-CARLSON P32505 12VDC, SPDT n.o., 200 ohm, Anti-vibration contacts #R92 $1.49 ea.
STROMBERG-CARLSON P32504 6VDC, SPST n.o., 100 ohm, Anti-vibrational contacts #R02 $1.49 ea.
COOK 102 8-12VDC Copper slug, slow release, SPDT, 200 ohm #R365 ....$2.49 ea.

SOLENOIDS



ALLEN BRADLEY B5A, 24VDC, SPST, 50 A, 100 ohms #R105 $1.95 ea.
G. E. CR9533K100A2, 24VDC, 2 SWITCHETTES, DPST n.c. & SPST n.o.; extra long throw #R132 $9.95 ea.
HART M569A, Cat #694R19, 24VDC, SPST, 200A, 75 ohms #R127A $2.95 ea.
AUTOLITE B8 SPEC., 32424A 24VDC, SPST, 200A, 6 ohms #R150 ....$2.75 ea.
CUTLER-HAMMER B8, 6041H139A, 24VDC, SPST, 200A, 10 ohms #R130..........$3.95 ea.
EPCO S47D, 12VDC, SPST, 25A, 35 ohms #R122 $1.95 ea.
ECLIPSE D1EA53538, 24VDC, 200A, 6 ohms #R126 $2.95 ea.
RBM BN5 24VDC, 50A, 200 ohms #R224..$1.95 ea.
G. E. #CR2800384A3, 24VDC, Double Make, 50 ohm 200A #R59B ....$3.95 ea.



AUTOLITE, SSK 4001, 12VDC, Double make, 20 ohm, 100A. #R74 $1.25 ea.
GUARDIAN 34585 Dual latching, 24 VDC each section. Double make one, double break one & alternate double make one, break one, 2100A, 24 ohms #R223 $4.75 ea

CAPACITORS

TRANSMITTING TYPE 4

MFD	WVDC	TEST	Each
.00003	1200	2500	.25
.00008	1200	2500	.25
.00011	2500	5000	.35
.001	600	1200	.15
.003	600	1200	.23
.01	600	1200	.25
.02	600	1000	.35
.025	600	1000	.40
.04	600	1000	.50

TS2A VARIABLE CERAMICONS

CAPAC. 1.5 to 7; 1.5 to 7.5; 3.5 to 30; 5 to 40 .28 ea., $25.00/c

Ceramic & Feedthru CAPACITORS

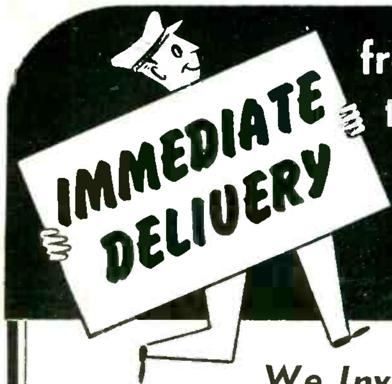
Type	No.	MMF Tol.	Ea.	perC
Button	CB	500 ±10%	.18	15.00
Button Standoff	FA	240 ±10%	.18	15.00
		2000 ±10%	.10	30.00
Standoff	324	1000 ±10%	.12	10.00
Feedthru		55 ±10%	.10	9.00

SILVER MICAS

MMF	TOL.	EA.	Per/10
8.5	±10%	.09	$7.00
25	± 5%	.12	10.00
100	±10%	.10	8.50
125*	± 1%	.10	8.50
250	±10%	.09	7.50
375	±10%	.09	7.50
1500	± 1%	.35	30.00
1700	±10%	.15	12.50
2500	±10%	.15	12.50

*On mounting block

WIRE • WRITE • PHONE • CABLE • COME IN



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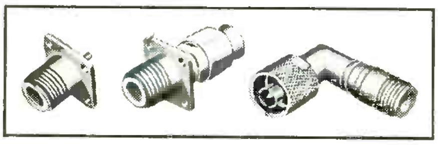

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ELECTRONIC, TELEVISION & RADIO COMPONENTS

TEST EQUIPMENT

X Band Spectrum Analyzer 8500-9600 Mc., calibrated linear below cut-off attenuator, calibrated frequency meter, tuned mixer, 4 i.f. stages, 3 video stages overall gain 125 db., reg. power supply.

S Band Spectrum Analyzer 2700-3900 Mc., similar to above.

K Band Test Load, low power....$20.00

X Band Test Load, 50 watts, average power ½" x 1" waveguide. Sand load TS 108 ....$35.00

HI POWER X BAND TEST LOAD, dissipates 350 watts of average power for ⅝" x 1¼" waveguide, VSWR less than 1.15 bet. 7 and 10 KMC........$150.00

S Band Test Load TPS-55P/BT, 50 ohms $12.00

HI POWER S BAND TEST LOAD, dissipates 1000 watts of average power, for 1½" x 3" waveguide. Range 2500 to 3700 MC.

Dummy Load, DA-21/U, X Band, High Power Load, VSWR less than 1.15.7 to 10 KMC. Dissipates 280 watts average power.

Dummy Load, TS-338/U2, S Band, High Power Load, 2500 to 3700 mc. Dissipates 600 watts average power. For 1½" x 3" waveguide.

X Band VSWR TEST SET, TS-12/AP, complete with linear amplifier, direct reading VSWR meter, slotted wave guide with gear driven travelling probe, matched termination and various adapters, with carrying case.

X Band Pick-up Horn, AT-48/UP with coaxial fitting $10.00

X Band Below Cut-Off Wave Guide Attenuator, with calibrated dial, type N input connector, output connects to ½" x 1" wave guide $55.00

TS-62 X Band Echo Box with r.f. cable and pick-up antenna.

TS-33 X Band Frequency Meter, 8500-9600 Mcs. Crystal detector and 50 micro-amp. meter. Indicates Resonance. Connection for scope available.

TS-45A-APM-3 Signal Generator, 8700-9500 mc., 110 V. 60-800 cps.

30 MC I.F. STRIP, VIDEO, and AUDIO AMPLIFIER and 110 Volt 60-2600 cps POWER SUPPLY, Bandwidth 10 mc, new, part of SPR-2 Receiver.

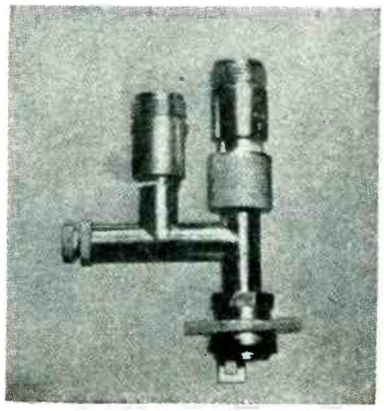
AMPLIFIER STRIP AM-SSA/SPR-2 contains I.F. amplifier, detector, video amplifier, pulse stretcher and audio amplifier and Rectifier Power Unit PP-155A/SPR-2 bandwidth 10 mc, center frequency 30 mc, sensitivity 50 microvolts for 10 milliwatts output. Power supply 80/115 V ac, 60-2600 cps 1.3 amps. Send for schematic...$65.00 less tubes

S Band Signal Generator Cavity With Cut-Off Attenuator, 2300-2950 mc., 2C40 tube, with modulator chassis....$30.00

UPN-1 S Band Beacon Receiver-Transmitter $75.00

TS-155 S BAND SIGNAL GENERATOR and Power Meter.

