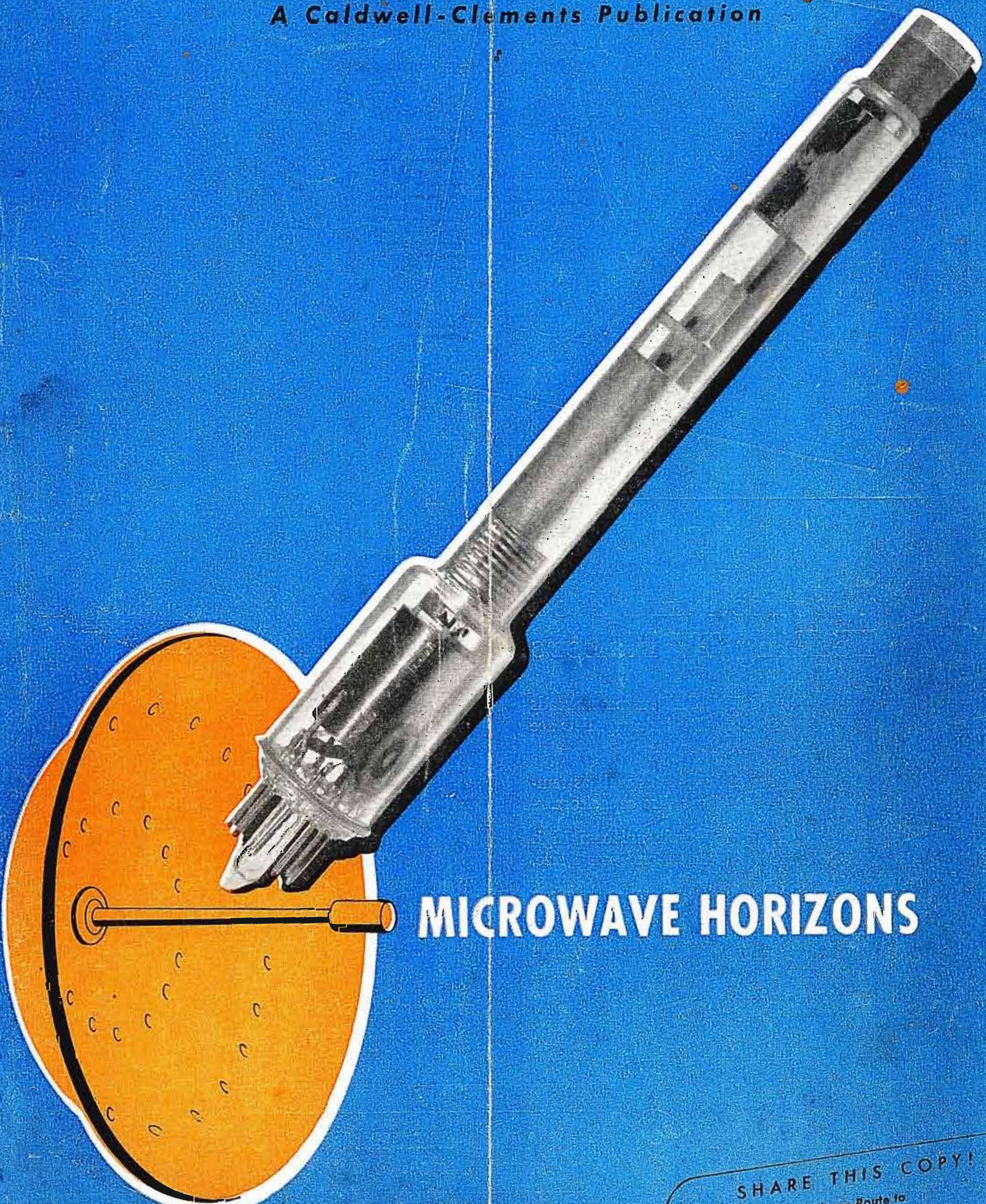
for the ELECTRONIC INDUSTRIES

TELE-TECH

A Caldwell-Clements Publication



MICROWAVE HORIZONS

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Please Route to

December • 1952

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RMC DISCAPS®
...Specified and Used by Leading TV Makers

The list of satisfied RMC DISCAP customers reads like the "Blue Book" of the TV industry. Few are missing from this top level roster.

RMC offers a full line of by-pass as well as temperature compensating ceramic disc capacitors.

Engineers specify them for their uniform high quality, low inherent inductance and small size.

Purchasing agents specify them because they can depend on RMC to make delivery when needed.

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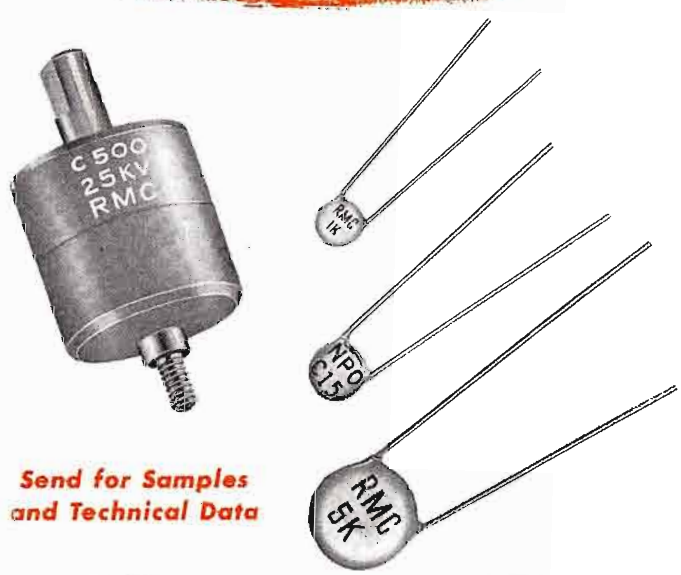

Send for Samples and Technical Data

DISCAP CERAMIC CONDENSERS

RMC

RADIO MATERIALS CORPORATION
GENERAL OFFICE: 3325 N. California Ave., Chicago 18, Ill.
FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.
Two RMC Plants Devoted Exclusively to Ceramic Condensers

TELE-TECH

& ELECTRONIC INDUSTRIES—RADIO-TELEVISION

Edited for the 19,000 top influential engineers in the Tele-communications and Electronic Industries, TELE-TECH each month brings clearly written, compact, and authoritative articles and summaries of the latest technological developments to the busy executive. Aside from its engineering articles dealing with manufacture and operation of new communications equipment, TELE-TECH is widely recognized for comprehensive analyses and statistical surveys of trends in the industry. Its timely reports and interpretations of governmental activity with regard to regulation, purchasing, research, and developments are sought by the leaders in the many engineering fields listed below.

•

Manufacturing

TELEVISION • FM • ELECTRONIC LONG & SHORT WAVE RADIO
AUDIO AMPLIFYING EQUIPMENT
SOUND RECORDERS & REPRODUCERS
AUDIO ACCESSORIES
MOBILE • MARINE • COMMERCIAL GOVERNMENT
AMATEUR COMMUNICATION
CARRIER • RADAR • PULSE
MICROWAVE • CONTROL SYSTEMS

Research, design and production of special types

TUBES, AMPLIFIERS, OSCILLATORS, RECTIFIERS, TIMERS, COUNTERS ETC. FOR
LABORATORY • INDUSTRIAL USE
ATOMIC CONTROL

Operation

Installation, operation and maintenance of telecommunications equipment in the fields of

BROADCASTING • RECORDING
AUDIO & SOUND • MUNICIPAL
MOBILE • AVIATION
COMMERCIAL • GOVERNMENT

DECEMBER, 1952

FRONT COVER: TRAVELING-WAVE TUBE FOR MICROWAVES heralds a significant advance in the relay art. Tube shown was recently developed by RCA Labs., Princeton, N. J. Other manufacturers of microwave equipment are also expending much research effort with an eye toward incorporating the tube in their systems. Inherently, this device is a wideband, high-gain amplifier, typical values being of the order of 800 MC and 40 db, respectively. A modified version of the tube has been built to operate as high as 50,000 MC. Basically, the traveling-wave tube consists of an electron gun, a helix and a collector. The electron beam is shot along the axis of the closely-coiled helix to the collector, guided and kept inside the helix by an axial magnetic field. Concurrently, a signal is fed through the waveguide input to the helix, traveling along the helical wire to the output. When the velocity of the electron beam is greater than the axial velocity of the wave on the helix, an interaction takes place in which the electrons deliver energy to the traveling wave, thereby amplifying the signal.

DEPARTMENTS:

TELE-TECH, Vol. 11, No. 12, December, 1952. 75 cents a copy. Acceptance under Section 34. 64 Postal Laws and Regulations authorized at Bristol, Conn., February 8, 1952 with additional entry at New York, N. Y. Annual Subscription Rates: United States and Possessions: $7.00; Canada: $8.00; All Other Countries $10.00. Please give title, position and company connection when subscribing. Copyright by Caldwell-Clements, Inc., 1952. Printed in U.S.A. Published monthly by

CALDWELL-CLEMENTS, Inc.
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Editorial/Business Offices, 480 Lexington Ave., New York 17, N. Y., Tel. Plaza 9-7880
Publishers also of TELEVISION RETAILING

TELE-TOTALS

Electronic Industries Output, 1952

Radio-TV manufacturing, sales, broadcasting, records, etc.	$4,000,000,000
Civilian radio-TV servicing	850,000,000
Induction-heating equipment	15,000,000
Dielectric heating equipment	2,000,000
Gas & vapor industrial tubes	13,000,000
Industrial vacuum tubes	50,000,000
Photo-electric tubes	18,000,000
Magnetrons and klystrons	27,000,000
Military electronic equipment, (manufacturers' prices)	3,000,000,000
Total yearly	$7,975,000,000

Electronic Industries Manpower

Manufacturing, military production	230,000
Manufacturing, civilian, home radios, TVs	105,000
Manufacturing, parts, components, etc.	25,000
Distribution and retailing, station operation	640,000
Total	1,000,000

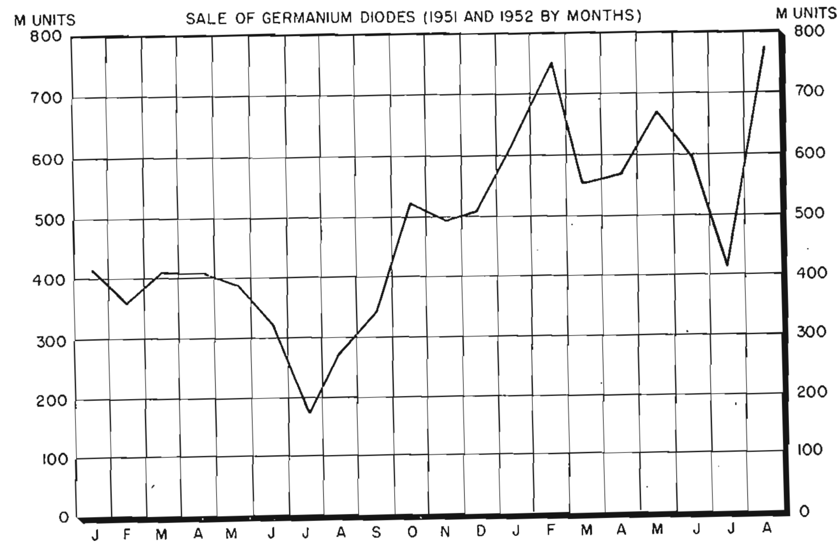
Total Tubes in Use, Dec. 2, 1952

In 19,000,000-plus television sets	400,000,000
In 110,000,000 radio sets	770,000,000
Telephone systems	3,000,000
Police and fire communications	1,000,000
Taxi radios	1,250,000
Aeronautics	1,000,000
Military equipment	15,000,000

Above from estimates compiled by Stanford Research Institute, Stanford, Cal.

Radio and TV Receiver Production

	TV		Radio
Oct. 1952		Home	400,000
		Battery	120,000
		Auto	180,000
		Clock	190,000
Total	790,000		890,000
First 10 months through Oct. 1952		Home	2,961,018
		Battery	1,125,668
		Auto	2,200,000
		Clock	1,318,817
Total	4,456,407		7,605,853
Year 1951	5,562,000		12,895,000
Year 1950	7,520,000		14,630,000



October 15 report on germanium-diode production shows that 814,040 units were shipped during September (a slight rise above August),—making a total of nearly six million units during the first nine months of 1952. Bulk of these went to new-set equipment, with replacements running about 6%, export 2% and government agencies about 13%.

Receiving-Tube Production

	Entertainment Types	Allied Types	Total
Sept. 1952	31,482,740	6,675,980	34,196,286
August, 1952			30,141,536
Sept. 1951			27,946,193
Nine months, 1952			245,689,629
Nine months, 1951			280,795,338

Broadcast Stations in U. S.

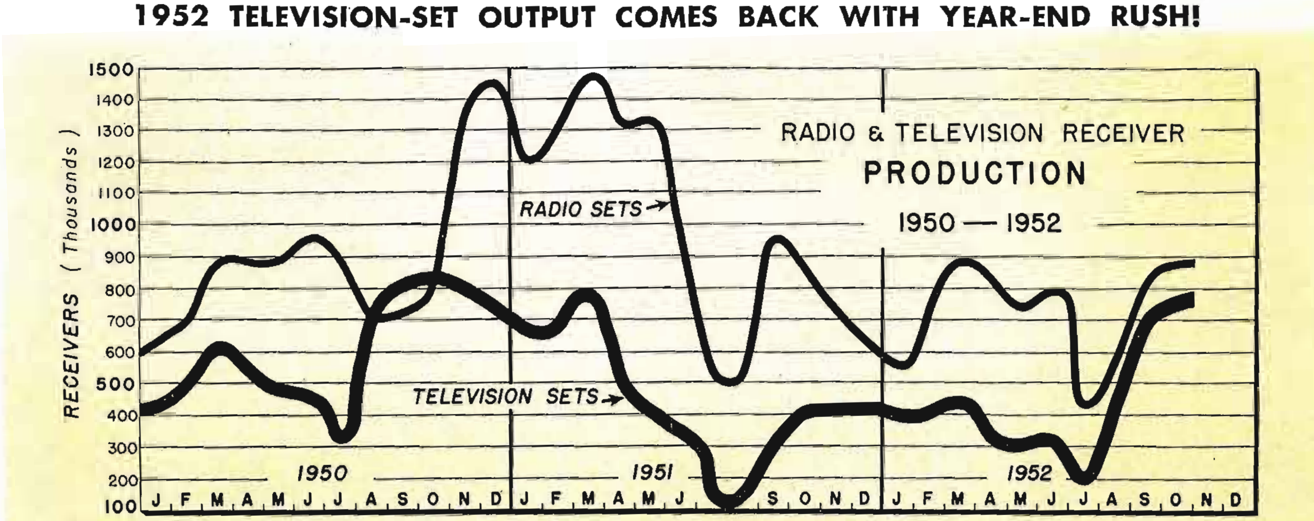
	AM	FM	TV
Stations on Air	2363	578	111 VHF & 2 UHF
Under Construction (CPs)	147	70	67 UHF & 25 VHF
Applications Pending	235	9	306 UHF & 401 VHF

Estimated Tube Output, 1952

Receiving tubes sold for initial equipment	255,000,000
Receiving tubes sold for replacements	75,000,000
Total receiving tubes sold	330,000,000
Total retail value (at $2.25 per tube)	$740,000,000
Cathode-Ray Picture Tubes, initial equipment	5,300,000
Cathode-Ray Picture tubes, replacements (new tubes) in addition to 800,000 rebuilt tubes	1,200,000
Total value 6,500,000 new picture tubes, retail	$227,000,000
Total value all new tubes, both receiving and picture tubes, 1952	$967,000,000

(Note: In comparison with above estimates for 1952, official RTMA figures for preceding years show that 375,643,697 receiving tubes were sold in 1951, and 382,960,599 receiving tubes in 1950. Total cathode-ray picture-tube sales in 1951 were 4,434,126.)

1952 TELEVISION-SET OUTPUT COMES BACK WITH YEAR-END RUSH!



See also Caldwell-Clements Statistics in World Almanac, Encyclopaedia Britannica, National Industrial Conference Board Fact Book, and "Information Please" Almanac

Unique PHELPS DODGE development

DRASTICALLY CUTS

- ✓ FAST WIRE-TO-WIRE BONDING INTO RIGID COIL.
- ✓ REDUCES FORMING AND ASSEMBLY OPERATIONS.
- ✓ FAR FEWER STEPS IN WINDING TYPICAL TV YOKE COIL.
- ✓ MAKES POSSIBLE UNUSUAL SHAPE COILS.

"Bobbin-less" coil

Fly-back coil

TV yoke coil

Hoop-shaped coil

"It takes the best

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CORPORATION

in Magnet Wire--BONDEZE*...

COIL WINDING COSTS!

BONDEZE is Phelps Dodge magnet wire with a special thermo-plastic film applied over the insulation. It offers a quick, economical means of bonding wires together, turn to turn, through simple application of heat or solvents. Complete information furnished on request.

Any time magnet wire is your problem, consult Phelps Dodge for the quickest, easiest answer.

*Bondeze is a Phelps Dodge Trade Mark

to make the best!"

PHELPS DODGE COPPER PRODUCTS CORPORATION — MINE TO MARKET — REG. U. S. PAT. OFF.

INCA MANUFACTURING DIVISION

FORT WAYNE, INDIANA

TELE-TECH

& ELECTRONIC INDUSTRIES—RADIO-TELEVISION

Services Rendered by the Publishers of TELE-TECH

Publishing services to the 5-billion dollar TV-Electronic-Radio industries by Caldwell-Clements, Inc., consist mainly of engineering and distribution magazines and coordinated services, as follows:

TELE-TECH*—Monthly engineering magazine of the TV-Electronic industries. Widely recognized for its technical excellence. Largest engineer-audience in design, manufacture and operation.

TELEVISION RETAILING—Monthly magazine of sales and service, devoted to TV, radio, records and appliances. Includes TV-Electronic Technician, monthly supplement for service technicians.

MANUALS—Special service to defense industries. Writing, illustrating and/or printing of technical manuals, instruction books, etc. (Caldwell-Clements Manuals Corp.)

DIRECT MAIL—Special mailing service for advertisers desiring to supplement or intensify their space advertising in Tele-Tech.

* Reg. U.S. Pat. Off.