S Band Mixer, tunable by means of slider, type N connector for the R.F. and local oscillator input, U.H.F. connector for the I.F. output, variable oscillator injection. $30.00



S Band Crystal Mixer, variable oscillator injection, illustrated $17.50

TS-110 S Band Echo Box 2400-2700 mc, portable $110.00

X Band Thermistor Mounts, VSWR less than 1.4 8500-9600 MC Fixed triple tuned, ½"x1" waveguide.......$40.00
Fixed triple tuned ⅝"x1¼" waveguide $50.00

Frequency Meter, 8500-9600, variable, absorption type for either ½'x1" or ⅝"x 1¼" waveguide, with calibration, ± 4 MC, precision ground thread...$150.00

X Band Crystal Mount, ½"x1" waveguide $25.00

X Band Attenuator, double van type, VSWR less than 1.4 8500-9600 MC 0-30 db, calibrated for 1¼"x⅝" waveguide $80.00

½"x1" to ⅝"x1¼" adapter, UG80/U $5.00

TS-203/AP CALIBRATED SELSYN..$10.00

GENERAL RADIO PRECISION WAVEMETER TYPE 724A, range 16 kc to 50 mc. 0.25% accuracy, V.T.V.M. resonance indicator, complete with accessories and carrying case NEW... $175.00

HEWLETT - PACKARD - AUDIO SIGNAL GENERATOR 205A $230.00

ESTERLINE Angus recording Milliameter 60 cycles, 110V. AC 1 ma full scale. $150.00

TS-89 Voltage Divider for measuring high video pulses, ratios 1:10 and 1:100 transmission flat within 2 db 150 c.p.s. to 5 mc., with cable for attaching to syndroscope $30.00

Waveguide Below Cut-off Attenuator L 101-A U.H.F. Connectors at each end calibration 30-100 db $15.00

WAVEGUIDE BELOW CUT-OFF ATTENUATOR same as above except input is matched in range of 2200-3300 mc. VSWR less than 1.2............$54.00

PULSE TRANSFORMER 132-AWP...$8.00

HYPERSIL CORE CHOKE, 1 Henry, Westinghouse L-422031 or L 422-32....$3.00

PULSE INPUT TRANSFORMER, permalloy core, 50 to 4000 kc., WE-D161310, impedance ratio 120 to 2350 ohms..$3.00

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	Each
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.00025 mfd. 25000 VDC OIL FILLED	2.95
50 mmfd—5KV—5 AMP Vacuum Cond	1.19

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Brand New Transmitter for VHF $29.95

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A Transtat controlled rectifier to produce high voltage DC from a 110 VAC 60 cycle source. Up to 11,500 volts DC at 50 watts. Metered high voltage (0-15 KV) and current (0-20 MA) ....New $74.50

MISCELLANEOUS SPECIALS!

	Used	New
RA 10 DA Receiver	$17.50	$24.95
RT7/APN 1 Transceiver	6.95	9.95
BC 347 Interphone Amplifier	—	2.95
APS 13 UHF Antenna, Pair	—	.98
FL 8 Filter	—	2.95
I-97 Bias Meter	3.95	4.95
RL 42 Antenna Gearbox Motor and Reel	4.95	7.50
BC709 Battery operated lightweight interphone amplifier, Complete with tube and shock mount, but less battery	—	3.95
C-18—Antenna coil assembly slug tuned used in BC 603 receiver. Frequency range 20-27 .9 Mc.-fully shielded		New 10 for $1.95
I 82 F—Five Inch 360 degree compass indicator and Selsyn receiver	—	$4.95
A-81-2 Transmitter Selsyn for I82 indicator (Both I82F & Trans. Selsyn for $7.00)	—	2.45

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1625	$ .39	807	1.89
1626	.39	813	8.95
211	.59	837	1.19
805	3.29	860	4.95

CATHODE RAY TUBES

3FP7	$1.95	5BP4	3.95
3GP1	1.95	5FP7	1.95
4AP10	1.95	5GP1	3.95
5BP1	3.95		

AS-138/ARN

10 INCH STREAMLINE LOOP as used with direction finding receivers. Fixed position, is ideal for planes, boats, automobiles ....New $1.95

SCR 625 Famous Army Mine Detector

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TS/10

Sound powered phones—Brand New
$10.00 ea.   2 for $17.95

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No. M-652 Jackson Audio Oscillator	used	$29.50
No. 155 A RCA Oscilloscope	used	75.00
No. M-840 Triumph Oscilloscope	used	39.95

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I-98-A	TS3/AP
I-114 P/O RC-68	TS10A/APN
I-135 P/O IE-17	TS16/APN
I-167 Weston Anal. =772	TS19/APQ5
I-183 Freq. Meter	TS27/TSM-1
I-185 Oscillator	TS36/AP
I-187 Synchronizer	TS59/APN-1
I-189 Calibrator	TS62/AP
IE-19	TS126/AP
	TS-251 Less Xtal

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Complete Line!

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TS-36/AP	TS-102A/AP
TS-108	TS-184A/AP

1-77 HICKOK TUBE CHECKER

UPM-1 COMPLETE TS-250/APN

BC-221 FREQUENCY METER

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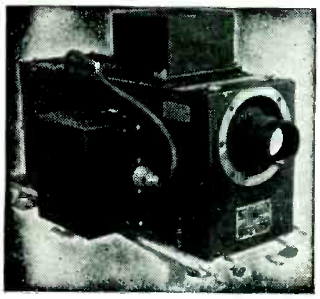
FERRIS MICROVOLTER MOD. 188

TS-111/CP	I-212
TS-117/GP	TS-5/AP
TS-3/AP	TS-19/APQ-5
TS-100/AP	TS-61/AP
TS-170/ARN-5	TS-10B/APN
TS-182/UP	TS-375 U
TS-127/U	TS-15A/AP

TELEVISION CAMERA



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BC-1100-A TRANSMITTER WITH REMOTE CONTROL. 125 W. 115 VDC OR AC.

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BC-348	ART-13
BC-611	ARC-1
RTA-1B	ARC-3
BC-1000	R5A/ARN7

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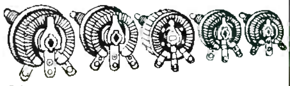


Ohms	watt	ea.	Ohms	watt	ea.
.5	25	1.24	200	25	1.24
.5	50	2.34	200	100	3.29
.5	150	4.45	225	50	2.10
1	50	2.34	250	25	1.86
2	50	2.34	250	50	1.49
2	100	3.51	300	50	2.11
2	225	4.95	300	100	3.29
2	300	6.32	350	25	1.24
3	100	3.51	350	100	3.28
3	225	4.95	370	25	1.24
3 x 3	300	29.70	378	150	4.95
4	225	4.95	400	25	1.24
5	25	1.24	400	75	2.95
5	100	3.51	500	25	1.24
6	25	1.86	500	75	2.95
6	50	2.10	500	50	1.49
6	75	2.95	500	100	3.29
7	25	1.24	500	150	3.51
8	50	1.49	585	150	4.95
10	25	1.86	750	25	1.86
10	100	3.28	750	150	4.45
12	25	1.86	1000	25	1.24
12	50	1.49	1000	150	4.45
15	25	1.24	1200	225	5.40
15	75	2.95	1250	50	2.22
22	50	2.10	1250	150	4.45
25	25	1.86	1500	25	2.11
25	100	3.29	1500	50	2.22
25	150	4.21	1800	150	4.68
50	25	1.24	2000	25	2.10
50	50	1.49	2000	50	1.49
60	25	1.24	2250	150	4.95
75	25	1.24	2500	150	4.95
75	75	2.95	2500	25	2.11
75	100	3.29	2500	50	2.22
75	150	4.21	2500	100	3.51
80	50	2.10	3000	25	1.24
80	500	9.13	3000	100	3.51
100	25	1.24	5000	25	2.22
100	50	1.49	5000	50	2.34
100	100	3.29	5000	100	3.75
125	25	1.86	7500	50	2.34
125	500	9.13	7500	100	3.98
150	50	2.10	10000	50	2.34
			10000	100	4.21
175	25	1.87	15000	25	2.67
185	25	1.24	20000	150	6.32

Specify whether shaft required is for knob or screwdriver adjust.

SELECTOR SWITCHES

Pole	Pos.	Deck	Type	Each
1	11	1	Bak-n/shtg	.60
1	21	3	Bak-n/shtg	.89
2	2	1	Cer-shtg	.50
2	6	2	bak-n/shtg	.60
2	11	2	bak-shtg	.75
3	4	2	bak-n/shtg	.58
5	8	2	Cer-n/shtg	.98
6	11	6	bak-n/shtg	1.95
10	5	5	cer-shtg	2.25
16	2	4	bak-n/shtg	1.35

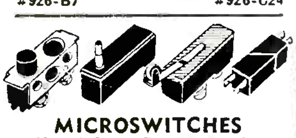
(Many other types in stock)

"AN" CONNECTORS

Large Variety Available
At Great Savings
Send your specs and let us quote

BIRTCHER TUBE CLAMPS

#926-A	**35c.**	#926-B22
#926-A1		#926-C
#926-A14		#926-C1
#926-B		#926-C5
#926-B1		#926-C10
#926-B7		#926-C24



MICROSWITCHES

A-#Y2-RS13 SPST "S" plunger, metal housing norm. op. .... .59
B-#B-RS10 SPDT type "S" plunger, 2-circuits: one op and one cl .59
#WZ-RL8 (not illus.) SPST leaf actuator, norm. cl. .... .59
#R-RL2T (not illus.) SPST 10a 125 vac roller plunger, norm. closed .... .59
C.G.E. SWITCHETTE 10a/115voltsAC
#CR1070-C103A3 SPST closed .. .59
#CR1070-C103E3 SPST open .... .59
#CR1070-C103R3 SPST closed .. .59
#CR1070-C123C3 DPST op/cl ... .59
(Many other types in stock)

OIL CONDENSERS

Mfd.	Voltages Avail.
.1	3-6-20K
.25	2-3-3½-4-5K
.5	600-1½-3K
1	600-1-1½-2-5-6
2	400-600-1-1½-2 3-4K
4	600-700-1-1½K
6	400-600-1½-2K
8	600
10	600-2½K
15	600-1K
30	90-vac. 3-ph
100	230-vac, 3-ph
3x4	500
3x8	600
4x3	600
4x8	600
3x10	90-vac

Special Prices on Request

BATHTUBS

Mfd.	Voltages Avail.
.033	400
.05	2-4-600
.1	4-6-1K
.15	600
.25	2-4-600
.35	400
.5	4-6-1K
.75	600
1	1-2-4-6-1K
2	4-600
4	50-100
8	500
25	25-50-75
40	25
50	25
100	15
200	12
300	6
2x.01	2-400
2x.02	6-1500
2x.045	600
.046x.055	600
.2x.05	6-1500
.1x.05	200
.1x.5	400x50
2x.1	4-600
2x.16	600
2x.2	600
2x.25	4-600
.3x.5	500
2x.5	4-600
1.x.05	500
1.x.1	300
1.x.5	200
2x1	600
2x10	25
2x200	9
3x.001	600
3x.05	600
3x.1	4-600
3x.25	4-600
3x.5	100-600
.015x.03x.045x.06x.12/ 600	

Also available CHANNEL Types. Special Prices on request.

SHOCKMOUNTS

100P-1.....	1 lb.	.15
100P2......	2 lb.	.15
100PR-2...	2 lb.	.15
100P-3.....	3 lb.	.15
100P-6.....	6 lb.	.20
150P-4.....	4 lb.	.20
150PH-8...	8 lb.	.45
150PH-15..	15 lb.	.49
156P-6.....	6 lb.	.35
200PD-15..	15 lb.	.59
200PHN-35	35 lb.	.75
204P-112...	112 lb.	.98

TERMINAL BOARDS

5 terminal ...... .98
8 terminal 1.67
12 terminal 2.49

TYPE "J" POTENTIOMETERS

TYPE "J" $1.50 ohms	ohms	ohms	TYPE "JJ" $2.50 ohms	ohms
50*	2500*	100K*	500-500*†	130 K-130K*
65*†	4000†	100 K†	600-600†	150 K-150K†
200†	5000†	125 K*	1500-1500†	250 K-250K†
300†	10 K*†	200 K†	2000-2000*†	350K-5K†
400*†	15 K*†	250 K*	2000-50K*	350K-25K†
500†	20 K*†	250 K†	2200-24K†	300K-300K†
600*†	25 K*†	500k*†	20K-2000†	350K-350K*
750†	50 K*†	1meg*	25K-10K†	800K-75K*
1000*†	50K*†	1meg†	35K-5000†	2meg-2meg†
1500*†	80K†	2meg*	50K-50K*	4meg-4meg†
2000*†		2meg†	100K-100K*	5meg-5meg†

TYPE "JJJ" $4.95

ohms	ohms
20K-200K-20K†	750K-750K-750K†
45K-27K-2500†	800K-800K-800K†
700K-700K-700K†	1meg-1meg-1meg†

* ⅜" screwdriver slotted shaft.
† Knob type shaft.

TRANSMITTING MICAS

mfd.	wv	type	ea.	mfd.	wv	type	ea.
.00001	600	4	.36	.0015	600	4	.36
.00003	600	4	.36	.00162	600	4	.42
.00005	600	4	.29	.002	600	4	.39
.00005	2500	9	.57	.002	1200	4	.72
.0001	600	4	.29	.0025	600	4	.39
.0001	2500	9	.57	.003	600	4	.43
.00015	600	4	.36	.004	600	4	.45
.0002	600	4	.29	.005	1200	9	.99
.00025	600	4	.29	.0047	600	4	.47
.0005	600	4	.29	.005	2500	9	1.86
.0005	2500	4	.75	.006	600	4	.54
.0005	2500	9	.77	.01	600	4	.65
.0006	2500	9	.85	.01	1200	9	1.41
.0007	600	4	.36	.02	600	4	.92
.00075	600	4	.36	.02	1250	9	2.12
.0008	600	4	.36	.025	600	4	1.08
.0009	600	4	.36	.03	300	4	.99
.001	600	4	.36	.03	600	4	1.34
.001	1200	4	.54	.043	600	4	1.75
.001	1200	9	.57	.05	300	4	1.19

(Many other sizes in stock)

"UG" and "UHF" CONNECTORS

UG-9/U	UG-25/U	83-1AP
UG-10/U	UG-27/U	83-1RTY
UG-12/U	UG-27/AU	83-1SP
UG-14/U	UG-57/U	83-1R
UG-15/U	UG-58/U	83-1D
UG-16/U	UG-88/U	83-1SPN
UG-18/U	UG-123/U	83-22R
UG-19/U	UG-185/U	83-22SP
UG-20/U	UG-260/U	83-2R
UG-21/U	UG-290/U	83-2SP
UG-21B/U	83-1AC	
UG-22/U	83-1F	
UG-24/U	83-1J	