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—with an eye to the ELECTRONIC future
presents this new brochure
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ENGINEERS HANDBOOK & CATALOG
HIGH TEMPERATURE STABILITY 450°F
PRECISION ASSEMBLY UNIFORMITY
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TIGHT INSERTS — SOLDERABLE
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LOW LOSS FACTOR
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MOLDABLE WITH FRAGILE INSERTS
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MINIMUM DIFFERENTIAL EXPANSION
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MYCALEX
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MYCALEX TUBE SOCKET CORPORATION
24-PAGES of complete and concise engineering data and specifications covering the various grades of Mycalex—see details on REVERSE SIDE


The Ideal End Closure -
for resistors...
for capacitors...
for other tubular components!
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E-I END SEALS SIMPLIFY MANUFACTURE, SPEED PRODUCTION, LOWER UNIT COST
No special skill is required to apply E-I seals. Assembly is rapid since all metal parts are tin-dipped for easy soldering. Rugged construction plus carefully annealed glass permits rough handling without weakening or breakage.
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Glass of the Pyrex family, chemically bonded to metal provides a permanently air-tight seal that readily withstands drastic pressure change, shock and vibration. All seals are silicone-treated for high resistance when exposed to salt-spray or humidity.
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Standard stock items are available to economically meet practically any requirement. Both pigtail lead and terminal connection types of seal are included. A standard, self-describing coding system affords maximum customer convenience in ordering.
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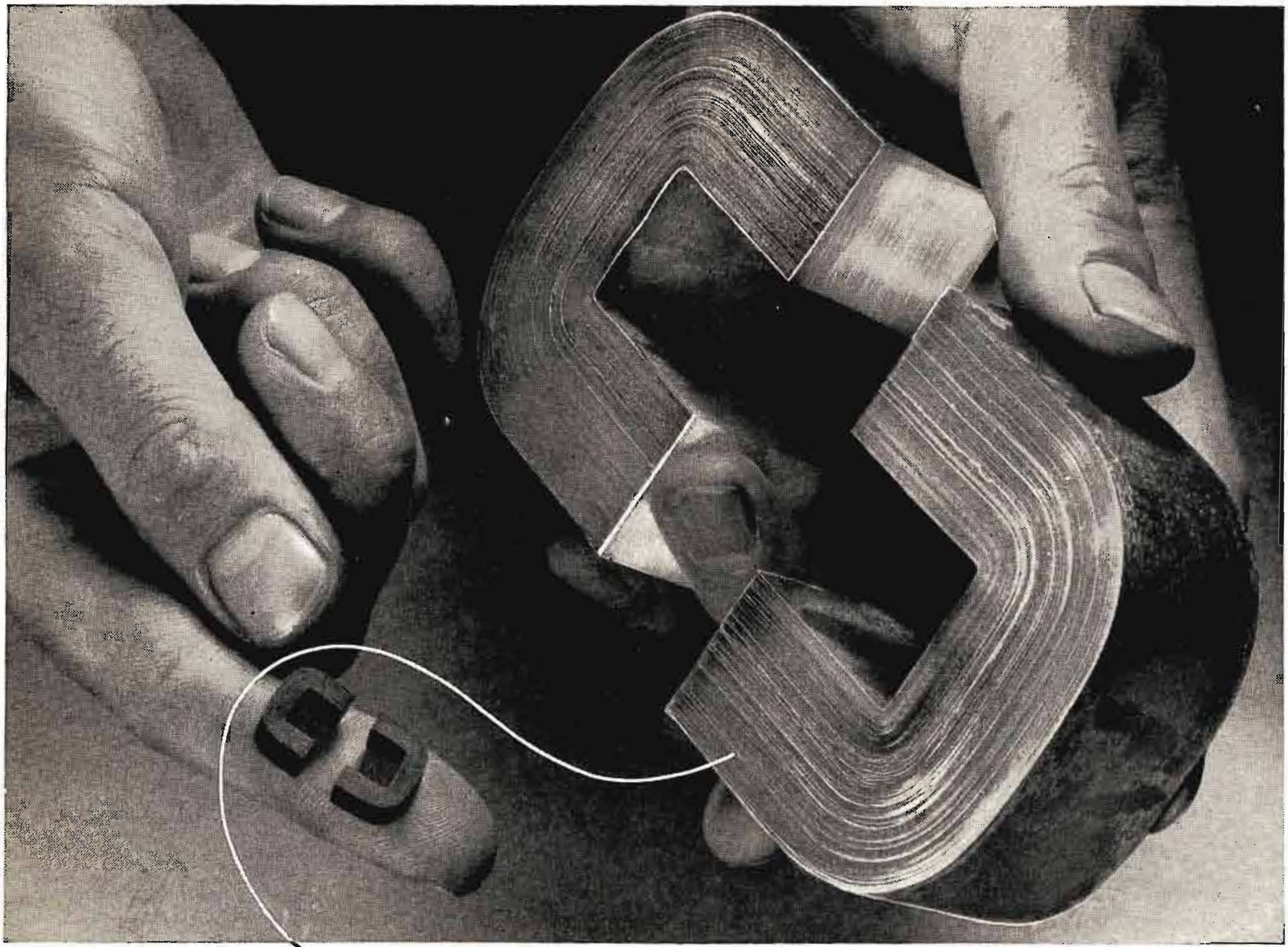

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...*any quantity and any size*

Wound from precision rolled oriented silicon steel strip as thin as .00025"

For users operating on government schedules, Arnold is now producing C-Cores wound from ¼, ½, 1, 2, 4 and 12-mil Silectron strip. The ultra-thin oriented silicon steel strip is rolled to exacting tolerances in our own plant on precision cold-reducing equipment of the most modern type. Winding of cores, processing of butt joints, etc. are carefully controlled, assuring the lowest possible core losses, and freedom from short-circuiting of the laminations.

We can offer prompt delivery in production quantities—*and size is no object, from a fraction of an ounce to C-Cores of 200 pounds or more.* Rigid standard tests—and special electrical tests where required—give you assurance of the highest quality in all gauges. ● *Your inquiries are invited.*

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SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois

W&D 4363

Another NEW Shunt Diode by

UNITED

High peak power capabilities of type X-80 in relation to its physical size have been accomplished through an unusually forceful combination of design features.

1. Exclusive UNITED bonded *thoria tungsten core filament* for high electron emissivity.

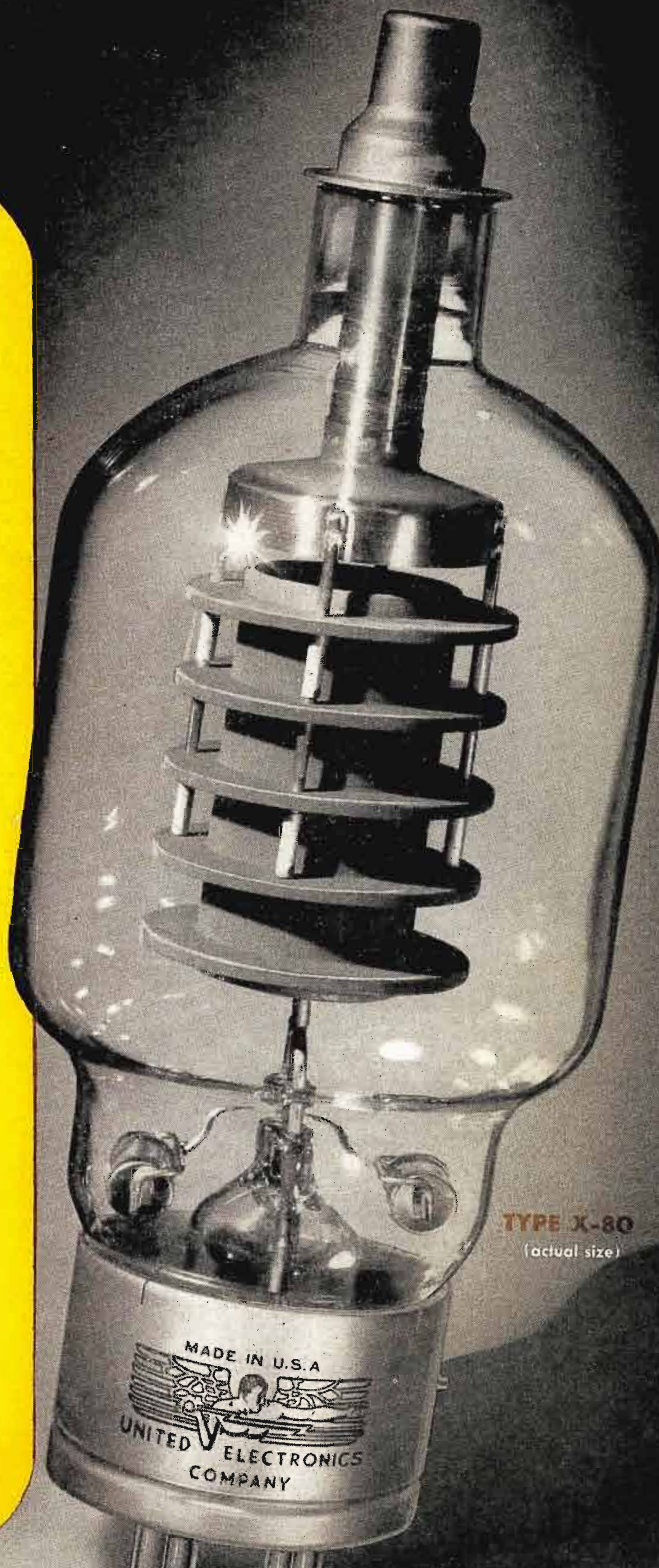
2. Exclusive UNITED *graphite anode* for maximum thermal dissipation.

3. Exclusive UNITED *isolated getter traps* for retention of hard vacuum and high voltage internal insulation.

Type X-80 will serve importantly as a high current clipper tube in radar equipment employing the large hydrogen thyratrons, as well as in power supply rectifier applications.

Write for detailed specifications.

40 Kilovolts Inverse Peak	80 Amperes Peak Plate Current as shunt diode
800 mAdc (average) as a rectifier	Filament Ratings 11 Volts Nominal 15.5 Amperes



TYPE X-80
(actual size)

UNITED ELECTRONICS, 42 Spring Street, Newark 2, N. J.

CABLE BY PHELPS DODGE

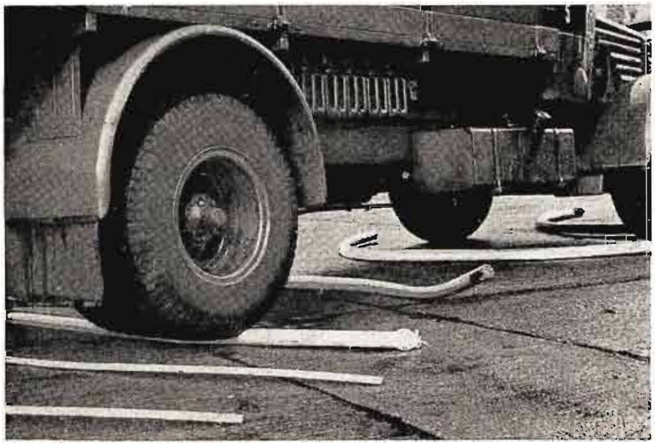
in semi-flexible 1000-ft. lengths without joints!

Reflections Reduced to Absolute Minimum in AM, FM, TV and Microwave Applications

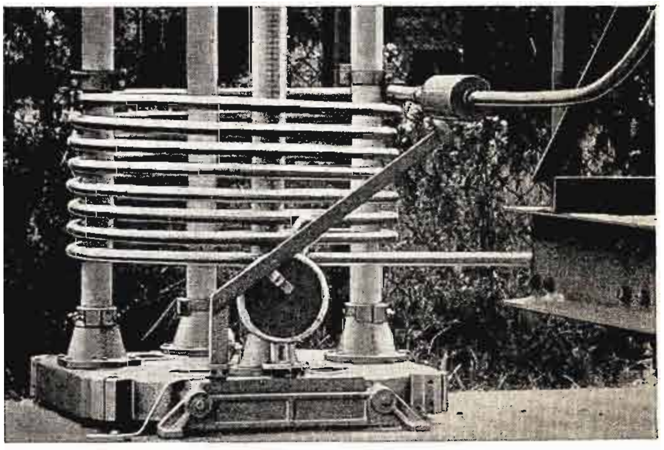
Phelps Dodge Copper Products Corporation's new semi-flexible, aluminum sheathed Styroflex cable is specially designed to meet the need for a high-power, efficient low-loss coaxial cable in the AM, FM, TV and microwave fields. The cable reduces reflections—which cause ghost images in television and distortions in communications—to an absolute minimum.

It was developed by Felten & Guilleaume Carlswerk, of Cologne, Germany, which has made a great many successful installations of the cable throughout Europe. Phelps Dodge is currently making the cable for sale in the United States in standard American sizes and impedances under a working agreement with the Cologne firm. The cable is manufactured in continuous 1000-foot lengths, without joints, and shipped on reels.

Outstanding feature of the cable is the use of insulating Styroflex film to form a helix. This helix, built up of hundreds of precision-wound Styroflex tapes, firmly supports and centers the inner conductor coaxially in an aluminum sheath at all times, assuring retention of excellent electrical properties. Essential flexibility of the Styroflex tape is obtained by special manufacturing techniques.



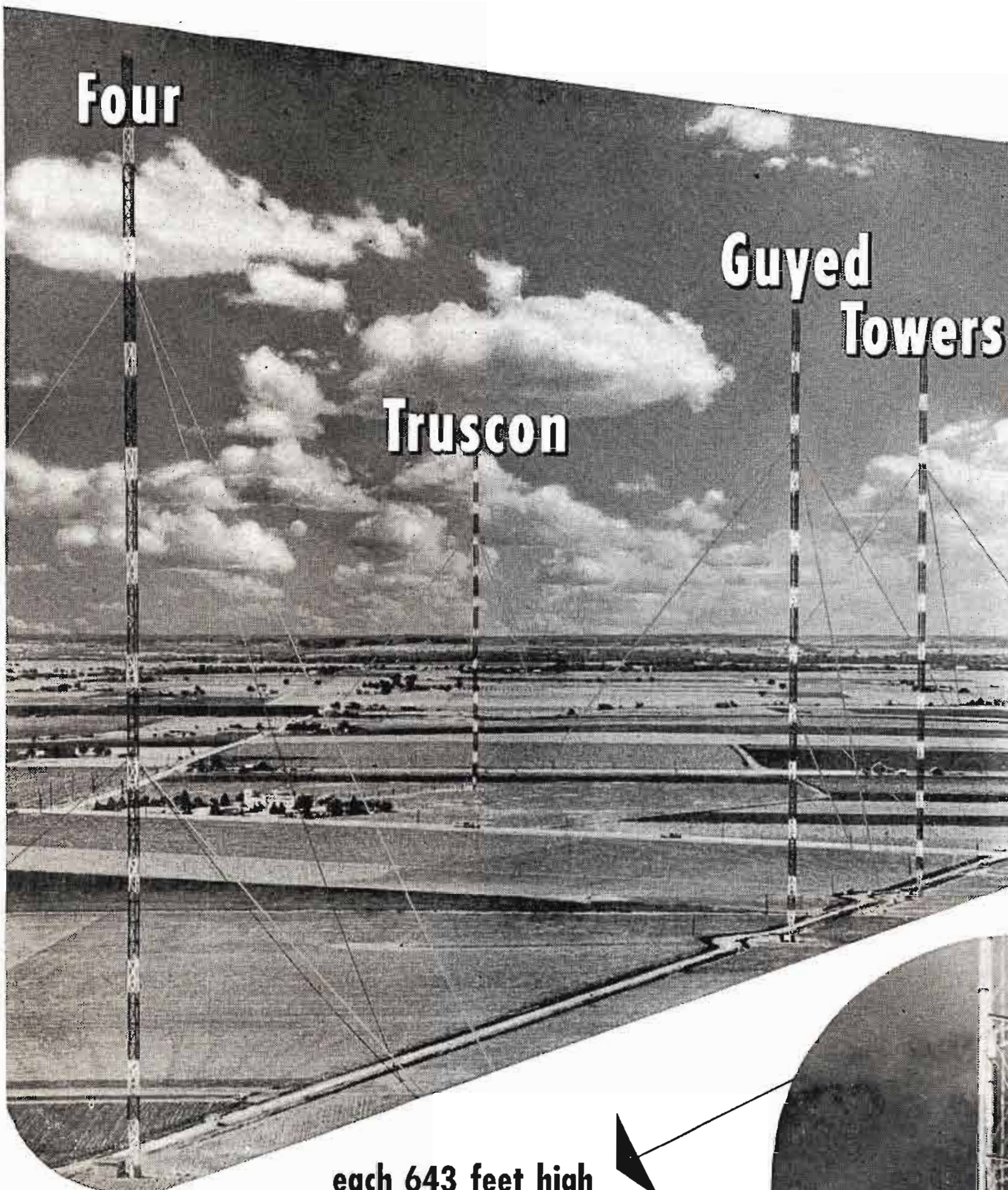
In test of strength and ruggedness of Styroflex coaxial cable, heavy truck drives over several samples without damaging them.



Perfect centering of inner conductor is maintained by Styroflex tape helix, regardless of bending or load cycling both during installation and in service.

PHELPS DODGE COPPER PRODUCTS CORPORATION

40 WALL STREET, NEW YORK 5, N. Y.

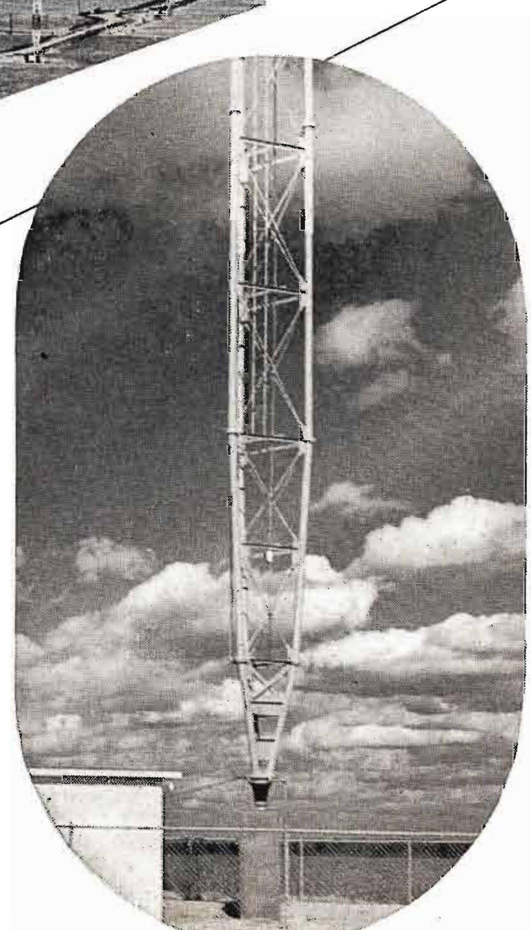


each 643 feet high
serving WFAA, Dallas and WBAP, Fort Worth

WFAA and WBAP divide time on two channels, 570 kc. regional with a three tower directional antenna array, and 820 kc. clear with an omnidirectional single antenna. With four Truscon Guyed Towers, each 643 feet high and situated equidistant from Dallas and Fort Worth, a great metropolitan and rural market is reached.

The tallest towers in the United States are of Truscon guyed tower design and manufacture. Truscon possesses many years of engineering knowledge and experience in the steel AM-FM-TV-MICROWAVE tower field. Truscon facilities for the complete design and production of steel towers are modern and efficient.

Your phone call or letter to any convenient Truscon district office, or to our home office in Youngstown, will bring you prompt, capable engineering assistance on your tower problems. Call or write today.



TRUSCON MARK OF MERIT PRODUCTS

TRUSCON® STEEL DIVISION
REPUBLIC STEEL CORPORATION
1092 ALBERT STREET • YOUNGSTOWN 1, OHIO

TRUSCON a name you can build on


ARE YOU, TOO, USING
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Products containing CLEVELITE are in use the world over.
Possibly right now we can be of service to you through our Research and Engineering Laboratory on some new product, or in helping you to improve performance and lower costs.
Yes, Clevelite will be made to your exact specifications, meeting the required tolerances.
Clevelite assures you of uniformity and continued, dependable performance at lower production costs.
Hundreds of thousands of Clevelite coil forms, collars, bushings, spacers, tubes and other items are giving continuous satisfaction. Play safe! Be sure you use CLEVELITE!
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TELE-TIPS

NEXT, FWC! After happy experience with the FCC, official Washington is now toying with the idea of a Federal Weather Commission, to have general jurisdiction over clouds, rain, snow and sleet, and to coordinate and control human efforts at rain-making, rain-prevention, etc. Already there are many amateur rainmakers in the Southwest and other sections of the country, who crank up a plane, grab a bag of iodide crystals, and go aloft to reconstruct the weather in their own interest, regardless of others. Now it is proposed to put all such efforts under license, and to issue weather allocations, RPs (rain permits) and even STAs (snow, temporary authorizations).

AUTOMOBILES coming into New York through the Lincoln Tunnel can now pick up traffic instructions and information by dialing their radios to 550, as advised by signs at the tunnel approaches. The low-intensity signal, operating under a system developed by William Halstead, can be heard throughout the tunnel but not outside. As the result of successful operation of the Lincoln Tunnel experimental installation, it is now the intention to install similar traffic-bulletin broadcasting on all the other bridges and tunnels operated by the Port of New York Authority.

GUIDED MISSILES—Dr. A. M. Zarem of Stanford Research Institute, points out that the electronic industry has been called upon to develop new equipment, instruments, and machines that can sense, react, think, calculate, and remember much more rapidly than a human being, in facing guided-missile problems. According to Dr. Zarem, it is a routine matter to consider guided missiles travelling at a speed of 1000 to 4000 miles per hour. At a speed of 1800 miles per hour, anything within 265 feet of the pilot, requiring $\frac{9}{10}$ of a second to reach, will be behind him before it is seen. Anything within 3700 feet, will be behind before it is recognized, according to Zarem. Electronics has therefore been called upon to react for the pilot, and the industry is now supplying the necessary equipment, said Dr. Zarem.