PRICES QUOTED ON REQUEST

Jones Connectors

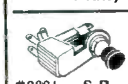
P-101-¼	.25
P-101-⅜	.30
S-101-D-MOD	.33
S-302-AB	.13
S-304-CCT	.25
P-306-AB	.16
P-306-CCT-L	.33
S-306-FHT	.24
S-308-AB	.21
P-312-AB	.24
P-312-CCT-L	.42
P-315-FHT	.40
P-315-EB	.30
P-315-CCE	.40
S-315-AB	.36
S-318-AB	.43
P-324-FHT	.74
P-324-EB	.58
S-330-AB	.84
S-404-AB	.33
P-406-AB	.33
S-406-CCT	.58
S-408-CCT	.69
S-2408-SB	.53
P-2412-SB	.61
S-2412-CCE	.87
S-502-DB	.97
P-508-CE	2.55
P-510-CE	3.04
P-512-CE	3.52
S-512-CE	3.95

Jones BARRIER STRIPS

2-140-Y	.13
6-140-Y	.33
10-140-¾W	.53
10-240	.38
13-140	.48
18-240	.66
4-141-W	.30
4-141-¾W	.30
7-141-Y	.49
11-141-Y	.76
12-141-Y	.82
13-141-Y	.89
15-141-Y	1.02
2-142-Y	.20
4-142-Y	.36
8-142	.48
3-150	.53
4-150-Y	.83
4-151	1.30
5-151	1.60
4-152	1.89
2002	.04
2008	.07
8-54	.22
8-6	.18

Many other types in stock

MALLORY PUSH SWITCH



#2001	S.P., make cont., non-L.	.45
#2003	S.P.D.T., non-lock	.48
#2003L	S.P.D.T., lock	.48
#2004	D.P., make 2 non-L	.55
#2004L	D.P., make 2 lock	.55
#2006	D.P.D.T., non-lock	.65

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- **BC-375 Transmitters**, Complete with tuning units, plugs, dynamotor, mountings, microphones. Export packed.......LIKE NEW $ 89.50
- **Mine Detector SCR625** for locating metal underground pipes, prospecting, etc. With manuals ..USED $39.50..NEW 69.50
- **BC-464 Target Receiver**—5 channel remote, sensitive relays, battery case, antenna—68-73MC. .... BRAND NEW 14.95
- **APR5AX Receiver** ....LIKE NEW 250.00
- **RU-19 Receivers**—Complete ....NEW 29.50
- **RA-10 Bendix Compass Receiver**.LIKE NEW 19.50
- **BC-640 Transmitter**—50 watt rack type—Same frequency as SCR-522........GOOD 695.00
- **Crystal and coil sets for Handy-Talkie**—3885, 4280, 4840, 5327.5, 5437.5, 5500 KC. 2 crystals and 2 coils per set..........SET 1.95
- **APN-1 Altimeter Indicator**, basic movement 0-1 ma., 5 ma. shunt. 250° dial. An excellent movement for constructing meters. NEW 1.95
- **HS-23 Hi Imp Headset**...........NEW 3.95
- **HS-33 Lo Imp Headset**...........NEW 4.95
- **Sound Powered Head & Chest Sets**—Manufactured by U. S. Instrument Co. EXCELLENT USED..$4.95 Each;..PAIR 8.50 FAIR USED ....2.95 Each;..PAIR 5.00
- **Teletype Paper**—8½" wide x 3½" dia. Rolls—White—Single .... .50
- **BC-1060 Oscillograph**—Same as DuMont #224 ....LIKE NEW 150.00
- **TS-224 DuMont Oscillograph**..GOOD USED 125.00
- **Insulation Tester**—Superior Model 610B, 200 megohms. Complete ....NEW 39.00
- **I-100A Test Set** for ARN-7 and 269 compass ....LIKE NEW 595.00
- **IE-19A Test Set** for SCR-522 Complete with manual, original factory packing....NEW 325.00
- **LM Frequency Meter** with calibration books, crystal, tubes ....EXCELLENT 79.50
- **BC-221 Frequency Meters**. Complete with calibration books, crystal, tubes EXCELLENT 79.50
- **TS-16/APN Test Set**....GOOD CONDITION 47.50
- **Standard Signal Generator** — Measurements Corp. Model 78-B 15-25MC. 190-230MC. EXCELLENT 89.50
- **Tube Checker**—Model CHI-60067—115V. 60 cycles ....EXCELLENT 39.50
- **Sweep Generator**—Model M for AN/APG13. Made by M.I.T. Radiation Laboratory EXCELLENT 49.50
- **Weston Model 506 Voltmeter** 0-20,000 volts with 4 Model 505 multipliers........NEW 39.50
- **LU-1 Radar Test Set**...............NEW 49.50
- **BC-906 Frequency Meter**......EXCELLENT 14.50
- **Matching Transformer** for HS-30......NEW .40
- **Weston Electrical Tachometer Model 545** for use with 724 Generator 0-2000RPM Ratio 2:1 0-5 M. A. ....NEW 14.50
- **TS-24A/ARR2 Test Oscillator**..EXCELLENT 19.50
- **Engine Cylinder Thermometer Tester**—Wheelco Inst. Co. Iron-Constantan, Copper Constantan, Chromel-Alumel 0-1400°C EXCELLENT 69.50
- **Engine Cylinder Thermometer Tester**—Mark II Wheelco Inst. Co. Iron-Constantan, Copper-Constantan 0-350°C .....EXCELLENT 49.50
- **Output Meter CWI 60ABJ** 115V. 60 cycles. P.O. ASB Radar with manual EXCELLENT 29.50
- **Delco Motor**—27 volts 2-4 amps—3600 RPM Constant Speed. Model A-7155 Governor Type Shunt ....NEW 4.95
- **RA-62 Rectifier Power Supply** for SCR-522 115V. A.C. ....EXCELLENT 120.00
- **PE-73 Dynamo Power Supply** for BC-375 1000V. D.C. Output. EXCELLENT....... 5.95
- **FL-8 Range Filters**..................NEW 1.95
- **BC-709 Interphone Amplifier**, tubes, battery operated ....NEW 3.95
- **Transformer**—High voltage, General Electric No. 6949101, Single phase. Plate 15,550 volts—5.2KVA. Input 115 volts 50/60 cycles. Filament 5V.-.065KVA. Input 60cy. 100V. ....EXCELLENT COND. 50.50
- **Variac**—General Radio Type 50A 115V. 60 cycles—5KVA. .....EXCELLENT COND. 95.00
- **Selsyn Transmitter**—Pioneer Inst. AY 14 excellent for indicator...EXCELLENT 3.50
- **Low Inertia Motor** Type No. 10047 2A 24 volt—Pioneer Inst. Precision Type.... 2.50
- **Onan Motor Generator Set MG G-1** Generates 115V. AC 5.3 amps, 26 D.C. 100 watts, 480 cycles 3.8 amps., Motor 115-230V. 60 cycles. Single phase, 2450 RPM 10.5 amps NEW 170.00
- **PE-94 Dynamotor** Power Supply for SCR-522 USED ....$3.50; NEW 5.50
- **PE-206 Inverter** 800 cycles — Will power APN4 and APN9 24V. D.C. Input: NEW ....$6.95; USED 3.95

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WE NEED TUBES 304TL, 250TH, 810, 811, 813, 814, 815, etc.

WE WILL BUY YOUR EXCESS NEW TUBES IN QUANTITY. PLEASE LIST EQUIPMENT, EXACT HONEST CONDITION, AND YOUR LOWEST PRICE.