(*Continued on page* 26)

These "Firsts" Helped Westinghouse Customers

1920 Westinghouse Makes First Dry Battery WD-11 Tube

1921 Westinghouse Testing New Indirectly-Heated Tube

1926 WESTINGHOUSE INVENTS NEW KU-610 THYRATRON

1928 Announce New Photo-Tube and Long-Life Cathode Ray Tube

1929 Westinghouse Patents KOVAR for Metal-to-Glass Tube Sealing

1931 Westinghouse Unveils First High Power UHF Tube

1932 Westinghouse Tells of New Ignitron Tube

1941 WL-530 in Radar at Pearl Harbor

USERS OF WESTINGHOUSE TUBES GET FIRST BENEFITS FROM MANY NEW TUBE DEVELOPMENTS

These are only a few of the "firsts" that Westinghouse created in the electronic tube industry. In each case, designers using Westinghouse Tubes gained advantages by having first chance to use these innovations.

Today, Westinghouse still pioneers in electronic tubes and tube making. For instance, Westinghouse 40 KV and 20 KV rectifying tubes are under 9 ounces, only 2¾" high. Designers seeking the ultimate in space and weight savings will find them in these new WL-6102 and WL-6103 tubes.

Radical new developments in other power tubes and receiving and television picture tubes are now being engineered at the *NEW* Westinghouse Electronic Tube Division at Elmira and Bath, New York.

NEW SERVICE, NEW DISTRIBUTION

Westinghouse plans for Electronic Tube Division expansion are in operation. New service facilities, new warehousing policies, and new distributors are opening rapidly.

New merchandising methods will aid distributors in serving industrial users—many of these business-building programs are totally new in the tube industry. Here, as elsewhere, Westinghouse plans to provide industry leadership in service.

It pays in profits to deal with Westinghouse and with Westinghouse distributors. For full information on how Westinghouse can help you with problems of design, service, or supply, call your nearest Westinghouse representative, or write to Department B-112.

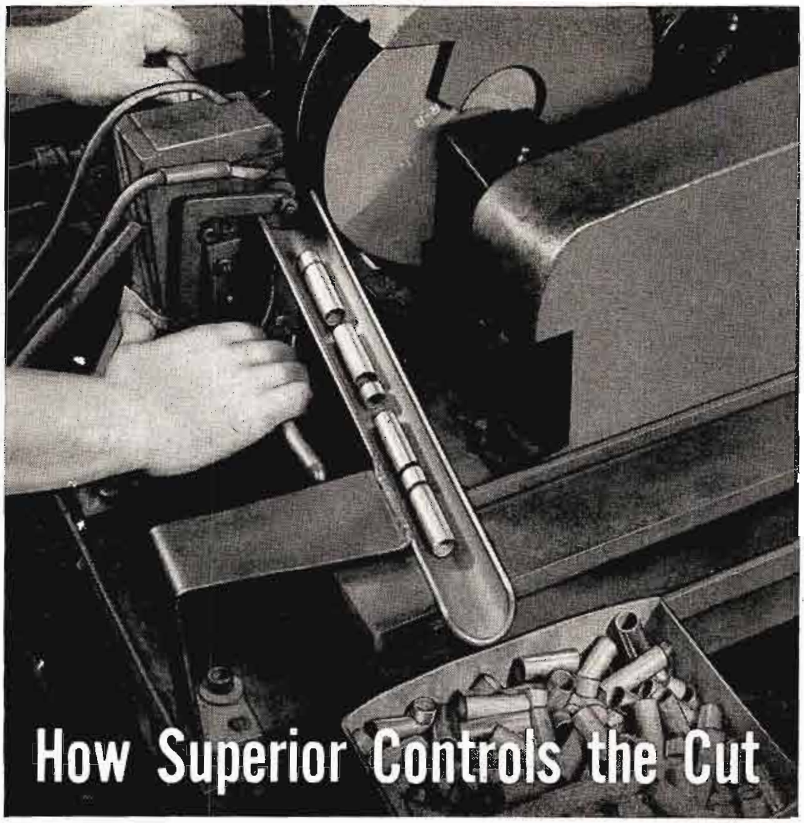
RELIATRON™ TUBES

YOU CAN BE SURE...IF IT'S Westinghouse

ET-95003

ELECTRONIC TUBE DIVISION

Westinghouse Electric Corporation
Box 284, Elmira, N. Y.



to give you better tubular parts

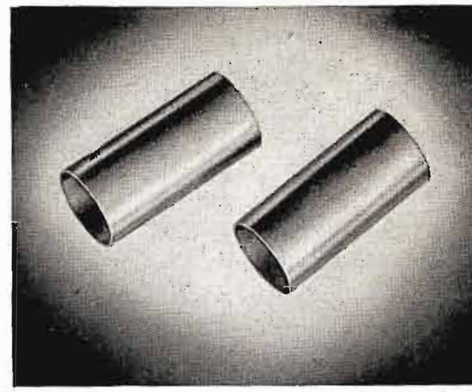
● Cutting tubing into exact lengths as the first step in the fabrication of tubular Electronic parts is a simple operation. Or is it?

Complications set in when the temper of the tubing is changed to meet customer specifications; when the tubing to be cut has a wall .010″ or thinner; when length tolerances as close as .010″ are required; when a 3° to 10° angle cut with a tolerance of ± ½° is called for; and when flattening, denting or other distortion must be prevented.

But overcoming complications in simple operations . . . and finding ways around them in other basically more difficult ones, is a specialty of the Electronics Division of Superior.

Our customers for Electronics parts have come to expect us to deliver the goods, exactly to specifications, whether standard production or complex experimental parts. What's more, they frequently ask us for suggestions about improvement on their designs and specifications . . . and they get them.

There is nothing unusual about all this—it's our job and we know how to do it. If you are a manufacturer or experimenter in the Electronics Industry and you need a tubular part that presents a problem, tell us about it. We'll probably be able to help and will gladly do so. Write The Superior Tube Company, 2508 Germantown Ave., Norristown, Pennsylvania.



Cutting and Tumbling. Cutting machines and jigs of many types and sizes are combined with extensive tumbling equipment to permit fast accurate production of quantities of parts at Superior.

Fabrication: Parts can be readily rolled at either or both ends, flared, flanged, expanded, or beaded (embossed) as required. The anode above is one of many such parts we produce at high speed and low cost.

The Finished Part. Final stage in the fabrication of the part shown above at three stages of production is a bend nicely controlled for both precise angle and freedom from other, unwanted distortion.

This Belongs in Your Reference File
. . . Send for It Today.

NICKEL ALLOYS FOR OXIDE-COATED CATHODES: This reprint describes the manufacturing of the cathode sleeve from the refining of the base metal. Includes the action of the small percentage impurities upon the vapor pressure, sublimation rate of the nickel base; also future trends of cathode materials are evaluated.

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THE BIG NAME IN SMALL TUBING

All analyses .010″ to ⅝″ O.D.
Certain analyses (.035″ max. wall) Up to 1¼″ O.D.

SUPERIOR TUBE COMPANY • Electronic products for export through Driver-Harris Company, Harrison, New Jersey • Harrison 6-4800

494 feet above Philadelphia's busiest streets

Most city building codes are easily complied with, but nature's caprices are unpredictable. So, when both the building's owners and WPEN's engineers laid plans for a new AM-FM station atop their new midtown building they called on Blaw-Knox to design, fabricate and erect a *safe* antenna tower. Their choice was based on the fact that Blaw-Knox has an unequaled record for successful tower installations in congested areas. WPEN's structure is designed to carry the additional load of TV bays if and when required.

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY

2070 Farmers Bank Building
Pittsburgh, Pa.

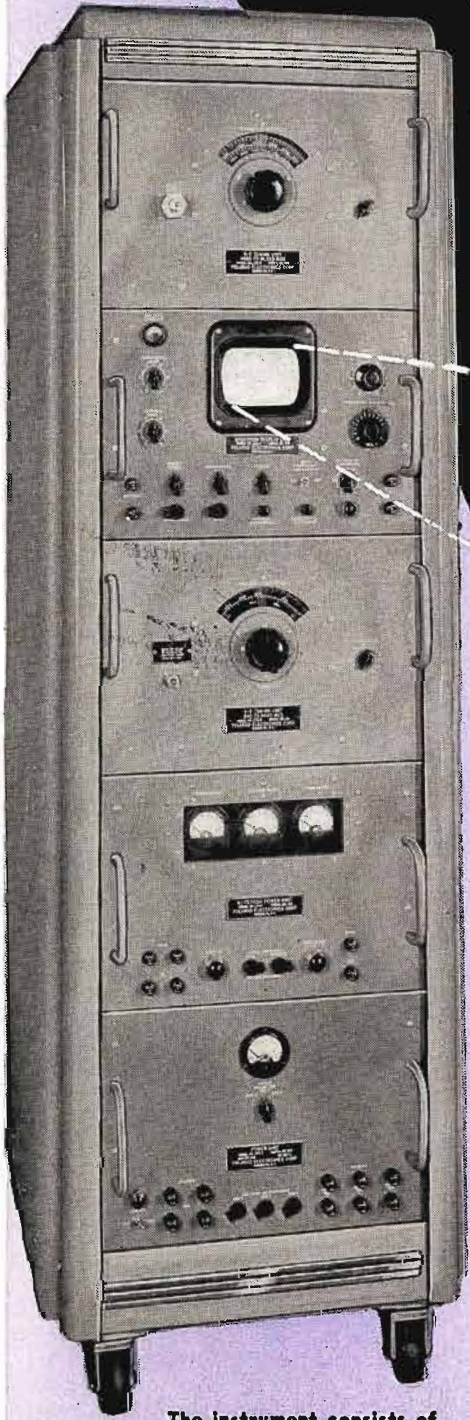
BLAW-KNOX ANTENNA TOWERS

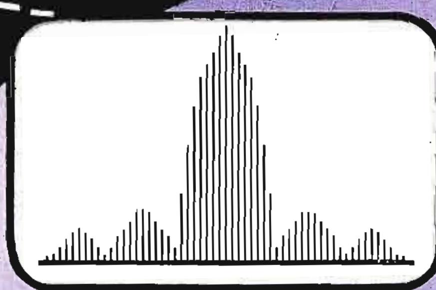
Distributed by GraybaR
OFFICES IN 100 PRINCIPAL CITIES

The FIRST and still the only all-band direct reading SPECTRUM ANALYZER

10 MCS TO 21,000 MCS

Polarad's Model LSA Spectrum Analyzer is the result of years of research and development. It provides a simple and direct means of rapid and accurate measurement and spectral display of an r.f. signal.





Outstanding Features:

- Continuous tuning.
- One tuning control.
- 5 KC bandwidth on final i. f.
- 250 KC to 25 MCS display at all frequencies.
- Tuning dial frequency accuracy 1%.
- No Klystron modes to set.
- Broadband attenuators supplied with equipment from 1 to 12 KMC.
- Frequency marker for measuring frequency differences 0-25 MCS.
- Only four tuning units required to cover entire range.
- Microwave components used latest design non-contacting shorts for long mechanical life.
- Maximum frequency coverage per dollar invested.
- 5 inch CRT display.

Where Used:

Polarad's Model LSA Spectrum Analyzer is a laboratory instrument used to provide a visual indication of the frequency of distribution of energy in an r.f. signal in the range 10 to 21,000 MCS.

Other uses are:

1. Observe and measure sidebands associated with amplitude and frequency modulated signals.
2. Determine the presence and accurately measure the frequency of radio and/or radar signals.
3. Check the spectrum of magnetron oscillators.
4. Measures noise spectra.
5. Check and observe tracking of r.f. components of a radar system.
6. Check two r.f. signals differing by a small frequency separation.

Write for Complete Details

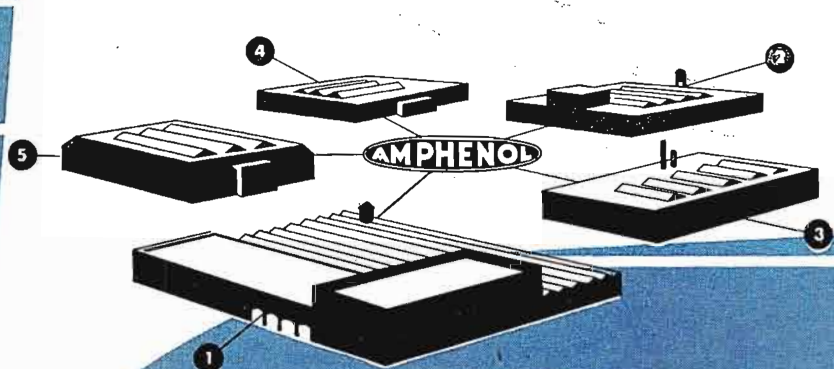
The instrument consists of the following units:

Model LTU — 1 R.F. Tuning Unit — 10 to 1000 MCS.
Model LTU — 2 R.F. Tuning Unit — 940 to 4500 MCS.
Model LTU — 3 R.F. Tuning Unit — 4460 to 16,520 MCS.
Model LTU — 4 R.F. Tuning Unit — 15,000 to 21,000 MCS.
Model LDU — 1 Spectrum Display Unit.
Model LPU — 1 Power Unit.
Model LKU — 1 Klystron Power Unit.

Polarad Electronics Corporation

**100 METROPOLITAN AVE.
BROOKLYN 11, N. Y.**

Manufacturers of broadband microwave laboratory instruments.



TELE-TIPS

(*Continued from page 20*)

FILM CONVERSION from the standard type to sound motion pictures may be accomplished by a new technique which allows a magnetic sound track to be placed between the perforations and edge of one side of the film. Formerly, the old film had to be copied on film with sprocket holes along one edge only. A retractable rubber roller on the projector holds the sound track in contact with the record head. This new system, developed by Bell & Howell Co., is less than one-third as expensive as the old method.

REFUELING TIME of the Douglas C-124A transport plane's 11,000-gallon fuel tanks has been cut from five hours to 18 minutes by the use of a recently developed pumping system. At this rate, an automobile tank would be filled in less than 1.5 seconds. The flow of gas into the aircraft's tanks requires monitoring and recording of 41 measurements simultaneously. Since fuel volume is a function of temperature, a thermocouple monitoring system records temperatures at various locations on a Brown recorder. Concurrently, three Consolidated Engineering recording oscillographs record the output of resistance-type pressure and capacitance-type quantity fuel gages.

OVER 1,500,000 British TV sets are now in use. Major General D. A. L. Wade of the British Embassy at Washington, corrects our earlier figure, pointing out that the number of TV receivers licensed in the United Kingdom as of June 30, 1952, was 1,538,550.

MEANINGFUL SIGN posted in the public relations department of a leading TV network reads: "If you can remain calm while others are losing their heads—maybe you don't understand the situation."

TELEVISION TROUBLES occur mostly in the horizontal circuits, according to a recent survey conducted by a large service organization. Twenty-five percent of all the requests for help received in the test period were in connection with horizontal problems. The most common was loss of horizontal sync, followed by width, automatic frequency control, and non-linearity. The latter is surprising, since today's trend seems to be to eliminate the linearity control from the horizontal output circuits.

LETTERS . . .

'52 Tube Sales Approach $ Billion

Editors, TELE-TECH:

I appreciate getting the additional data regarding the 1952 tube production. Those figures keep rolling gigantically. You are doing a fine service to the industry by continually publishing these statistics.

DR. LEE DEFOREST
United Engineering Laboratories,
1027 N. Highland Ave.,
Los Angeles 38, Calif.

Phonovision's Three Collection Methods

Editors, TELE-TECH:

Zenith has been working on subscription television since 1931 and has surveyed just about every possible collection and billing method. We have for a long period of time been testing various methods, and putting them into actual operation here at the factory. This has given Zenith a completely flexible Phonevision system which combines three collection methods *in the same* transmission to serve all homes in range of the television station, whether or not they have telephones. You are familiar, of course, with our mass testing of the telephone method.

With this flexible system, Jones will be charged on monthly billing, Smith will use a card purchased at the corner drug store, and Johnson will pay for his program by a coin box in his home, etc.

In the near future we shall invite you to a formal demonstration.

E. F. MCDONALD, JR.
President
Zenith Radio Corp.
Chicago, Ill.

Big Advertisers Turn to Subscription-TV

Editors TELE-TECH:

Faced with a constantly increasing cost for program advertising on television, many advertisers are looking with interest to "Subscription-TV" as a possible solution.

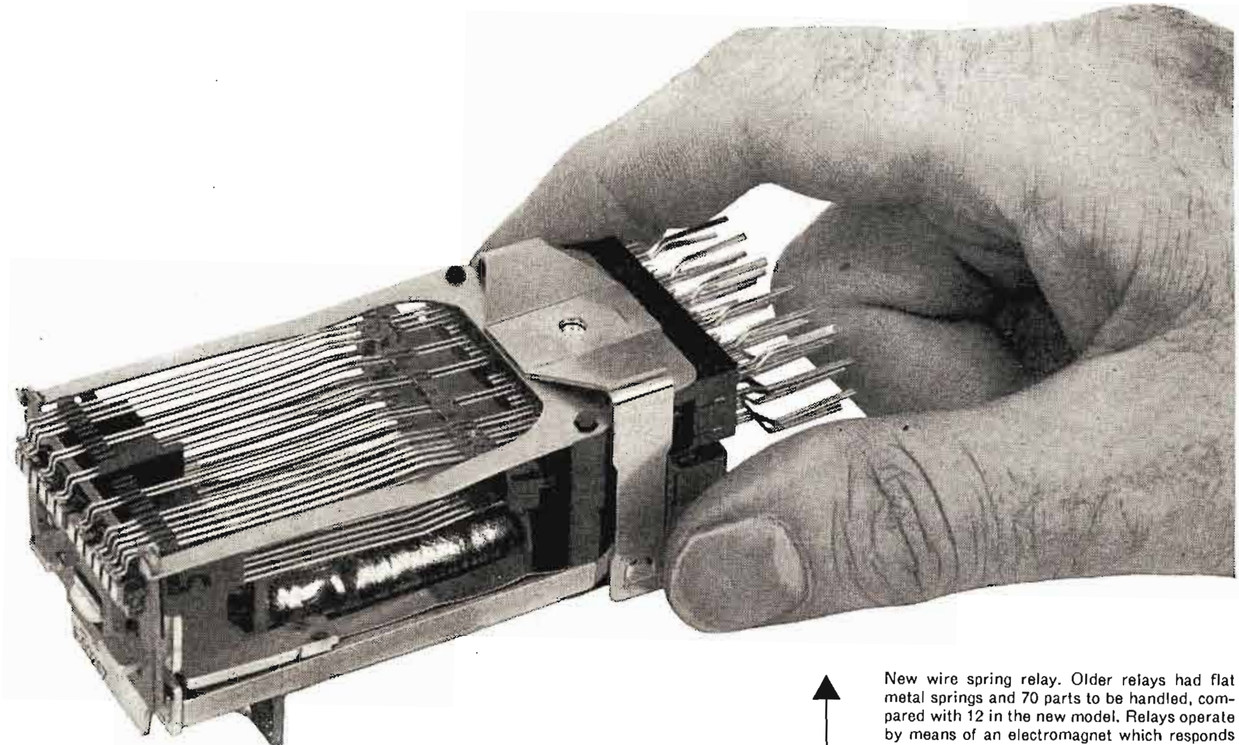
In the case of magazine and newspaper advertising, the advertiser shares with the general public the cost of the entertainment or editorial elements of the vehicle that carries its advertising. In radio, this has never been necessary.

However, television costs are becoming so much higher than radio costs that perhaps a sharing of those costs with the audience will be necessary if TV is to be affordable to the advertisers.

Television networks have already resorted to such devices as every-other-week sponsorship and split sponsorship to keep within the budgets of advertisers. However, even that may not be the total solution.

HENRY SCHACHTE
The Borden Co.
350 Madison Ave., New York 17

It splits seconds even faster

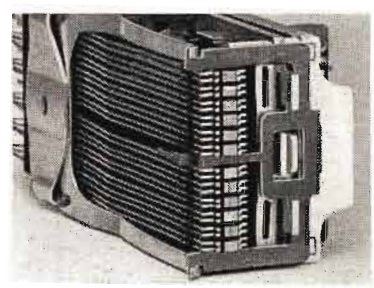


New wire spring relay. Older relays had flat metal springs and 70 parts to be handled, compared with 12 in the new model. Relays operate by means of an electromagnet which responds to high-speed pulses.

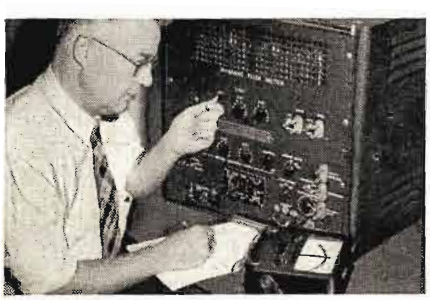
IN A split second, relays, which are high-speed switches, set up dial telephone connections. Then they are off to direct the next call. Yet even this speed is too slow for Bell Laboratories scientists in quest of still faster switching.

Scientists and engineers devised a new relay — the wire spring relay — and worked out the production problem with Western Electric, manufacturing unit of the Bell System. This is twice as fast, uses less power and costs less to make and maintain.

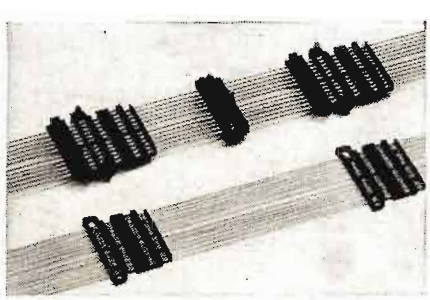
With speedier relays, switching can be done with less equipment . . . and calls go through faster. The wire spring relay is a practical example of how Bell Telephone Laboratories and Western Electric pool their skills to improve telephone service while keeping its cost down.



New relays must be able to operate one billion times—equal to once-a-second for 30 years. Employing a sound recorder as a precision vibrator, Bell scientists learned to evaluate the effect of sideways motion on relay life. Such rubbing motion is limited to one-thousandth of an inch in the new relays.



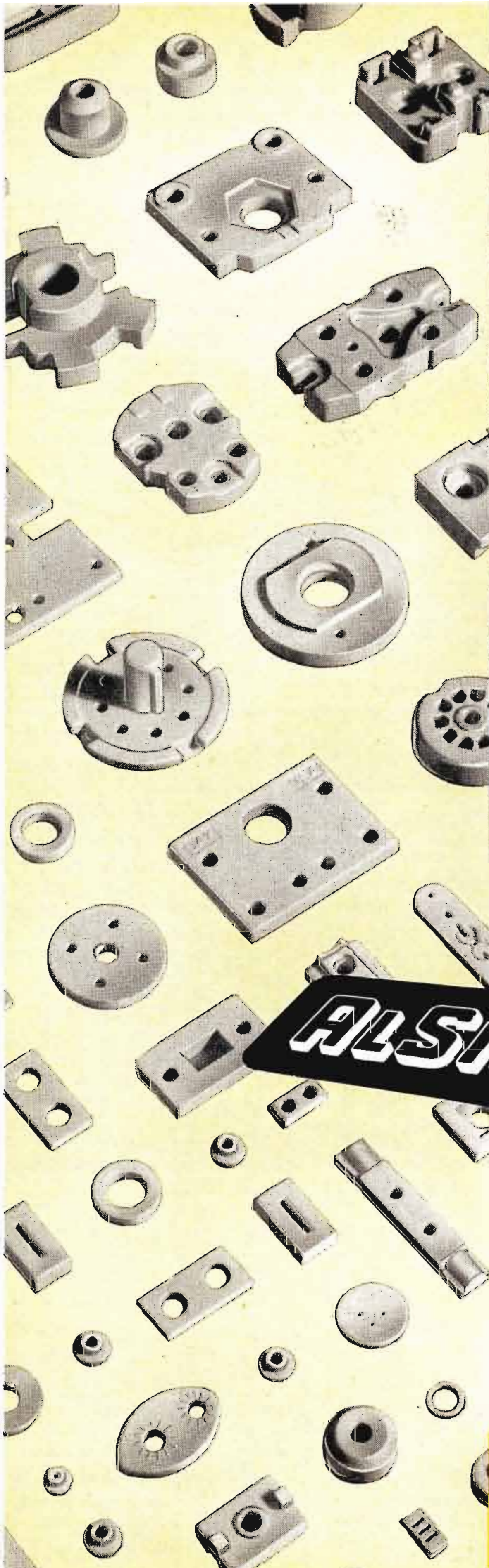
Dynamic Fluxmeter, developed by Bell Laboratories, indicates flux build-up in intervals of 25 millionths of a second. Precise information like this was essential to higher speed operation.



Relay springs as they come from Western Electric molding machine, before being cut apart for use. Molding technique saves time and money . . . makes possible the maintenance of precise adjustment.

Bell Telephone Laboratories

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS



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When you need die-pressed ceramics, American Lava Corporation has **(1) BIG CAPACITY (2) BETTER QUALITY (3) LOW COST (4) DEPENDABLE DELIVERY.** Here are a few pictures of our presses, from small tabletting presses and high speed rotaries to 100 ton hydraulics. This equipment, unmatched in the industry, is ready to serve you.

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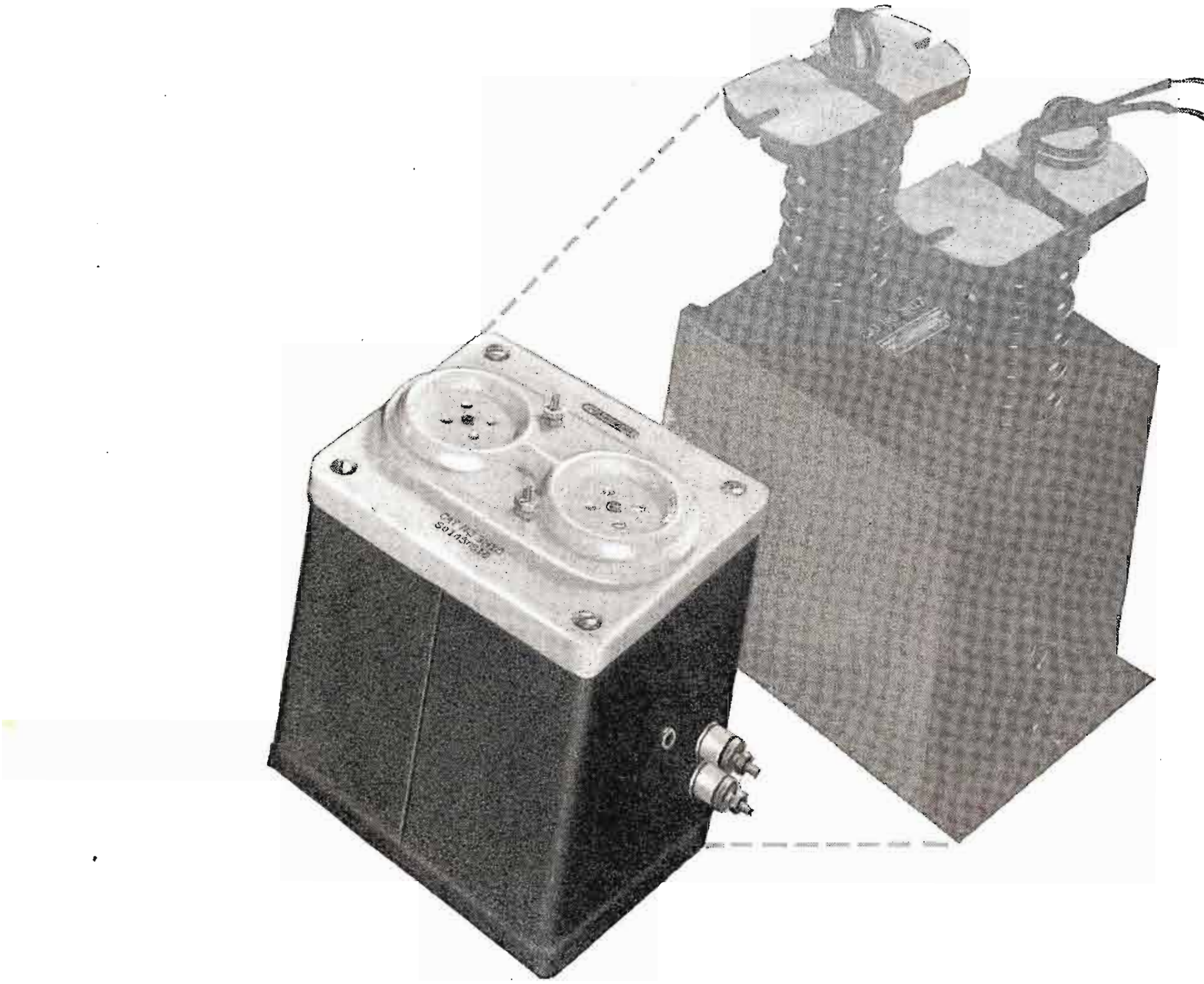


Making little ones out of big ones . . .

Many a design problem has been simplified by the Westinghouse ability to reduce transformer size and weight.

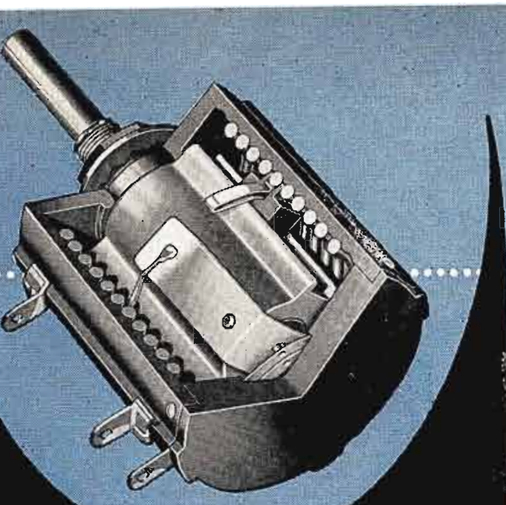
Here, for example, is a case where a transformer was required to work in a voltage-doubler circuit at 18,000 volts. The old model created a space problem.

First step in redesigning, Westinghouse engineers applied a smaller, lighter Hipersil® Core. That, plus improved insulation, made it possible to reduce coil size and spacing. Then a wet-process porcelain cap, with integral tube sockets, eliminated the need for stand-off insulators. The net result was an over-all reduction of 30% in both size and weight of the completed power unit . . . with a great big bonus: The saving to the equipment assembler in installation costs alone made the new design highly profitable, because it was no longer necessary to wire tube sockets.

Savings like this are available to you, too. If size, weight, performance, or quantity production have any bearing on your transformer problem, call your Westinghouse representative, or write Westinghouse Electric Corporation, Specialty Transformer Department, Sharon, Pennsylvania. J-70610

YOU CAN BE **SURE**... IF IT'S
Westinghouse
TRANSFORMERS

From the world's largest manufacturer of precision potentiometers . . . **Helipot**



come to **Helipot** *for the largest selection of* **multi-turn** *precision potentiometers*

advanced engineering! volume production!

HELIPOT is the organization that originated the helical potentiometer—the device that brought to electronic engineering new horizons of precise control by its greater resolution, higher linearity, mechanical precision, and broad range of resistance values. HELIPOT'S policy of constantly working to anticipate the needs of the industry has led to steady advancement in the basic multi-turn principle—and today, HELIPOTS are available in the industry's widest selection of ranges and designs to meet varying requirements.

HELIPOT offers you . . .

- **Advanced Engineering.** Through its years of leadership HELIPOT has built an organization unequalled in the industry—with trained engineers, specially-designed equipment, overall facilities to solve *tough* potentiometer problems.
- **Volume Production of Special Designs.** HELIPOT not only welcomes tough potentiometer problems, but also has expanded facilities to mass-produce special designs to rigid specifications—at economical cost!
- **Versatile Basic Designs.** Most of the basic units shown below can be readily adapted to special requirements—ganged assemblies, servo mountings, single or double shaft extensions, taps spot-welded to a *single* turn of winding at virtually any desired point, and many other individualized features to meet *your particular needs!*

Illustrated below are typical basic models of Multi-Turn Helipots . . .

MODEL A:
A 10-turn unit, approximately 1¾" diameter with 12 to 14 times the resolution of single-turn units of same diameter. Very versatile—low in price—wide range of applications.*

MODEL C:
Similar to Model A, but 3 turns of resistance winding instead of 10.*

MODELS B, D, & E:
Larger-diameter (3 5/16") designs. B has 15 turns—D, 25 turns—E, 40 turns, for applications requiring extreme ranges of adjustment and highest possible resolution.*

ultra-precision

MODELS AN, BS, BSP, & CN:
Similar to Models A, B & C in size and performance but feature precision ball-bearings and extra-close tolerances throughout. Have approximately twice the linearity accuracy of equivalent standard Helipots—are ideal servo units.*

miniature

MODELS AJ, AJS, AJSP:
Tiny multi-turn Helipots the diameter of a penny, weight 1 oz. All have 18.5" slide wire for high resolution (1/6550—50 K unit). AJ has threaded bushings, sleeve bearings . . . AJS, servo mountings, sleeve bearings . . . AJSP, servo mountings, ball bearings. Many other features.*

THE Helipot CORPORATION
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See Your nearest Helipot Representative for complete details—or write direct!

Field Offices: Boston (CO. 7-1961), New York (Rockville Center 6-3014), Philadelphia (COllingswood 5-3515), Rochester (CU. 7-640), Schenectady (DE. 2319), Cleveland (PR. 1552), Detroit (TO. 8-3130), Chicago (PA. 5-1170), St. Louis (SW. 5584), Los Angeles (RI. 1-6345), Seattle (FR. 7515), Dallas (ST. 3335), High Point, N. C. (1332) and Ft. Myers, Fla. (FO. 1285-M).
Canada: J. S. Root, Toronto (OR. 3003).
Export Agents: Frathom Co., New York City 36, (BR. 9-1296).

It makes tubes more reliable ... at less cost

SHOWN here, almost natural size, is DPi's new MB-10 Booster Diffusion Pump combined with a new port-and-valve unit. It's compact enough for any rotary exhaust machine, and it gives a big boost in performance—two ways.

1. This pump gives you a vacuum higher than 0.1 micron Hg at the tubulation before getter flash and in less time than other diffusion pumps of comparable size. Results: less residual gas to be gettered, less getter required, less getter deposited to affect operating characteristics, less gas that can be released from the getter to shorten tube life.

2. Despite the high ultimate vacuum, the pump tolerates high enough forepressure so that it can be installed in almost any rotary machine without extensive changes in slide valve and sweeps. For larger tubes, the port-and-valve can be adapted to permit rough pumping independently of the diffusion pump.

The unit is designed for easy installation of a leak detector to check bad seals or machine leaks. Valving is done mechanically, requiring no electrical circuits. The pump jet is specially designed for easy cleaning.

For complete engineering data, write to ***Distillation Products Industries,*** Vacuum Equipment Department, 629 Ridge Road West, Rochester 3, N. Y. (Division of Eastman Kodak Company).

high vacuum research and engineering

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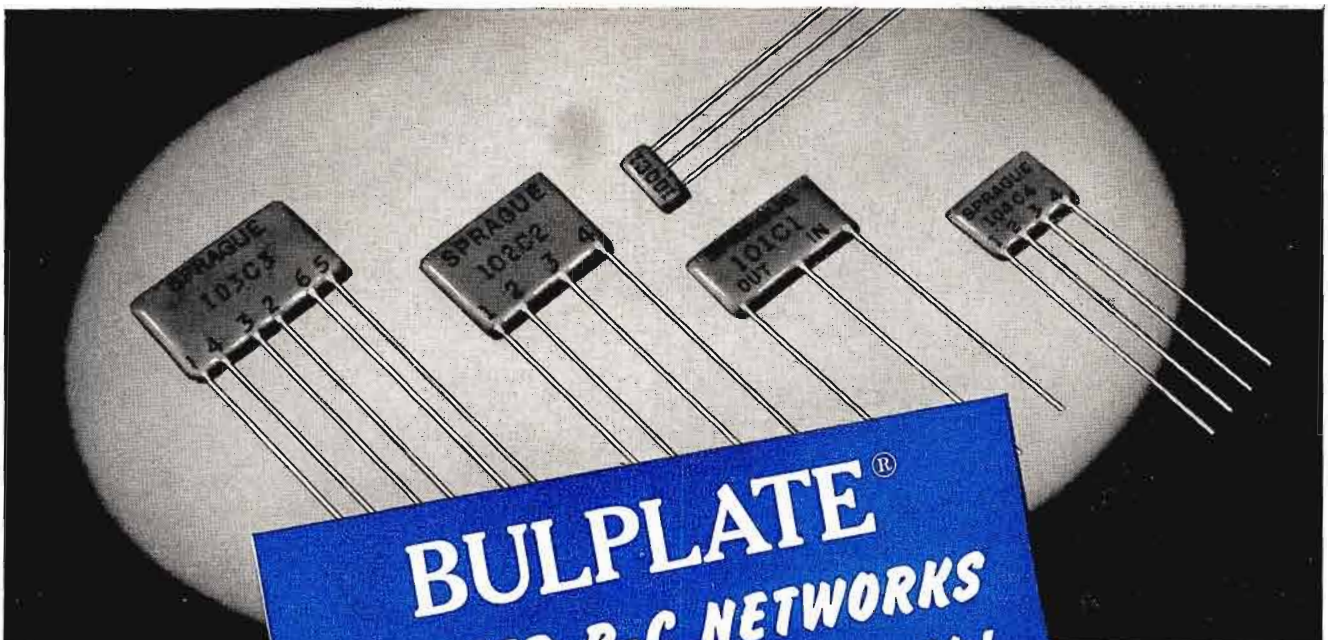
Also . . . vitamins A and E . . . distilled monoglycerides . . . more than 3500 Eastman Organic Chemicals for science and industry



BULPLATE®

PRINTED R-C NETWORKS

Can save you money, time, trouble!

Printed circuits like those shown here offer important advantages in radio and TV production—fewer parts to purchase, inspect, handle, and stock; fewer soldering operations and quicker assembly with minimal wiring errors; faster and easier inspection; greater compactness; and lighter weight. And usually they cost less than the individual capacitors and resistors they replace!

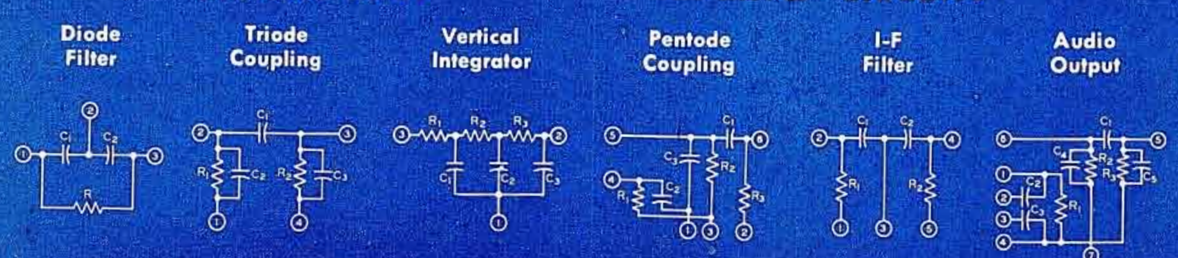
BULPLATE Printed Circuits are a logical outgrowth of Sprague-Herlec BULPLATE Multiple Ceramic Capacitors, first to use the active dielectric as a supporting medium for printed wiring. The printed resistor elements of these plates have proved to be highly stable, another important Sprague contribution.

Thousands of BULPLATES are now in use in radio, television, and military electronics. Are you overlooking a winning bet for your production?

And remember—if you have a special problem on a network which must perform a certain circuit function, Sprague will design it for you.

Write today for Engineering Bulletin 650 to Sprague Electric Company, 233 Marshall Street, North Adams, Mass.

TYPICAL RADIO AND TV BULPLATE CIRCUITS



SPRAGUE

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Export Division, Cable SPREXDIV, North Adams, Mass.

TELE-TECH
& ELECTRONIC INDUSTRIES—RADIO-TELEVISION
O. H. CALDWELL, Editorial Director ★ M. CLEMENTS, Publisher ★ 480 Lexington Ave., New York (17) N. Y.

MICROWAVES - - Weapon in Global Battle of Ideas!

It is recognized generally that the nations of the free world must do their utmost to strengthen their military defenses, and to attain unification of military action, as is now being accomplished in the NATO countries. Also it is clear that we are engaged in a fundamental war of ideas. On the one hand are the concepts of free enterprise and protection of the rights of the individual. On the other is the doctrine of the collectivist state.

To prevent further loss of ground in this conflict of ideas (for we have lost to date), military action and preparedness alone are not enough. The basic concepts and advantages of freedom and individual enterprise, as vital ideas, must be carried clearly, in constructive manner, to the minds of men, particularly in the underdeveloped areas of the free world, where ignorance, poverty, and disease are exploited aggressively by the Communists. In addition, means for development of better understanding and exchange of ideas between all nations of the free world now is a primary and urgent necessity.