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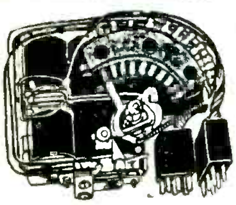
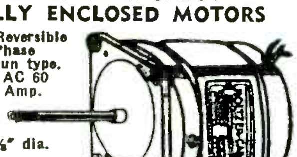
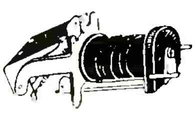


Automatic Electric 2 Decks 10 Points TELEPHONE RELAY 24 Volts D.C. $11.00

NEW HOLTZER-CABOT TOTALLY ENCLOSED MOTORS



50 R.P.M. Reversible Single Phase Capacitor-Run type. 115 Volts AC 60 cycle 0.3 Amp. Torque 100 oz. inches. 4¾" shaft ⅜" dia. $17.50 each



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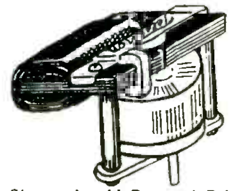
HOLTZER-CABOT M.G. 218. CONVERTER 400 CYCLE 110V A.C. 1 AMP ¼ H.P. D.C. 110V MOTOR $49.50

WE 24 & 12 volt Telephone lamp...doz. $1.50
CH 4 pole 35 ampere 115v. AC relay. $4.90
GE 3 ampere Mercury Switch ½" glass tube....3 for $2.50

Genuine TELECHRON Motors



2 RPM $2.90
3.6 RPM 3.15
1 RPM 3.95
60 RPM 4.30
One of Each $12.00

Stevens-Arnold Resonant Relay. Only two types in stock. 442 and 240 CPS either one..... $4.50
Both for $8.00

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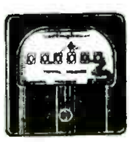
ISOLATION TRANSFORMER $1.95 Nat. known Mfgrs. 50 watt 2 windings, 115 V. to 115 V. 60 cy. Ideal to prevent shocks from small radios and medical and electronic devices.

ELAPSED TIME METERS $15.50



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450 ea.—AN/CRW 2 RECEIVERS with 3—6SL7; 1—6SN7; 1—6SG7; 1—6J5; plus Dynamotor DM 32; compensating relays and numerous condensers, resistors, chokes, etc., etc., **Each—$7.50**

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1000 each BRAND NEW DM 32A DYNAMOTORS— **Each—$8.50**

2000 ea.—CD318A—CORD assembly, 7' length, with SW141 switch plus JK48 jack and PL68 plug **Each—56 cents**

300 ea. CD605 cord assembly with PL55 plug and C410 xformer **Each—56 cents**

2000 ea. GE SELENIUM Rectifiers 2 plates 1" sq., input 12V a/c output 6V DC—150 m.a. **Each—49 cents**

1000 ea. UTC Transformers, subouncer Type SO-4. Pri 30,000 ohms, sec. 50 ohms. 1 ma winding, wt. 1/3 oz. **Each—$1.29**

5000 ea. Min. Sensitivity Control Wirt #WC 807—2 to 15 ohms. **Each—6 cents**

TUBES Standard Brand—Ind. Boxed.

OZ-4	.72	117Z3	.72
35L6	.82	6SN7	1.25

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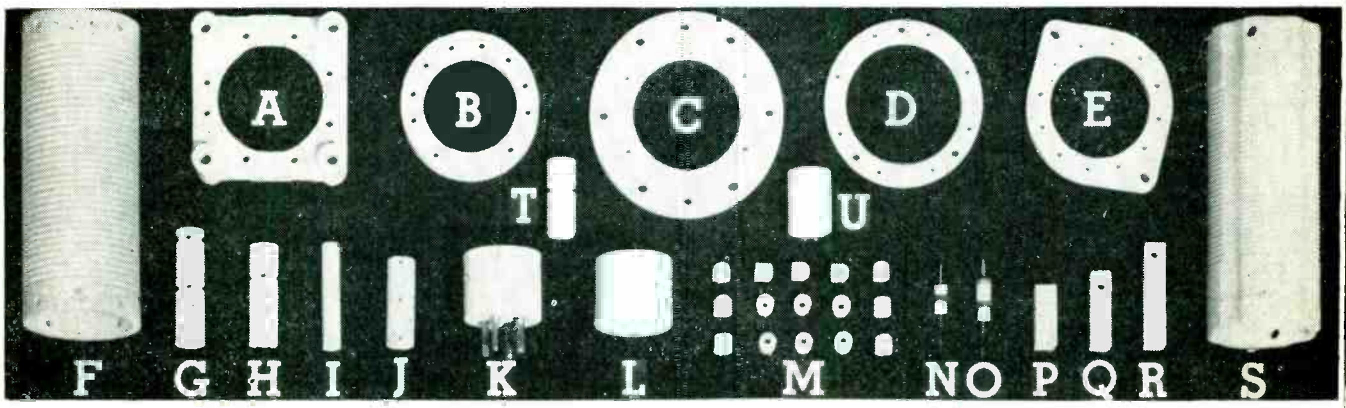

TYPES A,B,C,D,E BASES FOR VARIOUS TUBE SOCKETS YOUR CHOICE .05
F - COIL FORMS 2" DIA 4-7/8" LONG. 35 GROOVES - - - - - - - - .10
G - STANDOFF INS. 1/2" x 2 7/8" THREADED HOLE ONE END - - - - - .02
H - STANDOFF INS. 1/2" X 1 5/8" AND 1/2 X 2" THREADED HOLE BOTH ENDS .02
I - INSULATED SPACERS 5/16" X 1 3/4" THREADED HOLE BOTH ENDS - .015
J - COIL FORMS 1/2" X 1 1/2" 28 GROOVES - HOLLOW - - - - - - - .02
K - 4 PRONG TUBE BASES - STANDARD - - - - - - - - - - - - - .10
L - 4 PRONG TUBE BASES LESS ALL PINS - - - - - - - - - - - - .05
M - COAXIAL BEADS 5/16 X 3/8" - 1/8" HOLE (PER 1000) - 1.50
N - HIGH VOLTAGE FEED THRU INSULATORS 1/2" LONG 1 1/2" OVERALL - .02
O - HIGH VOLTAGE FEED THRU INSULATORS 3/4" LONG 1 5/8" OVERALL - .03
P - SQUARE INSULATED SPACERS 3/8" X 1" THREADED BOTH ENDS - .02
Q - SQUARE INSULATED SPACERS 3/8" X 1 1/4" THREADED ONE END - - .02
R - SQUARE INSULATED SPACERS 3/8" X 1 3/4" THREADED ONE END - - .02

S - THREADED COIL FORMS
YOUR CHOICE **10¢** EACH

Dia.	No. of Ribs	Winding Length	Overall Length
2"	9	1-3/4"	5"
2"	14	1-3/8"	5"
2"	6	1"	5"
2"	34	1-7/8"	5"
2"	11	1"	5"
2"	13	2-1/2"	5"
2"	9	1-5/8"	5"
2"	15	1-3/4"	6-3/8"
3"	55	4-1/2"	5-1/4"

SEND FOR OUR LATEST BULLETIN ON CURRENT SPECIALS

T - ROUND INSULATED SPACERS 1/2" X 1 1/4" THREADED BOTH ENDS - .02
U - ROUND INSULATED SPACERS 3/4" X 1" THREADED BOTH ENDS - .03

SAMPLES SENT TO BONA-FIDE MFG. ONLY
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1 .01 MFD—1200v. DCW. .45 ea.
2 .003 MFD—2500v. DCW .45 ea.
3 .0011 MFD—5,000v. .. 2.00 ea.
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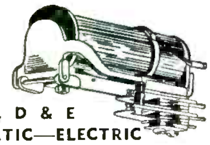
2x.05 MFD 600v. TT	.30	.5 MFD 400v. ST	.25
.25 MFD 600v. TT	.25	.5 MFD 600v. TT	.30
2x.25 MFD 600v. TT	.35	1.0 MFD 400v. ST	.30
.25 MFD 1,000v. ST	.45	1.0 MFD 600v. TT	.40