Can Microwaves Turn the Tide?

Luckily, we now have unique new technical means, not presently available to the Communists in any quantity, by which direct and speedy aid can be given to the peoples of these countries to vastly augment the work of teachers and specialists from the UN organizations and other agencies, who now can reach very limited numbers of people. This new means, surprisingly, is television broadcasting, combined with the new radio-relay techniques and strategically-located regional stations, on mountain-tops where available—by which, with relatively little expense and consumption of time, the people of an entire nation, or group of nations, can be reached effectively with the understandable "show-how" of sight-and-sound broadcasts.

In addition to the economic, social and cultural value of such a TV broadcast service in underdeveloped national areas, the same broadcast and relay system can carry multiple communication channels between urban centers, or between these centers and rural communities, as pointed out in TELE-TECH for November, pages 40, 41, etc. One mountain-top regional station, for example, by microwave or VHF relay to communities within its service range, could provide much-needed two-way telephone contact with the outside world. The same mountain relay stations would serve the airways and the military, by providing advantageous locations for radar and VHF ground-to-air and land-vehicle communication.

The cost of a TV and multi-channel telecommunica- of this nature, while a substantial figure, is relatively little when compared with present expenditures in other fields. The estimated cost of a complete nation-wide TV broadcast and telecommunication relay system for a country the size of Turkey or the Philippine Republic, totals less than $10,000,000. This will provide one national TV program channel, two high-quality radio broadcast program channels for linking existing AM broadcast stations, and microwave facilities for a large number of two-way telephone channels for international or intercity services.

Some Dollar Comparisons

In comparison, the cost of one B-52 bomber, with electronic equipments, totals approximately $10,000,000. The cost of one modern ocean liner (the "United States") is $78,000,000; the cost of one aircraft carrier of the Forrestal class is estimated at $200,000,000.

The cost of a national TV broadcast and relay system tion relay system linking New York City and London is estimated to be between $50,000,000 and $100,000,000. A similar type of network joining all NATO countries, and providing a coordinated system of mountain-top stations to give "blanket" coverage of the entire NATO area between England and the eastern border of Turkey is estimated to total less than $50,000,000! The known cost of the U. S. trans-continental microwave relay system, extending between the east and west coasts, is about $40,000,000—less than one-quarter the cost of one large aircraft carrier.

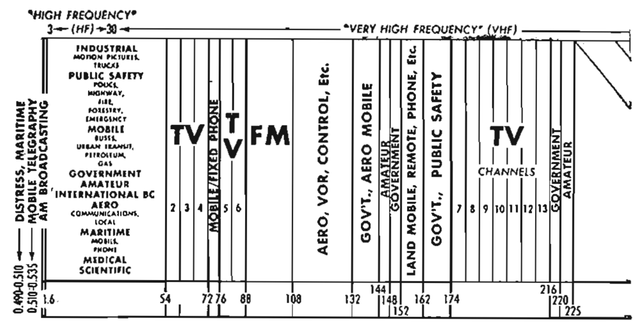
The long-range value to all nations of integrated networks of this type can be immeasurable. For military defense, for international air transportation, for international broadcast and telephone services, for unifying peoples of the free world, for better understanding between nations, and for the enrichment of the cultural, social, and economic life of all participating countries the system would be of major, lasting importance.

From microwave stations on the mountain-tops which dot most of the world, knowledge and inspiration would be drawn, giving a new meaning to the Biblical teaching—"Lift up thine eyes unto the hills whence cometh thy strength."

A guest editorial by William S. Halstead, consulting engineer, 25 Vanderbilt Ave., New York City; associate Crosby Laboratories; and co-author of the NARCOM plan for trans-Atlantic TV and global telecommunication services.

RADARSCOPE

Revealing Important Advances Throughout the Spectrum of Radio, TV and Tele Communications



INTERNATIONAL TV

EUROPEAN NETWORK—Close to 2,000,000 viewers in six European countries will watch the Coronation next summer on their television sets, if a revolutionary British Broadcasting Corporation plan works out. BBC plans to transmit its own TV coverage of the glittering pageant to France, Belgium, The Netherlands and possibly to West Germany and Denmark over Europe's first continent-wide television hook-up. It also hopes to show the televised Coronation in movie theatres in four major British cities, enabling thousands more than Britain's 1,538,550 TV set owners to see the spectacle. NBC earlier this year considered bringing the televised Coronation ceremonies to North America by means of a "moving staircase" of ten aircraft, carrying relay equipment, spaced out over the Atlantic ocean. But Romney Wheeler, NBC representative in London, reports that the project "is definitely off."

"It has fallen through because we simply could never get enough equipment," he explained. "All that kind of electronic apparatus is being used in the U. S.-Korean war effort." The BBC spokesman said his firm could transmit its Coronation coverage only "as far as the French north coast. Then it would be up to the French to relay it to the rest of the continent," he said. A conversion station will be required if the continental hook-up is to work, because BBC transmits a different type of picture (405-line) than that used in other European countries (625- and 819-line). Next to Britain, France has the largest number of video sets with 50,000—10,000 registered and 40,000 unregistered.

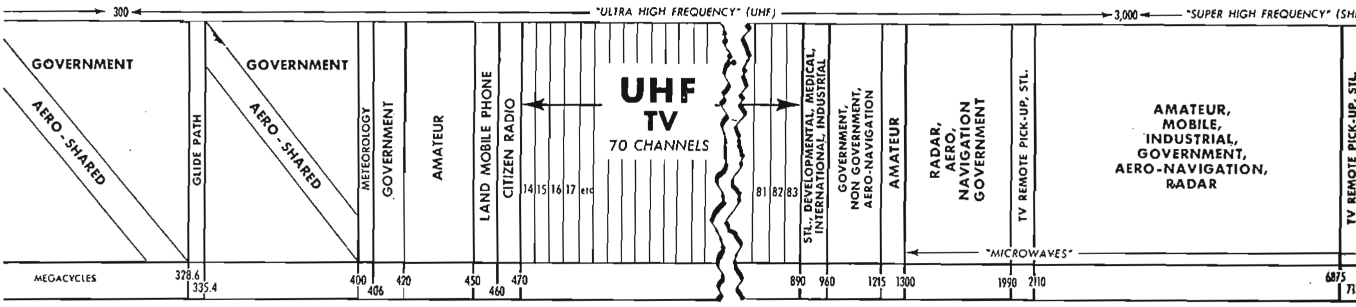
This Fairchild electronic engraver will make a four-column 85-line plastic halftone in 24 minutes, from a photograph of the same size. Already over 800 of these engraving machines have been installed in newspaper offices, making it possible for editors to produce engravings promptly and without sending the work out to the slow, old-fashioned acid-etching processes with many hand operations.

TUBES

1952 PRODUCTION—As the year closes, authoritative estimates indicate that 330,000,000 receiving tubes were made in '52 (down 12% from '51,) of which 75,000,000 were sold for replacements, while 255,000,000 went into new sets radio and TV. The average tube price at retail was $2.25, making a total value at retail of $740,000,000 for all receiving tubes sold. Picture tubes totaled 6½ million units, of which 5,300,000 went into new sets while 1,200,000 new tubes were sold for replacement (in addition to 800,000 rebuilt tubes also absorbed by the replacement market). At an average retail price of $35 per tube, the total value of all picture tubes at retail was about $227,000,000. This 1952 production represents an increase of about 29% over the 1951 output. Combined, the total retail value of all tubes sold in 1952 reached $967,000,000.

TELEVISION

REMOTE-CONTROL CAMERAS would have many applications in regular TV broadcasting, declare engineers of General Precision Laboratory. GPL's own new development has all the scope of a camera run by an operator in a studio. It swings right or left and tilts up and down to follow shifting action. Any of the four lenses may be swung into use and focussed instantly for short or long shots. The iris control may be adjusted to varying light conditions. In addition to manual operation by a camera man from afar, the unit also has a mechanical "memory" which enables it to shift instantly to any of six pre-set positions, merely by pushing a button at the distant control station. In covering baseball, for example, one pushbutton is set to cover home plate, with correct camera aim, lens and focus. A second pushbutton shifts the camera to first base, with all adjustments automatic, and four other buttons give a similar selection of pre-set positions. For network use, the unit may be installed ahead of time for coverage of conventions, or other mass meetings. From a remote vantage point, the camera will operate unattended hour after hour or day after day. Crews change places at the con-



trol station, without difficult travel to the camera site or interruptions to the program. Drapes, flowers or other decorations can make the camera relatively inconspicuous in locations where presence of a camera man might be distracting.

HOME PROJECTION

EIDOPHOR FOR HOMES?—Persons who have seen the Eidophor theatre-TV demonstrations, struck with the clarity and high illumination of the pictures, have questioned whether the Eidophor principle might not be modified for home-projection use, with large brilliant pictures. In answer to such an inquiry, E. I. Sponable, director of TV research for Twentieth-Century-Fox says: "It is unlikely that the Eidophor system will be reduced to the size of a home receiver until such time as a solid or semi-solid type of Eidophor material is developed that will be sufficiently low in vapor pressure so that it does not require continuous pumping of the system to hold vacuum. If such an improvement is made it will then be possible to place the whole Eidophor in a glass container and possible simplify it for the home market. Although such procedure has been considered, at the present time we are concentrating on commercializing the existing system for large-screen theatre use."

TRANSISTORS

TRANSISTORS & PRINTED CIRCUITS WED! Production of transistors has now reached a point where application in commercial electronic equipment becomes feasible. Initial effort of component manufacturers is to use the transistor in conjunction with a printed circuit for audio applications. First real production along these lines will probably be for hearing aids (Unofficially scheduled for Jan. 1, 1953). One TV manufacturer is also reported to be experimenting with use of transistors in the audio portion of his receiver.

STANDARDIZATION

AVIATION'S COMMON SYSTEM is almost half completed, and the plans of SC31 of the Radio Technical Commission for Aeronautics, and Special Working Group 5 of the Air Traffic Control and Navigation Panel of the Air Coordinating Committee, are well along the transition program. 438 VOR installations are expected to be completed and commissioned by fall. 250 ILS installations are well under construction. Out of 140 PAR's planned, ten are in operation, and about sixty are nearly ready for operation. Only the DME stations are in the slow-progress category—450 of these stations are envisioned, and at the present moment only eleven are in operation, and these for evaluation purposes only. However, this is a tremendous program, and progress is necessarily, generally speaking, unspectacular. One crash, due to improperly installed equipment would more than outweigh the slow but sure progress.

PERSONNEL

TRAINING ENGINEERS—Because of many inquiries asking which universities and colleges are training most of the nation's engineering students, we reproduce latest available figures compiled by the American Society for Engineering Education (Oct. 5, 1951). Statistics for the ten largest institutions offering accredited engineering courses are shown below.

	Undergraduate	Graduate	Total
1. Illinois Institute of Technology	5141	562	5703
2. Brooklyn Polytechnic	3380	1649	5029
3. Purdue University	3734	374	4111
4. University of Illinois	3102	406	3508
5. New York University	2432	921	3353
6. College of the City of New York	3026	231	3257
7. Massachusetts Institute of Technology	2359	810	3169
8. Rensselaer	2802	326	3128
9. Georgia Institute of Technology	2804	146	2950
10. Pennsylvania State	2549	79	2628

Liquid Dielectric R-F

New coax with flowing liquid dielectric performs well in indicated by twice corona rating and eight times

By R. M. SORIA, C. C. CAMILLO & J. G. KRISILAS
American Phenolic Corp., 1830 S. 54 Ave., Chicago 50, Ill.

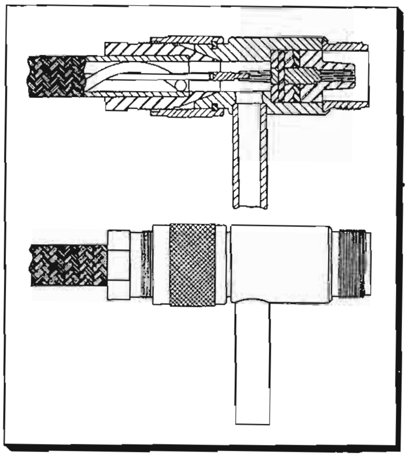


Fig. 1: Filament type liquid dielectric cable assembly employs low-reflection connectors

THE development of a flexible liquid dielectric radio-frequency coaxial cable is part of the current miniaturization program affecting all phases of the electronics industry. The demand for increased power handling capacities of coaxial cables with corresponding decrease in size and weight are of prime interest to the aircraft and allied industries. In particular, the main advantages gained by the development of a liquid dielectric coaxial cable have been the increased power handling capacities of at least eight times that of equivalent standard solid dielectric cables with no increase in the physical dimensions of the liquid cable, and the ability of the liquid cable to continue to operate under adverse environmental conditions of ambient temperatures from −65° F. to +450° F. and altitudes from sea level to 70,000 ft. Research in the fields of radio-frequency transmission lines, heat transfer and hydraulics were combined in the development of a flexible liquid dielectric coaxial cable and this paper is so divided for clarity.

A solid dielectric coaxial cable dissipates its heat to the environment by convection. At high altitudes, the "insulating" effect of the environment air is such as to greatly decrease the heat dissipation from the cable and thus the power input to the cable. In addition, if the environment temperature approaches the operating temperature of the cable, the amount of heat dissipated from the cable also decreases. However, a liquid dielectric cable, cooled by external means, will operate independently of these existing environmental conditions.

Three possible means exist for externally cooling a liquid cable:

1. Circulation of a coolant around the jacket
2. Circulation of a coolant through a hollow center conductor
3. Circulation of a coolant through the space between the center and outer conductors, that is, use of a liquid dielectric.

TABLE I

Physical Dimensions of Liquid Dielectric Coaxial Cable Sample

Symbol	Quantity	Nominal Value and Units
D_1	Center Conductor Diameter	0.085 in.
D_3	Inner Diameter of Outer Conductor	0.269 in.
D_4	Outer Diameter of Outer Conductor	0.405 in.
D_t	Diameter of Teflon Filament	0.1025 in.
A_e	Effective Cross-sectional Area for Flow of Liquid Dielectric	0.0548 in.^{2}
A_t	Cross-sectional Area of Teflon Filament	0.00825 in.^{2}
D_e	Equivalent Diameter of Effective Cross-sectional Area for Flow of Liquid Dielectric	0.1443 in.
L	Length of Cable Sample	30 ft.

The extremely poor heat conduction through high temperature solid dielectrics, such as teflon, eliminates the first possibility, while the requirements of miniaturization make the second possibility impractical. The third possibility of circulating a fluid through the space between the center and outer conductors and utilizing the fluid as a coolant and dielectric was successfully developed. The center conductor remains the same as in the solid dielectric cable while the jacket and braid are replaced by a metallic weatherproof flexible shield.

Heat Transfer Investigation

A theoretical analysis, using the established dimensional correlations of heat transfer and the theory of similarity, was undertaken to determine and predict the performance of an RG-8/U equivalent size liquid dielectric coaxial cable utilizing silicone oil as a coolant and dielectric liquid. The power handling capacity of the liquid dielectric cable was determined for variation of the environment air from −50° F. to +450° F. at normal atmospheric pressure, and from sea level to 70,000 ft. altitude at those temperatures normally existing at each elevation. The power ratings were determined for a 30 foot sample cable using the filament type construction shown in Fig. 1. Although a filament type construction was assumed for this analysis, the general results and

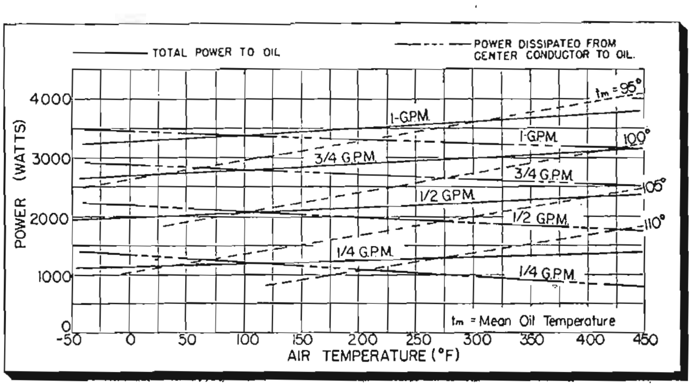
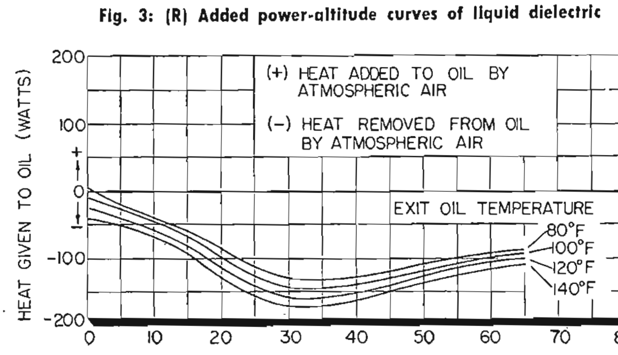


Fig. 2: (L) Absorbed power-temperature curves of liquid
Fig. 3: (R) Added power-altitude curves of liquid dielectric



Coaxial Cables

microwave region. Advance in miniaturization program power rating of equivalent standard coaxial cables

conclusions are applicable to other types of liquid dielectric cable constructions. The physical dimensions and characteristics of this liquid dielectric coaxial cable sample are presented in Table I.

As time and space preclude the presentation of the theoretical analysis, the results consisting of a working set of graphs will be presented. The following conditions were assumed to prevail in this analysis:

1. The temperature of the center conductor was assumed to be +170° F. so that a comparison of these results with equivalent size RG-8/U solid dielectric cable could be made.
2. Sufficient ultimate heat dissipating apparatus was assumed available to cool the liquid dielectric to an inlet temperature of +60° F. regardless of its exit temperature.
3. The total heat generated by the liquid dielectric cable was assumed to be generated in and dissipated from the center conductor.

TABLE II

Qualitative Rating of Flexible Outer Conductors

	Type of Tube Construction		
Characteristic	Over-lapping Strip	Deep Bellows Type	Shallow Bellows Type
(1) Liquid Seal	Very Poor	Good	Good
(2) Attenuation	High	Medium	Low
(3 Radiofrequency Leakage	High	Low	Low
(4) Flexibility	Fair	Fair	Good

The coaxial cable, under operating conditions, is thus generating heat which must be dissipated by the liquid dielectric. Superimposed upon the heating of the liquid dielectric by the center conductor is the effect of the environmental air temperature and pressure. When the environment temperature is above that of the liquid, a quantity of heat enters the cable and this additional heat load decreases the power handling capacity of the liquid dielectric cable. When the environment air temperature is below the average liquid temperature a quantity of heat flows from the cable to the environment which increases the power rating of the cable. Heat is transferred from the inner cable surfaces to the liquid by the mechanism of forced laminar convective heat transfer while the heat transferred from the outer cable surface to the environment air is by natural or free convection.

Results of Calculations

The results of the calculations with the cable at sea level for various environment temperatures are shown in Fig. 2.

The power absorbed by the liquid dielectric from the center conductor and the total power absorbed (taking into account the effect of the environment air) are plotted versus the air temperature with the flow rate and mean liquid dielectric (oil) temperature as parameters. It may be seen that the amount of heat absorbed by the liquid increases only slightly as the environment air temperature increases since the amount of heat transferred between the cable and the environment air is much smaller than the amount of heat transferred to the liquid from the center conductor.

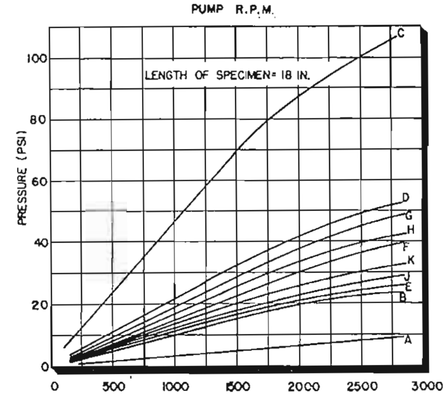
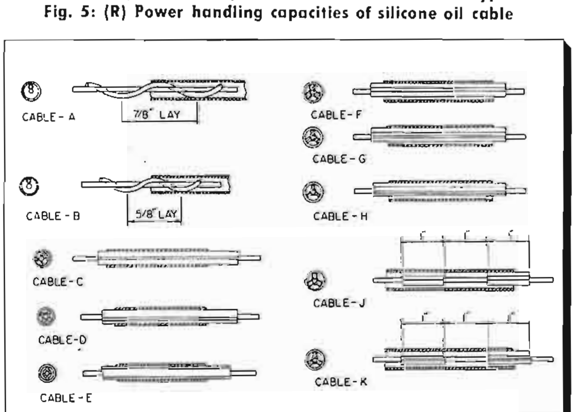


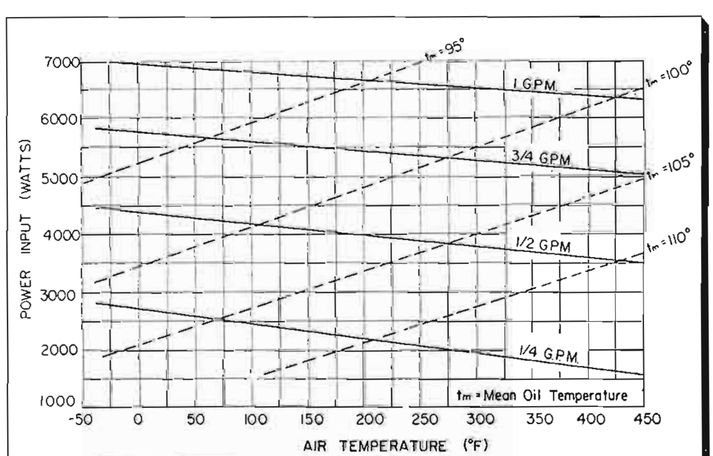
Fig. 6: Pressure drop for various cable types

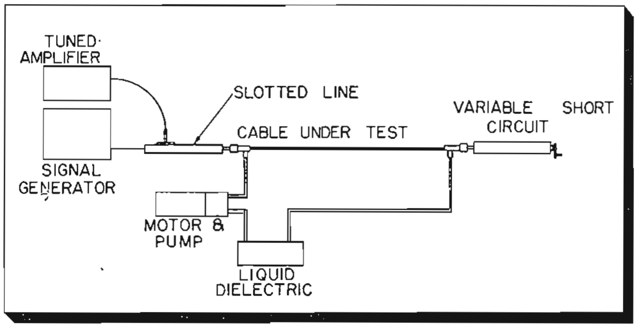
The effect on the power handling capacity of a decrease in atmospheric pressure (increase in altitude) was also derived since the temperature and density of the air decreases as the altitude increases. Fig. 3 is a plot of the heat lost from the cable to the atmosphere for various altitudes with the oil exit temperature as a parameter. The cable in every case gives up heat to the environment, thus, the power handling capacity increases slightly at various altitudes, assuming that the environment air surrounding the cable is at the same temperature normally existing at the particular altitude. The amount of heat removed from the liquid by the environment increases from sea level to approximately 32,000 ft. because of the predominant role of the low atmospheric temperatures, and decreases at altitudes above 32,000 ft. because of the increasing insulation effect of the rarefied air.

The values of the power input to the cable, calculated from the power

Fig. 4: (L) Various liquid dielectric coaxial cable types
Fig. 5: (R) Power handling capacities of silicone oil cable







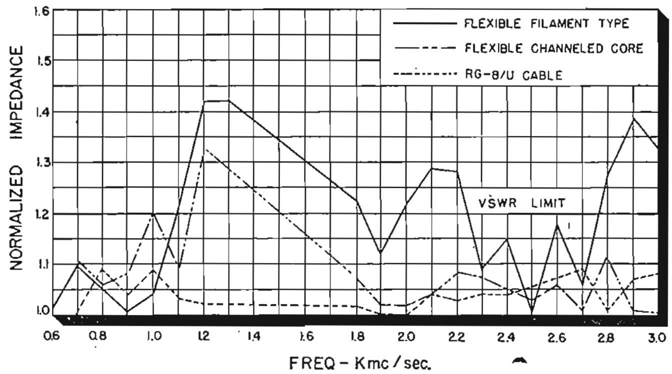


Fig. 7: (L) Set-up for slotted line variable short-circuit measurements. Fig. 8: (R) Normalized impedance versus frequency for various cable samples

attenuation relation, were plotted versus the environment air temperature with the flow rate and the mean liquid dielectric temperatures as parameters, as shown in Fig. 5. These curves enable the prediction of the operational characteristics of the liquid dielectric cable, giving the maximum power input value and the resultant average liquid temperature for any environment air temperature and desired flow rate.

Power Handling Capacity

It can be concluded that the power handling capacity of liquid dielectric cables remains relatively constant, within ±10%, as the air temperature varies from —50° F. to +450° F. The effect of the variation of altitude is negligible; affecting the power rating a maximum of ±3% at 32,000 ft. and may thus be disregarded for all practical purposes. The average liquid temperature also remains within a small temperature range regardless of the variation of the environment air temperature or altitude. The power handling capacities for liquid dielectric cables having other physical dimensions, other types of dielectrics, other environmental conditions, and other attenuation values may be computed in a similar manner. It therefore follows that the power handling capacities of liquid dielectric coaxial cables remain practically constant regardless of the existing environmental conditions.

In addition to the development of a suitable cable construction permitting the use of a liquid as a coolant and dielectric, it was necessary to design the cable so that sufficient flow rates to satisfy the heat transfer requirements could be attained with minimum friction losses. Pressure requirements within 100 psi for a 25 foot cable length were desirable to permit the utilization of low cost fractional horsepower, positive displacement pumps.

Performance tests were conducted with mineral and silicone oils to determine the pressure losses of the cable samples described in Fig. 4. The pressure drop values at various flow rates to maintain the desired rates of heat transfer are presented in Fig. 6. The data for both the silicone and mineral oils are comparable.

Hydraulic Characteristics

The best hydraulic characteristics were exhibited by cables No. A and B in which a filament was spirally wound around the solid or stranded center conductor and spaced such that the ratio of the outer conductor diameter to the inner conductor diameter remains constant when the cable is flexed. The liquid dielectric may then be circulated in the space created by the dielectric filament which separates the center conductor from the outer conductor while the required rates of fluid flow, from heat transfer considerations, may be maintained with minimum pressure requirements. Although the channel type constructions E and H have less desirable pressure characteristics, the pressure loss can be materially decreased by making the supporting ribs thinner and thus increasing the effective flow area.

In addition to the investigation of the friction losses, the determination of the heat transfer characteristics required knowledge of the type of flow encountered in the liquid dielectric cable. The Reynold's number, a dimensionless correlation of the fluid velocity, channel diameter, and kinematic viscosity, is used to describe the prevailing characteristics of fluid motion. For Reynold's numbers greater than 2100, the flow is described as being turbulent, while for Reynold's numbers below 2100, the flow is described as being laminar or streamlined. The Reynold's numbers of the filament and three-legged channeled cable constructions are approximately 50

TABLE V

Characteristic Impedance Versus Frequency of Liquid Dielectric Cables Mineral Oil Dielectric

Frequency Kmc	Characteristic Impedance—Ohms Filament Type	Channeled Core	RG-8/U Cable
0.70	55.0	44.9	50.0
0.80	52.6	52.9	54.5
0.90	50.3	45.8	52.0
1.00	47.9	41.4	54.5
1.10	41.3	45.9	49.4
1.20	35.2	37.5	51.1
1.80	40.6	46.5	49.1
1.90	44.5	48.9	49.7
2.00	40.9	49.1	50.0
2.10	37.6	47.9	47.8
2.20	37.7	46.0	48.3
2.30	55.1	46.6	47.9
2.40	43.7	47.6	47.9
2.50	49.8	48.6	47.2
2.60	42.3	47.2	46.4
2.70	47.4	50.5	45.8
2.80	39.1	44.6	49.3
2.90	36.0	50.5	46.7
3.00	37.5	50.0	46.3

TABLE III

Properties of Liquid Dielectrics

Property	Requirement	#9996-100 Silicone Oil	#340 Mineral Oil
Loss Tangent	<0.0006 (1 to 10,000 mc)	0.00006 (1 mc)	0.00065 (1000 mc)
Dielectric Permittivity	1.7-2.5	2.58	2.3
Density, gms/cc	2.0	0.9653	0.890
Boiling Point ° C.	200	—	260° C
Viscosity, SSU	65	650	369.6
Specific Heat, Cal/gm ° C.	0.25	0.370	0.278
Flash Point, ° C.	350	350	200°

TABLE IV

Physical Characteristics of Experimental Liquid Dielectric Cables

	Cable A Filament Type	Cable B Channeled Core
Center Conductor	19 Strands #25 Tinned Copper Wire	7 Strands #21 Copper Wire
Center Conductor Support	0.108 in. diameter Teflon	Three Legged Polyethylene Core
Outer Conductor	Titeflex #136-5 Flexible Metal Bellows	Titeflex #136-5 Flexible Metal Bellows

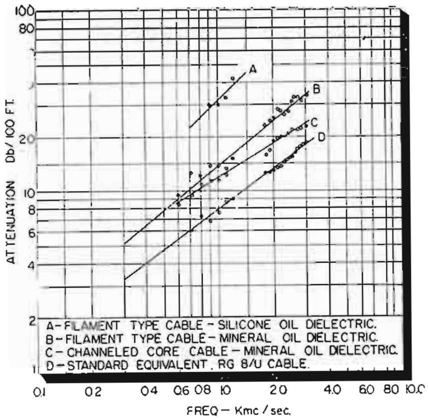


Fig: 9: Attenuation-frequency characteristics of three oil dielectric and standard cables

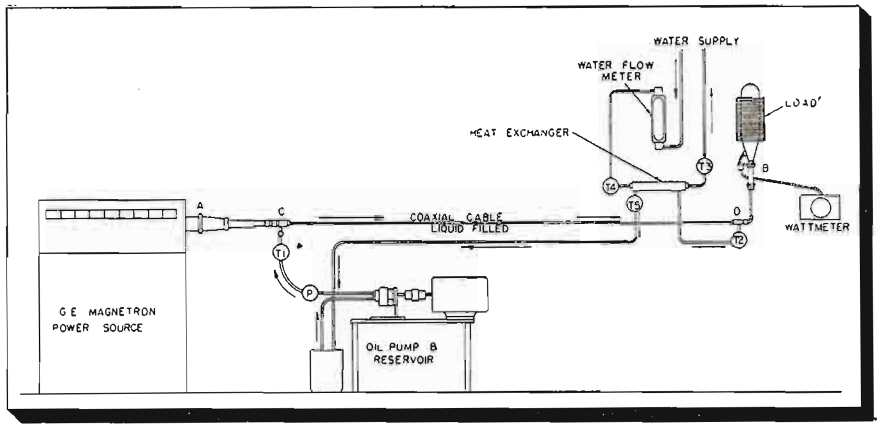


Fig. 10: Experimental installation for measurement of power ratings of coaxial cables. The r-f generator power source is variable from 100 to 5000 watts at a fixed frequency of 915 mc

which indicates that a very laminar flow exists.

The main requirements, from the electrical viewpoint, for the practical application and utilization of liquid dielectric coaxial cables are as follows:

1. The power rating must be at least eight times that of equivalent size standard solid polyethylene dielectric coaxial cables.
2. The support mechanism must hold the inner conductor in its

(*Continued on page* 110)

TABLE VI

Power Rating Exploratory Test Results

Cable Power Input (watts)	Cable Power Output (watts)	Liquid Dielectric Temp. Rise (° F.)	Liquid Dielectric Flow Rate (g.p.m.)
1500	725	63.0	.176
1600	810	55.8	.220
2400	1200	73.8	.228
3075	1575	69.3	.330
3760	1920	81.0	——

TABLE VII

Liquid Dielectric Temperature Versus Flow Rate

Cable Power Input (watts)	Cable Power Output (watts)	Liquid Dielectric Temp. Rise (° F.)	Flow Rate (g.p.m.)	Liquid Dielectirc Pressure (psi)
2800	1775	25.2	.252	93
2800	1825	28.8	.238	84
2800	1850	30.6	.224	75
2800	1850	34.2	.189	61
2800	1890	39.6	.160	50
2800	1920	50.4	.139	40
2800	1920	64.8	.105	29

Coaxial Cell for Microwave Spectroscopy

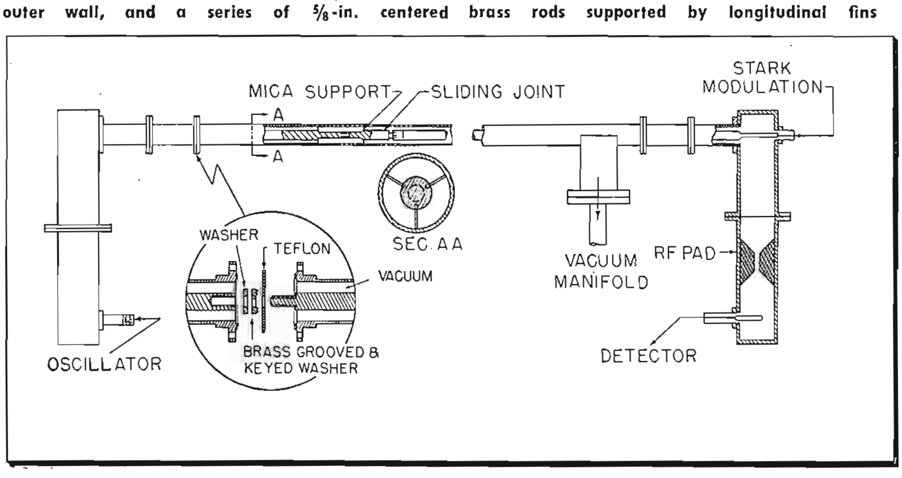
A coaxial absorption cell, recently developed by the National Bureau of Standards, permits an extension of microwave gas-absorption investigations to a new and extremely low range of frequencies. The cell is now being employed in spectroscopic investigation of gaseous compounds over a broad range of microwave frequencies. Already its use has led to the discovery of the full series of absorption lines of the deutero-ammonias. The apparatus is conveniently small-sized and is designed to function between 900 and 3400 MC without changing either the gas sample under investigation or the spectroscope absorption cell as the operating frequency is varied.

Properties of Gases

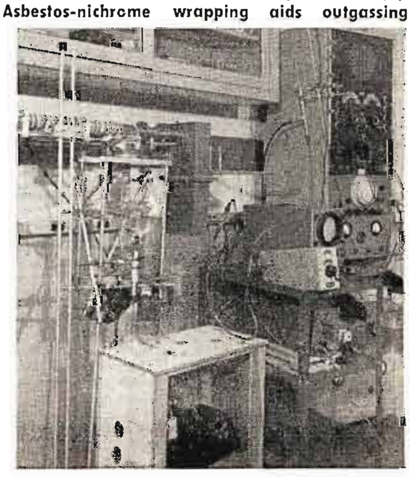
In recent years microwave spectroscopic techniques have come to be used in many laboratories to provide supplementary information on the atomic and molecular properties of gases. The method involves subjecting the gas to an electromagnetic field and varying the frequency of the field over broad ranges that include the natural resonant frequency of the gas molecule. A sharp decrease in the detected radio-frequency energy at a point of resonance provides a measure of the gas absorption. A metallic waveguide serves both as the gas container and as the instrument for the propagation of the radio-frequency energy. However, the size of

(*Continued on page* 128)

Vacuum-sealed coaxial Stark cell comprises a 10-ft. section of 1.5-in. brass tube which forms the outer wall, and a series of 5/8-in. centered brass rods supported by longitudinal fins



Input end of spectograph absorption cell (1). Asbestos-nichrome wrapping aids outgassing



Theatre TV Specs

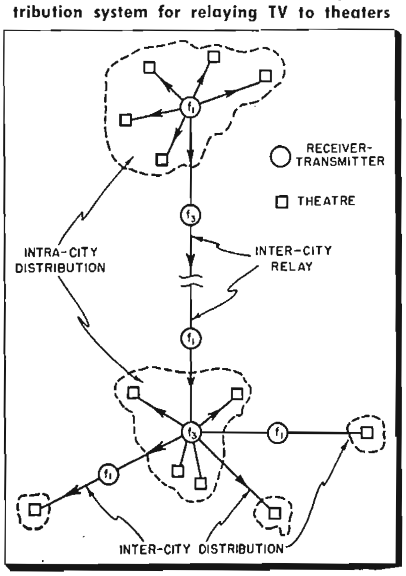
DISCLOSED for the first time, in a hearing before the Federal Communications Commission, are the engineering requirements for a far-flung TV network planned by the Motion Picture Industry. Officially listed as "Allocation of Frequencies and Promulgation of Rules and Regulations for a Theatre Television Service" this petition to the FCC was presented jointly by the Motion Picture Association of America, Inc. and National Exhibitors Theatre Television Committee. Each group has its own consulting engineers and lawyers whose efforts are coordinated under the direction of Attorney J. L. Fly.

How Does Industry Propose to Use TV?

In this October hearing only the engineering testimony was heard. In the latter half of the hearing, scheduled for January, we will learn how the movie industry plans to use television and why it will be in the public interest to set aside the spectrum space required. Cross-examination of the engineering witnesses will take place then and the Bell System engineers will have an opportunity to show how the Bell System will be able to meet the broadband TV relaying and distribution requirements of the theatre. Mr. Fly said that, instead of the Industry itself operating the proposed network, "Company X," such as Aeronautical Radio or Press Wireless, would operate the proposed system.

The meagre information now available as to the system's use indicates that entertainment features, either on film or "live," will be distributed to theatres within a city by intra-city networks; to nearby cities by inter-city circuits and over long distances, perhaps across the continent, by inter-city relay. The basic setup is shown in Fig. 1 and the planned New York-Philadelphia-Washington network is given in Fig. 2.

Fig. 1: Basic inter-city and intra-city distribution system for relaying TV to theaters



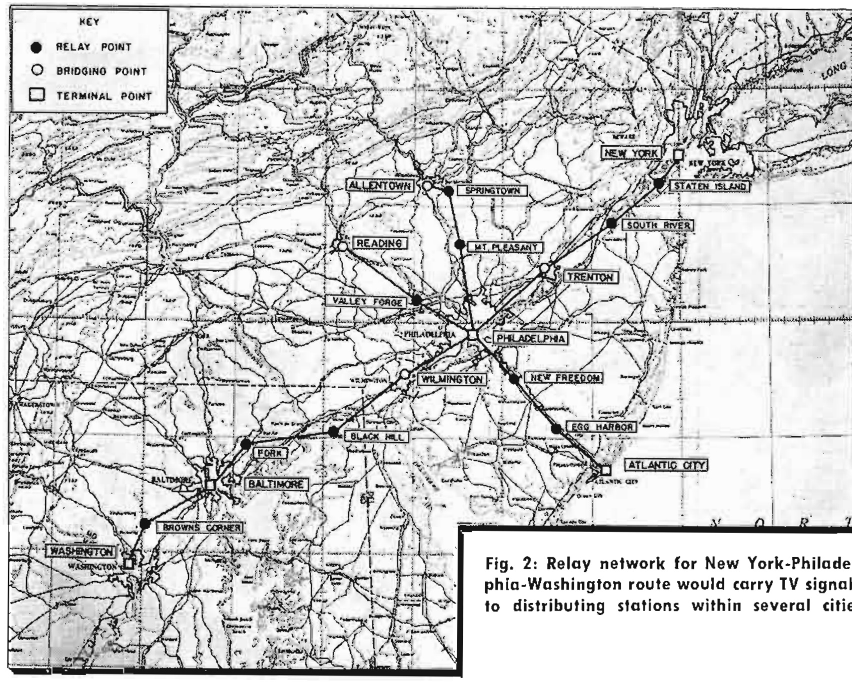


Fig. 2: Relay network for New York-Philadelphia-Washington route would carry TV signals to distributing stations within several cities

New Standards Proposed

Much engineering study and some experimentation has been carried out by the two firms of consulting engineers, McIntosh & Inglis (MPAA) and Jansky & Bailey (NETTC), and by others in the motion picture industry, in order to arrive at a proposed set of standards for this new use of TV. Assuming that the reader is familiar with the FCC standards for TV broadcasting it will be necessary to mention only the changes or additions proposed for theatre television. Briefly, the technical reasons lying behind these suggested standards will be given. Standards relate to monochrome pictures unless otherwise stated.