UPRIGHT CONDENSERS

.1 MFD 600v. TT	.25	1.0 MFD 1,000v.	.45
1.0 MFD 600v. TT	.35	1.5 MFD 330v. AC	.40

2X2 Low Loss Tube Sockets .19

TELEPHONE RELAYS



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"3102"
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TYPE	OUR PRICE	TYPE	OUR PRICE	TYPE	OUR PRICE	TYPE	OUR PRICE
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1A5GT	0.70	6B8G	0.93	6SK7GT	1.04	VR150/30	1.00
1G6GT	0.72	6BE6	1.20	6SN7GT	1.50	2E22	2.50
1LN5	0.90	6C4	0.95	6SS7	1.05	3AP1	8.75
1R5	1.60	6C5GT	0.51	7Q7	0.80	6C21	30.00
1S4	0.96	6C6	0.85	12A6	0.48	357A	22.50
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5U4G	1.40	6H6	1.04	12SH7	0.96	805	2.90
5V4G	1.58	6J5	0.86	12SK7	0.98	807	1.59
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6AC7	1.65	6K6GT	0.91	12SR7	0.90	813	7.00
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Variable output 0-15,000 v. d-c @ 500 mils. Input 115 v. 60 cy. SP. Army type RA-38. Size 63½" x 53¾" x 56⅞". Wt. 2040 lbs. Units are new, complete with spare tubes and remote control. Write for detailed information.

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2 for $22.50—4 for $40.00

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2x.15 mfd., @ 8000 v. or .075 mfd. @ 16,000 v. Vitamin Q........ $2.90

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Meter only, less multiplier........ $ 4.95
Ammeter, a-c 3" Westinghouse NA-35 or Weston Model 476, 3 amps, f.s. deflection; scale calibrated 0-120, includes doughnut type current transformer w/200-5 ratio at 25-133 cy. $8.50

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.0001 @ 5000 V. .... 49¢ each
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These excellent controls were made to sell for $2 each. They are the finest ww potentiometers made in the two and four watt size. The four watt has a 1-9/16" dia. x 11/16" metal body. The two watt has a 1-¼" x 9/16" bakelite body. Both use DUAL wipers for extra quiet action. SPECIAL PRICE ....$.45

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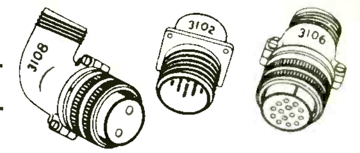
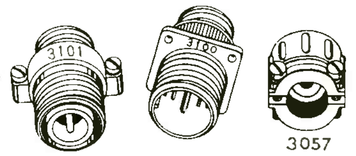


3100, 3101, 3102, 3106, 3108 with any of following suffixes:



Insert	14S-12P	18-8P	20-9S	22-5P	22-29P	28-3P	32-9P
	16S-1S	18-9S	20-9P	22-6S	22-30S	28-4S	32-10S
8S-1S	16S-1P	18-9P	20-10S	22-6P	22-30P	28-4P	32-10P
88-1P	16-2P	18-10S	20-11S	22-8S	22-36S	28-5S	32-16S
10S-2S	16S-3S	18-10P	20-11P	22-8P	24-1S	28-5P	32-16P
10S-2P	16S-3P	18-11S	20-13S	22-9S	24-1P	28-6S	32-20S
10SL-3S	16S-4S	18-11P	20-14S	22-9P	24-2S	28-6P	32-20P
10SL-3P	16S-4P	18-12S	20-14P	22-10S	24-2P	28-7S	36-1S
10SL-4S	16S-5S	18-12P	20-15S	22-10P	24-3S	28-7P	36-1P
10SL-4P	16S-5P	18-13S	20-15P	22-11S	24-3P	28-8S	36-3P
12S-3S	16S-6S	18-13P	20-16P	22-11P	24-4S	28-8P	36-7S
12S-3P	16S-6P	18-16S	20-17P	22-12S	24-4P	28-9S	36-7P
12S-4S	16-7S	18-16P	20-18P	22-12P	24-5S	29-9P	36-8S
12S-4P	16-7P	18-20S	20-19S	22-13S	24-5P	28-11S	36-9P
12-5S	16S-8S	18-20P	20-19P	22-13P	24-7P	28-11P	36-10S
12-5P	16S-8P	18-22S	20-20S	22-14S	24-9S	28-12S	36-10P
14S-1S	16-9S	18-22P	20-21P	22-14P	24-9P	28-12P	36-11P
14S-1P	16-9P	18-30S	20-22S	22-15S	24-10S	28-15S	36-15S
14S-2S	16-10S	18-30P	20-22P	22-15P	24-10P	28-15P	36-15P
14S-2P	16-10P	18-31S	20-23S	22-16S	24-11S	28-16S	36-19S
14-3S	16-11S	18-31P	20-23P	22-16P	24-11P	28-17S	40-1S
14-3P	16-11P	20-1S	20-24S	22-17S	24-12S	28-17P	40-1P
14S-4S	16-12S	20-1P	20-24P	22-17P	24-14S	28-18S	40-2P
14S-4P	16-12P	20-2S	20-26S	22-18S	24-14P	28-18P	40-9S
14S-5S	18-1S	20-2P	20-26P	22-18P	24-15S	28-19S	40-11S
14S-5P	18-1P	20-3S	20-27S	22-21S	24-15P	28-19P	44-1S
14S-6S	18-2S	20-3P	20-27P	22-22S	24-16S	28-20S	44-1P
14S-6P	18-2P	20-4S	20-28S	22-22P	24-16P	28-20P	44-4S
14S-7S	18-3S	20-4P	20-28P	22-23S	24-17S	32-1S	44-4P
14S-7P	18-3P	20-5S	20-29S	22-23P	24-18P	32-1P	44-9S
14S-9S	18-4S	20-5P	22-1S	22-24S	24-19P	32-6S	48-3S
14S-9P	18-4P	20-6S	22-1P	22-25S	24-20P	32-6P	
14S-10S	18-5S	20-6P	22-2S	22-25P	24-21S	32-7S	3057-3,
14S-10P	18-5P	20-7S	22-3S	22-26S	24-28S	32-7P	4, 6, 8,
14S-11S	18-6S	20-7P	22-4S	22-26P	28-2S	32-8S	10, 12,
14S-11P	18-6P	20-8S	22-4P	22-27S	28-2P	32-8P	16, 20,
14S-12S	18-8S	20-8P	22-5S	22-27P	28-3S	32-9S	24.

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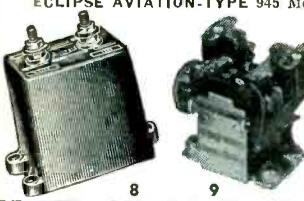

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Full-Wave Bridge

UP TO 18 VOLTS AC INPUT
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2 Amps....$2.50 8 Amps....$6.00
4 Amps.... 4.00 12 Amps.... 8.00

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Full Wave C.T., 3φ, Volt. DBLR, and ½ Wave Types
Special rectifiers made to order
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LOW FREQUENCY SQUARE WAVE GENERATOR

$14.95

Fundamental range—10 to 30 cycles

Wave shape perfect steep sided & flat topped. This device is the answer to the problem of securing perfect low frequency square waves for testing the low frequency response of video and audio amplifiers.