NUMBER OF LINES—735. Reasons: To approach the quality of a 35 mm motion picture as to resolution; freedom from spurious signals; whatever noise appears on the screen will be "fine grained" instead of "course grained."

VIDEO BAND WIDTH—10 mc. This gives a ratio of horizontal to vertical resolution of 1.5.

SIGNAL-TO-NOISE RATIO—Signal-to-weighted-Noise Ratio should be not less than 41 db for monochrome, and 37 db for color.

LINEARITY—Deviation from straight-line Transfer Characteristic shall not exceed 10%.

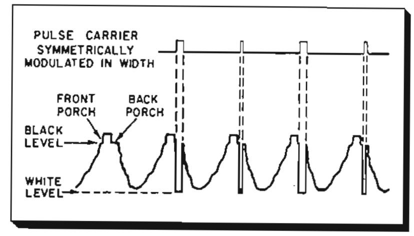
TRANSMISSION OF SOUND—Sound is duplexed on picture carrier by Pulse-Width Modulation of pulse placed on "back porch" of horizontal sync signal. See Fig. 3. Audio frequencies up to 8,000 cycles can be transmitted.

MODULATION FOR PICTURE CARRIER—Frequency modulation. Reasons: Improvement in signal-to-noise ratio; suppression of undesirable co-channel signals and the ease with which microwave tubes, especially the klystron, can be frequency modulated. Both sidebands will be transmitted.

MODULATION INDEX—0.5 (below 10,000 mc) and 2.0 (above 10,000 mc). Reason: Good compromise between spectrum space and noise suppression.

R-F BANDWIDTH—30 mc, when carrier is below 10,000 mc; 55 mc

Fig. 3: Proposed picture carrier contains sound information in pulse on back porch of sync



Proposed to FCC

Motion picture industry proposals request allocation of at least 360 MC of microwave spectrum. Signal standards for single channel include 30-MC or 55-MC r-f bandwidth, 10-MC video bandwidth, FM for picture carrier, and 735-line scanning

when carrier is above 10,000 MC. Reason: These are the bandwidths required if above standards are used and a total guard band space of 3 MC is employed below 10,000 MC. Above 10,000 MC the total guard band will be 6 MC.

FREQUENCY TOLERANCE OF CARRIER—0.02%. (FCC regulations allow 0.03%)

TRANSMITTER POWER OUTPUT LIMIT—No limit.

Allocation Principles

The FCC has not been called upon to formulate allocation principles for these new frequencies. It was suggested by the petitioners that somewhat more flexible "Industry Standards" first be set up patterned after the following:

DESIRED-TO-UNDESIRED SIGNAL RATIOS—At least 40 db for co-channel and at least 20 db for adjacent channel disturbances.

DIRECTIONAL ANTENNAS—Undesired-signal suppression of 20 db with respect to maximum radiation in major lobe shall be assumed in every other direction than that of the major lobe.

CROSS POLARIZATION—Undesired-signal suppression of 10 db results from use of cross polarization. (Based on tests made by Twentieth Century-Fox).

PROPAGATION—Assume interference only on line-of-sight paths. Also assume signal intensity along this path to be inversely proportional to the distance from the transmitter.

NUMBER OF CHANNELS PER CIRCUIT—2. Reason: Number is based on allocation considerations and requirements of theatre TV. Alternate channels should be assigned each circuit as shown in Fig. 1.

The Industry has decided that six independent circuits are required for a competitive system which will furnish the service indicated in Fig. 1. This means 12 circuits, plus 2 required on a pool basis for remote pickups, a total of 14 channels. If these are allocated below 10,000 MC the total spectrum would be 420 MC; if above 10,000 MC the total would be 770 MC, but these higher frequencies are not suitable for long distance relaying, only for intra-city distribution. For perspective, compare these figures with 498 MC, the space set apart in the VHF plus the new UHF region for broadcast television for the entire U.S.A.

PROPOSAL No. 1: Allocate 5,925 to 6,285 MC exclusively to Theatre TV. (Apparently the two remote pickup channels are left out temporarily, thus making the total required space 360 MC). Provide a transition period in which present occupants of these frequencies can move to between 6,285 and 6,425 MC. The present licensees in the requested band are the Bell System, with TV circuits and Western Union with a TV link connecting New York with Philadelphia.

PROPOSAL No. 2: If exclusive use, part of Proposal No. 1, is not feasible then classify theatre TV as an Industrial Service; expand the 6,575 to 6,875 MC band downward thus providing space for theatre TV on a frequency-sharing basis. A. T. & T. is the sole licensee in this band.

Assignments Above 10,700 MC

However, if frequencies below 7,125 MC are shared on a non-priority basis, then it will be necessary to have assignments above 10,700 MC to relieve congestion in larger population centers. In such case the assignments should start at 10,700 MC and progress upward in frequency. Such frequencies it is understood are not suitable for long-distance relay use.

Take for an example the city of Washington with its 101 movie theatres. Since 6 circuits are planned, the theatres are divided into 6 groups. Two transmitters, on elevated sites, are required but it was found that sub-distributing points would also be needed to serve a small number of the theatres so located that excessively high receiving antennas would be necessary to give them line-of-sight reception from either of the two main transmitters.

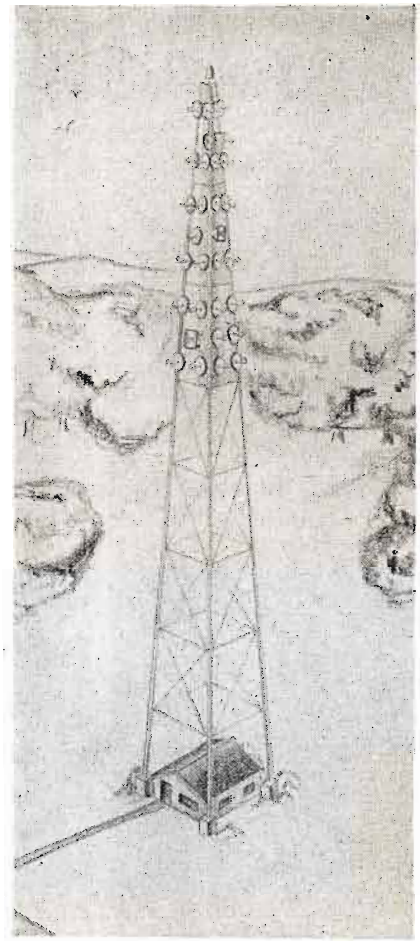


Fig. 4: Distributing station within city uses 200-ft tower to retransmit TV to theatres

At the two main distributing stations signals would be received from 3 inter-city circuits and retransmitted to the theatres. The towers, about 200 ft. high, would carry the receiving antennas and the 4-ft. paraboloid transmitting antennas, one for each theatre served. See Fig. 4. Each theatre would have its antenna supported by a tower approximately 100 ft. high, as shown in Fig. 5.

TV Projection Equipment

The systems described at the hearing were: Eidophor, Simplex Direct-Projection (General Precision Labs.) and the Film Storage System (Paramount Pictures Corp.). The RCA theatre TV equipment, which it is believed has found widest use at present, was not presented.

Tables of estimated costs of equipment, installation and maintenance for inter-city trunk systems,

(*Continued on page* 104)

Rotary Linear Microwave Phase

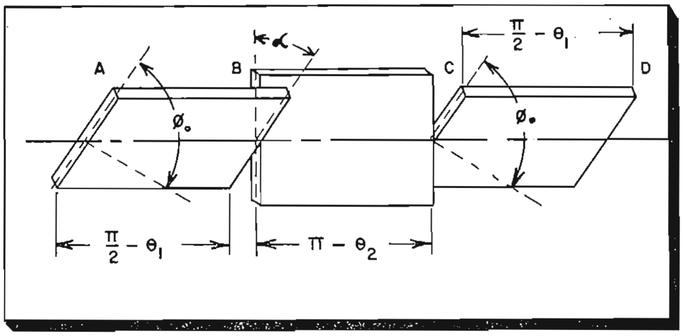


Fig. 1: Basic elements of rotary phase shifter

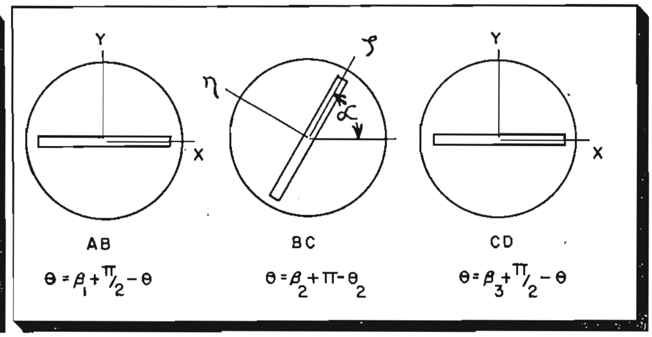


Fig. 2: Coordinate axes in phase shifter analysis

Continuously variable device employs physically-fixed terminals, measures shift in angular units. Significant advantages shown over dielectric-insert method

By *M. SIMPSON & A. SAWELSON*

W. L. Maxson Corp., 460 W. 34 St., New York 1, N.Y.

THE rotary phase shifter is designed to provide a continuously variable and linear phase shift at microwave frequencies. In this respect it is similar to an old fashioned line stretcher, with the important differences that the terminals are physically fixed, and the phase shift is measured in angular rather than linear units. If properly designed, the insertion loss due to mismatch should be infinitesimal, assuring complete transmission of incident power. The power handling capacity may be made to approximate that of the waveguide itself, by means of a design to be discussed later in this paper. The phase linearity is generally the most important characteristic of this type of unit. In this respect it has significant advantages over other types of phase shifters which depend on variable dielectric insertion or variable guide width. These units have a nonlinear phase characteristic, and therefore require linearizing elements, which place a stringent limitation on the achievable accuracy, if used in a linear system.

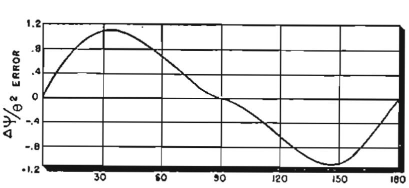
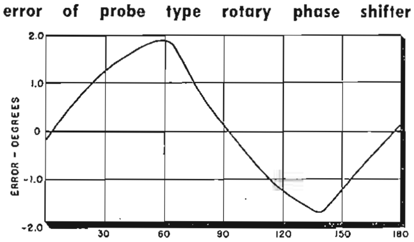


Fig. 3: (Above) Theoretical error in rotary phase shifter. Fig. 4: (Below) Experimental error of probe type rotary phase shifter



This type of rotary phase shifter was initially proposed by A. G. Fox of Bell Telephone Labs. Further work on these units was done at MIT and the Naval Research Lab.

Basic Elements

A diagram of the basic elements in the rotary phase shifter is given in Fig. 1. These elements represent plane discontinuities which effect a phase shift of the indicated amount on only one of a set of orthogonal waves being propagated in the TE_{11} mode through cylindrical waveguide. The discontinuities may be either lumped or distributed elements and are shown as plane blocks only in symbolic form.

For the purposes of initial discussion, let θ_1 and θ_2 be zero. Thus, sections AB and CD are exactly $\pi/2$ radians, while the rotating member BC is π radians. If normal rectangular waveguide is used as a transmission medium, a coupling section must be used to transform to the circular guide of the phase shifter. This coupler may be a broadband tapered unit with a gradual change from the rectangular to circular cross-section, or, as was used in our work, a compact quarter-wave transformer type coupler.

If section AB is oriented at approximately 45° with respect to the plane of the X axis in the rectangular guide, that is, $\phi_0 = 45°$, the TE_{10} mode in the rectangular guide will be split into two equal orthogonal TE_{11} modes. The principal plane of

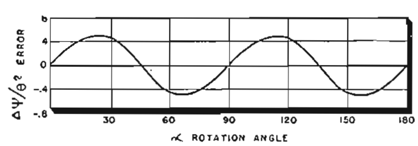


Fig. 5: Error for phase shifters in tandem

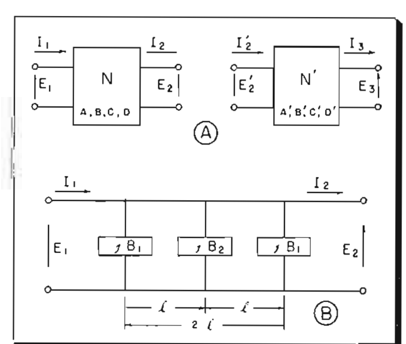


Fig. 6: (a) Generalized two terminal pair linear passive network (b) three-element network

one being parallel to the plane of AB. This mode will receive a differential phase shift, in this case 90°. Therefore at B we have the condition which can be simulated by two vectors that are in quadrature in space and time. This is obviously the condition for circular polarization.

Shifters

The direction of rotation will be from the leading vector to the lagging vector.

Let the fixed phase at the far end of section AB be designated as B, and assume that the resultant vector is rotating in the counter-clockwise direction looking into AB. Since BC is oriented at an angle α with respect to AB, the phase at the near end of BC will therefore be $(\beta_1 + \alpha)$.

Since BC is designed to have a differential phase shift of π radians, it will reverse the direction of the vector parallel to its plane. Therefore, at C, the formerly leading vector will become the lagging vector and the direction of rotation of the circular mode will be reverse to that existing at B, or, in accordance with our original assumption, clockwise looking into A.

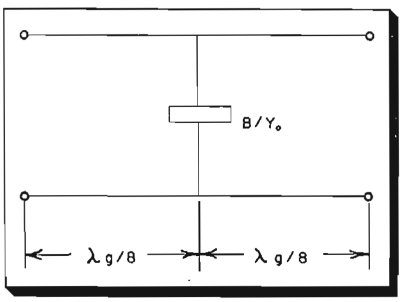


Fig. 8: Typical section of *n* element network

Resultant Wave Phase

The phase of the resultant wave at the far end of BC will now be $\beta_1 + \beta_2 + \alpha$, where β_2 is the fixed phase shift in BC. Since CD is oriented at an angle $(-\alpha)$ with respect to BC, the phase at the near end of CD will be $B_1 + B_2 + 2\alpha$.

CD produces a differential phase shift of 90° and therefore removes the time quadrature effect from the two orthogonal waves, resulting in a linearly polarized wave at D, with an additional fixed phase, β_3 due to CD. Therefore, if we neglect fixed phases, we have shown qualitatively that rotation of BC produces a phase shift directly proportional to twice the angle of rotation.

A more rigorous derivation of this effect will now be given, taking into account the error effects of θ_1 and θ_2. The following assumptions are made in this analysis:

a. Sections AB and CD are oriented at the same angle ϕ_0 with respect to the plane of the X axis of the rectangular waveguide.

b. Sections AB and CD are identical, i.e., have the same phase error θ_1.

c. Transitions and phasing sections are properly matched to the modes they are designed to propagate.

Let the axes for the three sections be chosen as indicated in Fig. 2. For the purposes of analysis the (X,Y) coordinates have been chosen parallel and perpendicular to the planes of AB and CD, while the (ζ, η) coordinates are made parallel and perpendicular to the plane of BC, which is at an angle α with respect to AB and CD.

Tables I and II give the mathematical derivation of the phase error as a function of the angle α.

The first right hand term in the phase error expression is the linear term and clearly shows that the phase shift is proportional to twice the angle of rotation of section BC. The second right hand term is the error as a function of the rotation angle, with θ_1 and θ_2 as parameters. A common error is of the type where $\theta_2 = 2\theta_1$. This would occur if two identical quarter-wave sections were placed in cascade to produce a half-wave section. In such case the phase would reduce to

$$\psi = 2\alpha + \theta^2, \sin 2\alpha \ (1 + \tfrac{1}{2} \cos 2\alpha)$$

The normalized right hand error term is plotted in Fig. 3. It is seen that this curve is a somewhat distorted sine curve and has a period of π.

Experimental Unit

It might be well at this point to compare this curve to the results obtained with an experimental rotary phase shifter unit. This experimental error curve is given in Fig. 4. Due to the nature of the assumptions made in the above analysis, the agreement between theoretical and experimental curves is considered fair. One effect that contributes to the depar-

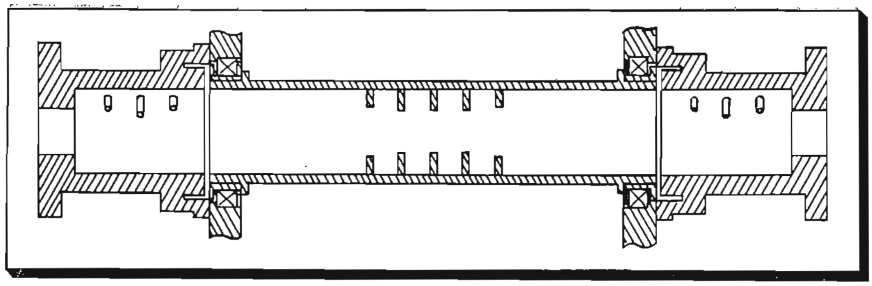


Fig. 7: Cross-sectional view of rotary phase shifter using staggered pin susceptance elements

TABLE I

$A_{(X,Y)}$	$E_X = E_Y = Ee^{j\omega t}$		
$B_{(X,Y)}$	$E_X = Ee^{j(\omega t - \beta_1 + \pi/2 - \theta_1)}$ $E_Y = Ee^{j(\omega t - \beta_1)}$	SIMPLIFIED:	$E_X = e^{j(\pi/2 - \theta_1)} = je^{j\theta_1}$ $E_Y = 1$
$B_{(\zeta,\eta)}$	$E\zeta = je^{-j\theta_1} \cos\alpha + \sin\alpha$ $E\eta = -je^{-j\theta_1} \sin\alpha + \cos\alpha$		
$C_{(\zeta,\eta)}$	$E\zeta = -e^{-j\theta_2}(je^{-j\theta_1} \cos\alpha + \sin\alpha)$ $E\eta = -je^{-j\theta_1} \sin\alpha + \cos\alpha$		
$C_{(X,Y)}$	$E_X = -je^{-j(\theta_1 + \theta_2)}\cos^2\alpha - e^{-j\theta_2}\sin\alpha\cos\alpha + je^{-j\theta_1}\sin^2\alpha - \sin\alpha\cos\alpha$ $E_Y = -je^{-j(\theta_1 + \theta_2)}\sin\alpha\cos\alpha - e^{-j\theta_2}\sin^2\alpha - je^{-j\theta_1}\sin\alpha\cos\alpha + \cos^2\alpha$		
$D_{(X,Y)}$	$E_X = je^{-j\theta_1} (je^{-j(\theta_1 + \theta_2)}\cos^2\alpha - e^{-j\theta_2}\sin\alpha\cos\alpha + je^{-j\theta_1}\sin^2\alpha - \sin\alpha\cos\alpha)$ $E_Y = -je^{-j(\theta_1 + \theta_2)}\sin\alpha\cos\alpha - e^{-j\theta_2}\sin^2\alpha - je^{-j\theta_1}\sin\alpha\cos\alpha + \cos^2\alpha$		

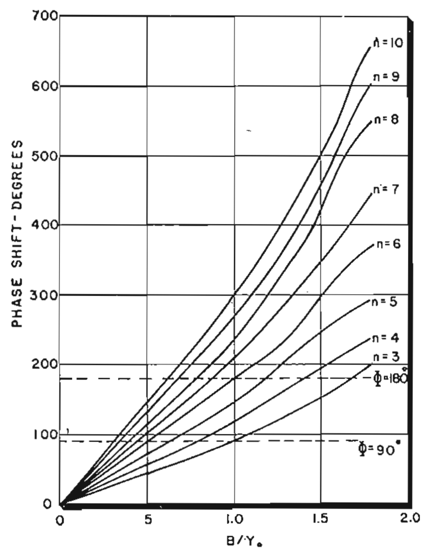


Fig. 9: Phase shift-susceptance function

ture from the theoretical curve is the non-equality of the two wave components in the phase shifter. This could be caused by some degree of attenuation in the phase shifting elements. Another source of difficulty is the imperfect match of the phase shifting elements or the transition sections, resulting in undesired reflections and additional contributions to the error term.

Many applications require the use of two or more phase shifters in a tandem or differential system. In such cases, it is possible to effect a substantial reduction in the total error by ganging them in such a manner that their individual errors will subtract from each other. This is accomplished in the simplest case by rotating one 90° with respect to the other and subsequently operating the two in synchronism. A curve of the expected error for this type of operation is given in Fig. 5.