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VR-150	1.05	394-A	4.50
1B38	30.00	5BP1	4.50
1LC6	1.15	5CP1	4.25
ILH4	1.15	6SJ7	1.50
307-A	4.95	707-B	22.50

ARCBY ELECTRONICS
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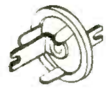
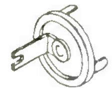
Louisville, Ky.

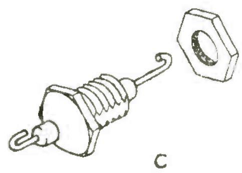
CERAMIC FEED THRU CAPACITORS



A



B



C

Type A—300 mmf—100 for $20.00
Type B—300 mmf—100 for $20.00
Type C— 55 mmf—100 for $10.00

ELECTRO IMPULSE LABORATORY
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LAE	TS14	TS100	TS239
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1222	TS34A/AP	TS173/UR	TS323
TS3/AP	TS35	TS174	TSK-4SE
TS12	TS36	TS175	TSS-4SE
TS13	TS47APR	TS195	TSX-4SE

We will also purchase Rad-Lab equipment, GR, Ferris, Boonton, Stoddart, Dolittle, Hewlett-Packard, etc. Prompt replies assured.

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Weston 93, Massachusetts

1951 TUBE HQ

2E24	$ 3.95	RK65	24.95
2J26	5.00	7JP4	$ 18.50
2J36	89.95	10BP4	24.00
2J48	13.50	12LP4A	25.00
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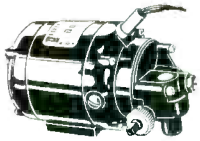

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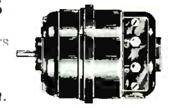

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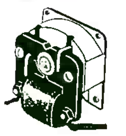

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5Z3	1.09	6L6G	3.15	12A5	1.39	26	.79	FG166	49.00	805	4.98
5Z4	1.35	6L6GA	2.98	12A6	.98	27	.75	FG172	42.50	807	1.98
C6A	7.45	6L7	1.15	12A7	1.39	FG27A	8.70	182B	1.20	808	2.39
6A3	1.65	6N4	2.39	12A8GT	.89	RK28A	6.95	FG190	12.80	809	2.45
6A4	1.89	6N6G	1.95	12AH7GT	2.15	28D7	1.39	200	22.98	810	11.96
6A5G	2.30	6N7GT	1.26	12AL5	1.11	30	.89	203A	5.98	811	3.25
6A6	.98	6P5GT	.98	12AT6	.83	31	.59	205B/VT2	1.69	812	3.95
6A7	1.39	6Q7	.98	12AT7	1.61	HY31Z	2.75	CE206	3.15	813	11.75
6A8GT	1.05	6R7	.98	12AU6	1.11	32	.49	211/VT4C	1.89	814	3.95
6AB4	1.39	6R8	1.39	12AU7	1.44	FG32	7.90	RX215	9.95	815	3.98
6AB5/6N5	1.33	6S4	.98	12AV6	.83	32L7GT	1.69	WE215A	.15	816/866Jr.	1.29
6AB7/1853	1.42	6S7	.98	12AV7	1.78	FG33	18.98	227A	2.65	826	.98
6AC5GT	1.19	6S8GT	1.65	12AW6	1.75	33	.59	231	1.20	SD828	.98
6AC7	1.61	6SA7GT	1.19	12AX7	1.45	34	.79	242C	7.20	829	12.98
6AD7	1.60	6SB7Y	1.20	12AY7	5.95	35/51	1.00	244A	4.15	829B	14.98
6AE5	.89	6SC7	1.45	12BA6	1.00	35A5	.95	247A	9.95	832	10.98
6AE6G	.79	6SD7GT	1.19	12BA7	1.75	35B5	1.11	249B	3.75	832A	12.98
6AF5G	.89	6SF5	.98	12BD6	1.75	35C5	1.11	250TH	21.29	833A	48.90
6AF6G	1.33	6SF7	.98	12BE6	1.00	35D5	1.11	250TL	21.29	836	4.98
6AG5	1.47	6SG7	1.45	12BF6	.85	35L6GT	1.00	HK254	15.49	837	1.39
6AG7	1.98	6SH7GT	1.07	12BH7	1.33	35TG	4.95	262A	3.98	838	3.98
6AH5G	1.49	6SJ7	1.19	12C8	1.39	35W4	.69	262B	3.98	842	2.75
6AH6	2.17	6SK7GT	1.19	12F5	.75	35Y4	.87	271A	9.95	843	.39
6AJ5	1.49	6SL7GT	1.25	12H6	.89	35Z3	.90	274B/5R4	1.50	845	5.95
6AK5	1.98	6SN7GT	1.22	12J5GT	.73	35Z4GT	.75	282B	8.49	851	60.00
						35Z5GT	.90	300	27.50	860	12.98
						REL36/6J4	.50	304TH	24.98	861	49.95
						36	.65	304TL	24.98	864	.38
						37	.69	307A/RK75	6.45	865	1.39
						38	.69			866A	1.75
						39/44	.69	310A	6.98	869	25.98
						CRC40	.54	316A	2.98	872A	2.45
						41	.79	323B	12.25	GE872A	4.98
						42	.79	327A	2.50	873	15.98

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6AK6	1.98	6SN7WGT	1.90	12J7GT	1.00	43	.85	350A	8.95	874	1.39
6AL5	1.05	6SQ7GT	.98	12K7GT	.98	45	.98	350B	5.95	878	1.95
6AL7GT	1.89	6SR7	1.08	12K8	1.07	45S/VT52	.69	354A	24.98	884/6Q5G	1.80
6AN5	5.95	6SS7	.90	12Q7GT	.90	45Z3	.89	355A	14.15	885	1.80
6AQ5	1.11	6ST7	1.33	12S8GT	.98	45Z5	.90	HK357C	39.49	893A	250.00
6AQ6	1.25	6SU7GTY	3.37	12SA7GT	1.05	46	.99	367A	3.98	922	.98
6AQ7GT	1.23	6SZ7	1.05	12SC7	1.39	47	.89	368AS	7.95	923	1.75
6AR5	.91	6T7G	.98	12SF5GT	.75	48	3.90	371B	.98	927/CE25	1.00
6AR6	5.49	6T8	2.45	12SF7GT	.69	RK48A	14.85	380A	.79	929	1.33
6AS5	1.39	6U4GT	.95	12SG7	.89	49	.83	388A	2.69	930	1.05
6AS6	2.49	6U5 6G5	.98	12SH7	1.10	50	1.19	393A	9.95	931A	4.98
6AS7G	4.98	6U6GT	1.05	12SJ7GT	.89	EF50	.98	394A	4.90	HK953E	78.00
6AT6	.83	6U7G	.79	12SK7	1.25	50A5	1.22	393A	4.98	954	.25
6AU5GT	1.47	6V6	2.25	12SL7GT	1.07	50B5	1.11	394A	4.98	955	.49
6AU6	1.11	6V6GT	1.25	12SN7GT	1.22	50C5	1.03	X400	14.98	956	.39
6AV5GT	1.47	6V6GTY	1.65	12SQ7GT	.91	50C6	1.49	WL414	63.95	957	.39
6AV6	.83	6V7G	1.18	12SR7	.98	50L6GT	.94	417A	9.49	958A	.98
6AW6	1.98	6W4GT	1.08	12X3	.90	50X6	1.10	GL434	14.98	SD968	.98
6AX5GT	1.25	6W4WGT	1.48	12Z3	.98	50Y6GT	.90	446A/2C40	1.19	991	.40
6B4G	1.98	6W5GT	.98	14A4	1.19	50Y7GT	.99	446B	1.75	FM1000	1.50
6B5	1.29	6W6GT	1.35	14A7/12B7	1.08	52	.99	450TH	47.50	1000T	85.00
6B6G	.98	6W7G	1.33	14AF7/XXD	1.18	53	.78	450TL	44.50	CK1005	.49
6B7	1.29	6X4	.89	14B6	1.08	55	1.06	GL451	.89	CK1006	.64
6B8G	1.39	6X5GT	.75	14B8	.98	56	.85	460/HF200	15.95	CK1007	.89
6BA4	1.08	6Y5	1.85	14C5	1.19	57	.89			HK1054	130.00
6BA5	1.98	6Y6G	1.25	14C7	1.09	58	.89	WL468	8.95	CK1089	3.98
6BA6	1.00	6Y7G	.89	14E6	1.10	59	1.78	RH507	9.98	CK1090	2.69
6BA7	1.20	6Z5 12Z5	1.18	14E7	1.33	RK65	24.95	527	35.00	R1100	5.00
6BC5	1.11	6Z7G	.89	14F7	1.10	HY69	2.75	GL530	49.69	R1130B	12.00
6BD6	1.11	6ZY5G	.89			70A7	1.59	WL531	3.75	HY1231Z	5.39

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6BF6	1.49	7A5	1.10	14H7	1.09	71A	.98	544	4.98	1280	1.98
6BG6G	1.95	7A6	.85	14J7	1.23	72	.95	GL546	1.69	1603	3.00
6BH6	1.35	7A7	1.45	14N7	1.35	CRP72	1.37	550P1	19.95	1609	5.98
6BJ6	1.35	7A8	.90	14Q7	1.10	73	1.67	575A/975	13.75	1613/6F6X	1.05
6BQ6GT	1.78	7AD7	1.56	14R7	1.19	NR74	.29	WL579B	12.98	1614	2.05
6C4	.91	7AF7	.87	14S7	1.33	75	.83	601B	.19	1616	1.98
6C5GT	.83	7AG7	1.98	14W7	1.23	HY75A	4.59	HY615	.18	1619	.29
6C6	.89	7AH7	1.15	14X7	1.23	76	.83	WL619	18.90	1620	4.95
6C7	1.26	7B4	.83	14Y4	1.20	77	.75	WL632A	8.98	1621	1.29
6C8G	.98	7B5	1.23	15	.98	78	.83	701A	6.98	1622	2.26
6C21	42.50	7B6	1.00	15E	1.98	79	.89	702A/702B	2.65	1625	.49
6CB6	1.11	7B7	.90	15R	.98	80	.74	703A	7.95	1626	.49
6CD6G	2.98	7B8	.90	FG17	3.98	81	1.75	704A	1.05	1629	.39
6D4	2.85	7C4/1203A	.79	RK18	.98	FG81A	3.75	705A/8021	1.25	1631	1.25
6D6	.89	7C5	1.00	18	.98	82	1.29	707A	13.50	1632	.77
6D7G	.89	7C6	1.00	19	.65	82V	1.39	707B	24.98	1633	.75
6D8	.98	7C7	1.26	19BG6G	2.98	83	1.89	710/8011	1.98	1634	1.80
6E5	1.10	7C23	72.00	19J6	2.49	83V	1.98	710A/8011	1.75	1635	1.49
6E6	1.39	7E5/1201	1.25	19T8	1.98	84/6Z4	.94	713A	1.00	1641/RK60	1.98
6E7	1.39	7E6	.98	20	1.17	85	.98	715A	7.90	1641/RK60	.75
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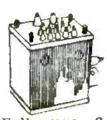

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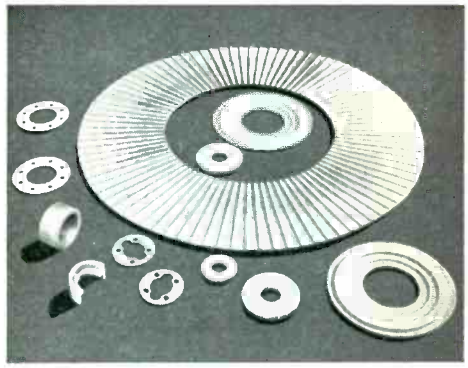
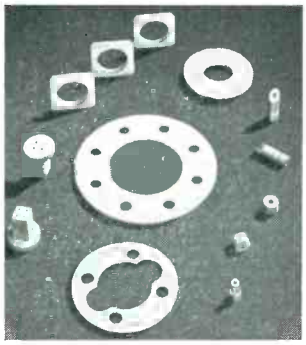
TEFLON

ELECTRONIC PARTS

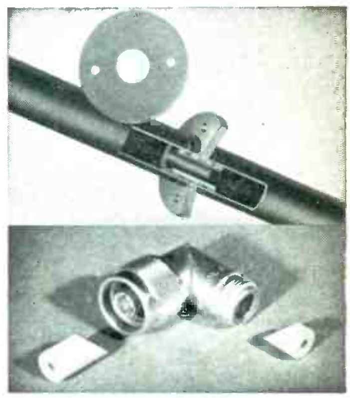
Teflon's outstanding electrical properties make it an ideal insulating material for high-voltage, high-temperature, high- or ultra-high-frequency service. Component parts fabricated of Teflon are finding a steadily increasing number of applications in radio, radar, TV and other electrical and electronic equipment.





Teflon's loss factor is less than 0.0005; its dielectric constant only 2.0—at all frequencies measured to date. Teflon is serviceable throughout the entire temperature range of —110° F. to 575° F. with negligible change in critical electrical characteristics. Teflon is tough, somewhat resilient, weather-proof, has zero water absorption and is absolutely non-corroding.

We manufacture all types of molded or machined Teflon parts including coaxial spacers and coaxial connectors for electronic equipment, component parts for switches, relays, and contactors, as well as tube sockets, high-voltage brackets for power resistors, gaskets, specialties, etc. For more information request Catalog No. 400. Also available — Teflon sheets, cylinders, rods, tubing and bars. *We are the country's foremost manufacturer of Teflon products.*



Teflon Products Division

UNITED STATES GASKET CO.

600 N. 10th Street • CAMDEN, NEW JERSEY

Typical Properties of "Teflon"

Tensile Strength @ 77 F	1500 to 2500 psi.
Elongation @ 77 F	100 to 200%
Flexural Strength @ 77 F	Did not break (D790-44T)
Stiffness @ 77 F	60,000 psi.
Izod Impact Strength @ 70 F / 77 F / 170 F	2.0 ft.-lb./in. / 4.0 ft.-lb./in. / 6.0 ft.-lb./in.
Durometer Hardness	55 to 70
Compressive Stress @ 0.1% Deformation	1700 psi.
Deformation under Load @ 122 F, 1200 psi., 85 hr.	4 to 8%
Coefficient of Linear Thermal Expansion from 77 to 140 F	5.5×10^{-5} per deg. F
Thermal Conductivity	1.7 Btu./hr./sq. ft./deg. F/in.

Specific Heat	0.25 Btu./lb./deg. F
Heat Distortion Temperature for 66 psi.	270 F
Surface Arc-Resistance	Does not track even after 1200 seconds of exposure ASTM D 495-42
Volume Resistivity	10^{15} ohm-cm.
Surface Resistivity @ 100% Rel. Hum.	3.6×10^6 megohms
Dielectric Constant, 60 to 10^8 Cycles	2.0-2.05
Power Factor, 60 to 10^8 Cycles	0.0005
Water Absorption	0.0%
Flammability	Nonflammable
Resistance to Weathering	Excellent
Specific Gravity	2.1 to 2.3

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