It is seen from the previous analysis that the design of the rotary phase shifter is based on the realization of precise phase shifts of 90° and 180° in the fixed and movable sections, respectively. The phase equation indicates that the nonlinear error term is a function of the departure of the quarter-wave and half-wave sections from their prescribed values. It therefore becomes imperative to investigate carefully the various methods for producing these sections with a high degree of precision.

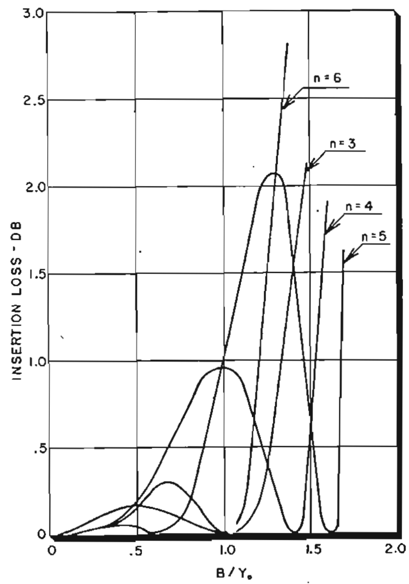


Fig. 10: Insertion loss-susceptance function

On this basis, several alternate methods for producing the required phase shifts have been analyzed. Laboratory measurements have been made to confirm this theory.

The dielectric strip is the most common technique employed to obtain variable or fixed phase shift in a waveguide. If the dielectric strip is reasonably thin, it will have an effect primarily on the wave whose maximum E field is parallel to the plane of the strip. The effect of the dielectric is to change the guide wavelength, λ_g, and thus produce a differential phase shift between the two orthogonal waves. In order to prevent standing waves from being set up in the line, matching sections must be provided at the ends of the dielectric.

To determine if the dielectric phase shift was exactly 90° or 180°, as required for the rotary phase shifter, a measurement was made of the ellipticity in the circular mode. In addition, the standing wave ratio was measured in order to optimize the match.

Although undoubtedly good for broadband applications, it was found that other lumped constant phase shift techniques were superior for narrow band, high precision uses, such as the particular phase shifter under consideration. This was due partly to the difficulty of providing an accurate theoretical treatment for the effect of the dielectric in circular guide, for the TE_{11} mode. Also there was some evidence that the finite attenuation in the dielectric made it difficult to establish two equal orthogonal waves, as required by the theory.

Metal Fin

A metal fin is another example of a distributed constant element that may be employed to produce a differential phase shift. If the fin is very narrow, it will primarily affect the wave whose maximum E vector is parallel to the plane of the fin. This results from the effective capacitor loading of the fin, resulting in a decreased phase velocity and increased phase shift. Steps or tapers are generally provided at either end for matching purposes.

At high power levels a voltage breakdown problem exists due to the high electric field that is set up between the ends of the metal fins. It was also found out that the matching was critical for this type of unit.

This leads to the consideration of lumped constant elements for use as differential phase shifters.

It is well known that very close

TABLE II

$$(E_X + E_Y) = \left[2e^{-j(\theta_1 + \frac{\theta_2}{2})}\right]$$

$$\left[\cos\theta_1 \cos\frac{\theta_2}{2}\cos 2\alpha - \sin\theta_1 \sin\frac{\theta_2}{2} - j\cos\frac{\theta_2}{2}\sin 2\alpha\right]$$

$$\tan\psi = \frac{\cos\frac{\theta_2}{2}\sin 2\alpha}{\cos\theta_1\cos\frac{\theta_2}{2}\cos 2\alpha - \sin\theta_1\sin\frac{\theta_2}{2}}$$

FOR $\theta_1, \theta_2 \ll 1$

$$\psi \approx \tan^{-1}\left[\tan 2\alpha \left(1 + \frac{\theta_1^2}{2} + \frac{\theta_1\theta_2}{2\cos 2\alpha}\right)\right]$$

BY EXPANSION INTO TAYLOR SERIES

$$\psi \approx 2\alpha + \frac{1}{2}\sin 2\alpha\,(\cos 2\alpha\,\theta_1^2 + \theta_1\theta_2)$$

FOR $\theta_2 = 2\theta_1$

$$\psi \approx 2\alpha + \theta_1^2 \sin 2\alpha\,(1 + \frac{1}{2}\cos 2\alpha)$$

TABLE III

$$E_1 = AE_2 + BI_2$$

$$I_1 = CE_2 + DI_2$$

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} \begin{bmatrix} E_3 \\ I_3 \end{bmatrix}$$

TRANSMISSION LINE SECTION OF LENGTH "l":

$$\begin{bmatrix} \cos\beta l & jZ_0\sin\beta l \\ jY_0\sin\beta l & \cos\beta l \end{bmatrix} = [u]$$

SHUNT SUSCEPTANCE "B"

$$\begin{bmatrix} 1 & 0 \\ jB & 1 \end{bmatrix} = [B]$$

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = [B_1]\,[u]\,[B_2]\,[u]\,[B_1] \begin{bmatrix} E_2 \\ I_2 \end{bmatrix}$$

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} \cos(2\beta l + \theta) & jZ_0\sin(2\beta l + \theta) \\ jY_0\sin(2\beta l + \theta) & \cos(2\beta l + \theta) \end{bmatrix}$$

$$\frac{B_1}{Y_0} = \frac{\sin\theta\cos\beta l - (1 - \cos\ )\sin\beta l}{\sin\beta l\ \sin(2\beta l + \theta)}$$

$$\frac{B_2}{Y_0} = \frac{\sin 2\beta l - \sin(2\beta l + \theta)}{\sin^2\beta l}$$

TABLE IV

$$[u] = \begin{bmatrix} \cos 45 & j\sin 45 \\ j\sin 45 & \cos 45 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ B & 1 \end{bmatrix} \begin{bmatrix} \cos 45 & j\sin 45 \\ j\sin 45 & \cos 45 \end{bmatrix}$$

$$Y = j2X$$

$$[u] = \begin{bmatrix} -X & j-jX \\ j+jX & -X \end{bmatrix}$$

$$[u] = [K] \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} [K]^{-1}$$

$$\lambda_1 = -X + \sqrt{X^2 - 1} = e^{\alpha}$$

$$\lambda_2 = -X - \sqrt{X^2 - 1} = e^{-\alpha}$$

$$\lambda_1 + \lambda_2 = e^{\alpha} + e^{\alpha} = 2\cosh\alpha$$

$$[u]^n = \begin{bmatrix} \cos\alpha n & -j\left(\frac{\sinh\alpha}{1+X}\right)\sinh\alpha n \\ j\left(\frac{1+X}{\sinh\alpha}\right)\sinh\alpha n & \cosh\alpha n \end{bmatrix}$$

$$= \begin{bmatrix} A_n & B_n \\ C_n & D_n \end{bmatrix}$$

$$\text{INSERTION LOSS: } L_n = \left|\frac{A_n + B_c + C_n + D_2}{2}\right|^2$$

$$\text{FOR } X<1\text{: } L_n = 1 + X^2 \left[\frac{\sin(\cos^{-1}X)}{\sqrt{1 - X^2}}\right]^2 = 1 + X^2 U_n^2$$

$$\phi_n = \tan^{-1}\left[\frac{\frac{1}{\sqrt{1-X^2}}\sin(n\cos^{-1}X)}{\cos(n\cos^{-1}X)}\right] = \tan^{-1}\left[\frac{U_n}{T_n}\right]$$

approximations to lumped constant susceptances may be obtained by the use of certain types of discontinuities in waveguides. In particular, thin metal posts can be used as inductive or capacitive susceptances. Moreover, if sufficiently thin, these posts may be considered to affect only one of the two orthogonal modes that are propagated in the circular guide. It is now possible to apply rigorous lumped constant network theory to the design of the quarter-wave and half-wave elements. Since the susceptance elements are discrete a matrix formulation of the problem is suggested.

The design of 90° and 180° differential phase shift sections by the use of matrix theory is shown in Fig. 6. The design equations for B/Y_0 given in Table III, are obtained by equating the A,B,C,D, constants of the actual network to the equivalent constants of the ideal lossless network containing the desired differential phase shift, θ. The solution is generally not unique. Thus, the parameter, l, or one of the susceptances, B/Y_0, or both, may be chosen to optimize the bandwidth, as shown by Simmons of N.R.L. Another design goal may be maximum power handling capacity, which would be obtained by the use of low values of susceptance.

A cross-sectional view of a rotary phase shifter using staggered pin susceptance elements is shown in Fig. 7.

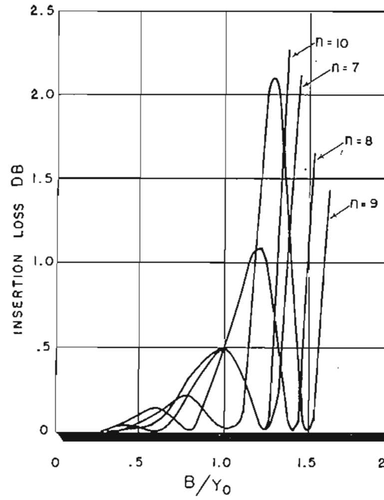


Fig. 11 Insertion loss-susceptance function

Particular attention must be given to the rotary joints. The bearings must be accurately set in order that elliptical motion is reduced to a minimum. Quarter-wave chokes are used in the rotary joints to assure good coupling between the fixed and

(*Continued on page* 100)

TIMETABLE of NEW TV STATIONS COMING on the AIR

A geographical listing of the 83 new commercial TV stations and 9 non-commercial educational oulets for which "post-freeze" FCC grants and construction permits had been issued through November 1, 1952. Where possible, estimated date for start of telecasting is shown.

STATE AND CITY	CALL LETTERS	CHANNEL	DATE ON AIR
ALA.: Mobile	WKAB-TV	48	December, '52
Montgomery	WCOV-TV	20	March, '53
ARK.: Little Rock	KRTV	17	March, '53
Little Rock	KETV	23	*
CALIF.: Fresno	KMJ-TV	24	May, '53
Los Angeles (NCE)	*	28	*
COL.: Denver	*	20	*
Denver	KBTV	9	Now on air
Denver	KFEL-TV	2	Now on air
Denver	KDEN	26	Spring '53
Pueblo	KCSJ-TV	5	*
CONN.: Bridgeport	WICC-TV	43	January, '53
Bridgeport	WSJL	49	February, '53
New Britain	WKNB-TV	30	January, '53
Waterbury	WATR-TV	53	*
FLA.: Ft. Lauderdale	WITV	17	February, '53
Ft. Lauderdale	WFTL-TV	23	March, '53
St. Petersburg	WSUN	38	May, '53
ILL.: Peoria	WEEK-TV	43	March, '53
Rockford	WTVO	39	March, '53
IND.: Muncie	WLBC-TV	49	*
South Bend	WSBT-TV	34	Maich, '53
IA.: Sioux City	KWTV	36	*
KANS.: Manhattan (NCE)	KSAC-TV	8	*
KY.: Ashland	WPTV	59	July, '53
LA.: Baton Rouge	WAFB-TV	28	January, '53
MARYLAND.: Frederick	WFMD-TV	62	*
MASS.: Fall River	WSEE-TV	46	May, '53
New Bedford	WNBH-TV	28	*
Springfield-Holyoke	WWLP	61	January, '53
Springfield-Holyoke	WHYN-TV	55	March, '53
MICH.: Ann Arbor	WPAG-TV	20	April, '53
Battle Creek	WBKZ-TV	64	*
East Lansing	WKAR-TV	60	August, '53
Flint	WCTV	28	January, '53
Saginaw	WKNX-TV	57	February, '53
MINN.: Duluth	WFTV	38	*
MISS.: Jackson	WJTV	25	December 25, '52
MO.: St. Joseph	KFEQ-TV	2	August, '53
Springfield	KTTS-TV	10	May, '53
NEB.: Lincoln	KOLN-TV	12	February 1, '53
Lincoln	KFOR	10	May, '53
N. J.: Asbury Park	WCEE-TV	58	Late '53
Atlantic City	WFPG-TV	46	December, '52
N. Y.: Albany (NCE)	WRTV	17	*
Binghampton (NCE)	WQTV	46	*
Buffalo (NCE)	WTF	23	*
New York City (NCE)	WGTV	25	*
Rochester (NCE)	WROH	21	*
Syracuse (NCE)	WHTV	43	*
N. C.: Asheville	WISE-TV	62	*
Raleigh	WETV	28	February, '53
OHIO: Akron	WAKR-TV	49	Winter '53
Massilon	WMAC-TV	23	March, '53
Youngstown	WUTV	21	July, '53
Youngstown	WFMJ-TV	73	January, '53
Youngstown	WKBN-TV	27	*
ORE.: Portland	KPTV	27	Now on air
PA.: Bethlehem	*	51	*
Harrisburg	WHP-TV	55	April, '53
New Castle	WKST-TV	45	January, '53
Reading	WEEU-TV	33	July 1, '53
Reading	WHUM-TV	61	December, '52
Scranton	WTVU	73	January, '53
Scranton	WGBI-TV	22	February, '53
Wilkes Barre	WBRE-TV	28	December, '52
Wilkes Barre	WILK-TV	34	January, '53
York	WNOW-TV	49	March, '53
York	WSBA-TV	43	December, '52
S. C.: Charleston	WCSC-TV	5	*
Columbia	WNOK-TV	67	January, '53
Columbia	WCOS-TV	25	Spring '53
TENN.: Chattanooga	WTVT	43	March, '53
Chattanooga	WOUC	49	*
TEX.: Amarillo	KGNC-TV	4	March, '53
Amarillo	KFDA-TV	10	*
Austin	KCTV	18	*
Austin	KTBC-TV	7	December 1, '52
Austin	KTVA	24	*
El Paso	KROD-TV	4	December, '52
El Paso	KEPO-TV	13	*
El Paso	KTSM-TV	9	January, '53
Houston (NCE)	KUHT	8	*
Lubbock	KCBD-TV	11	April, '53
Lubbock	KDUB	13	November, '52
VA.: Roanoke	WROV-TV	27	December, '52
Roanoke	WSLS-TV	10	January 1, '52
WASH.: Spokane	KHQ-TV	6	Early '53
Spokane	KXLY-TV	4	December, '52
HAWAII: Honolulu	KGMB-TV	9	December, '52
Honolulu	KAMI	11	Early '53
PUERTO RICO: San Juan	WKAQ-TV	2	Late '53

* Information not available at press time.

(NCE) Noncommercial educational station.

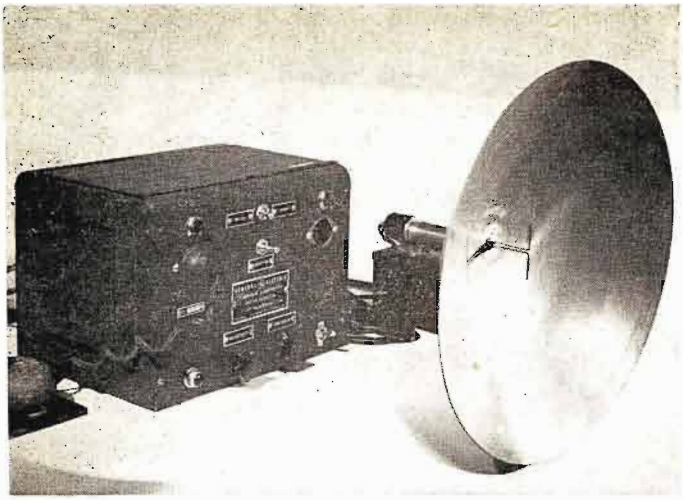


Fig. 1: Approach alarm comprises control unit, oscillator attached to dipole and reflector

Microwave Vehicle Approach Alarm

Control and monitoring device operates on Doppler reflection principle to detect moving objects

By
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The Knolls
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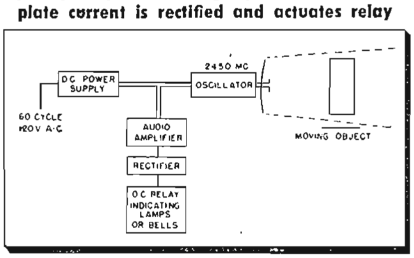
IN view of the wide use of light beams with photoelectric relays for control functions in industry, it is rather surprising that microwave beams to date have found but little application in that field.

Of course, a microwave beam is relatively broad in comparison with light for a given size of reflector or lens but, on the other hand, there are the following advantages over light: (1) The beam is not affected by snow, fog or smoke; (2) The microwaves will penetrate with little attenuation such non-conducting materials as paper, wood, brick, glass and plaster; (3) In comparison with light, microwaves can be reflected from dark, rough or irregular surfaces; (4) Doppler effect becomes of practical usefulness for objects moving in the speed range of motor vehicles.

Doppler Effect

All of these factors, particularly that of Doppler effect, are utilized in a vehicle approach alarm device recently installed in the gatehouse of the General Electric Research Laboratory at The Knolls, Schenectady, N. Y. This Laboratory is located in the open country several miles from the city of Schenectady and the main General Electric plant. The grounds are beautifully landscaped and it was felt that a gate, or even sections of a fence, near the entrance would detract from its appearance. The gatehouse at the entrance is far removed from any other structure and is at the top of a slope so that it is exposed to the wind and weather. Therefore, in bad weather it is difficult to hear the approach of an automobile and, in view of his other duties, the guard cannot continuously focus his attention on the road traveled by an approaching vehicle.

Fig. 2: Alarm operates by moving object reflecting wave to antenna according to Doppler principle. Resulting ripple in oscillator plate current is rectified and actuates relay



The frequency used by this device is one allocated by the Federal Communications Commission for industrial and experimental use. The equipment consists of a low-power (under ¼-watt) lighthouse tube microwave oscillator sending out a 2450-MC (five-inch wavelength) beam focused by an 18-in. diameter parabolic reflector. The wave reflected back to the parabolic reflector from an approaching car is higher in frequency (in cycles per second) than the transmitted 2450 MC by twice the number of five-inch wavelength distances traveled by the car per second. This factor of two results from the Doppler effect on the reflected returning wave as well as the outgoing wave. In other words, at ten miles (or 633,600 in.) per hour, the car approach is at the rate of about 35 wavelengths (of five inches) per second. Therefore, if the frequency of the transmitted beam is 2,450,000,000 cps, the reflected beam returning to the parabolic reflector has a frequency of 2,450,000,070 cps. This difference or beat frequency of 70 cps actually reacts on the oscillator and thus appears as a 70-cycle-per-second ripple in the plate current supplying the oscillator. This ripple is amplified and then rectified to operate a relay.

Thus, the effect of an approaching object in the beam is periodically to change the radiation resistance of the antenna and this change is reflected back through the oscillator to the power supply.

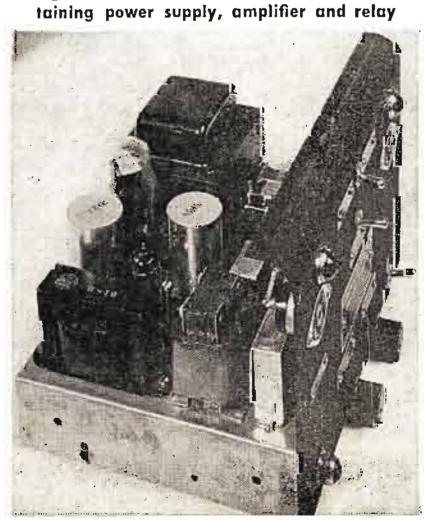
Two Units

The equipment has only two units: (1) The oscillator cavity to which is attached the radiating dipole and its parabolic reflector. This is mounted as high above the ground, up to about 12 ft., as conditions permit. (2) A small control cabinet containing power supply circuits, a low-frequency amplifier and a relay. A circuit to delay the opening of the relay for a second or two is also included. This is used to avoid repeated off-on operation of the alarm bell which might otherwise occur when the reflecting area of the approaching car passes through small-area "dead spots" that may occur in some locations.

The parabolic reflector is mounted

(*Continued on page* 151)

Fig. 3: Interior view of control cabinet containing power supply, amplifier and relay



Page from an Engineer's Notebook

Number 16—Spurious Response Chart

Curves provide convenient method of determining harmonic frequencies and crossovers produced by mixing any two signals. Chart is presented on following page

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Collins Radio Co., Cedar Rapids, Iowa

In superheterodyne receivers and other communications equipment spurious responses occur whenever two frequencies are mixed together to yield either a sum or difference frequency. Harmonics of the two mixed frequencies, at certain points in the band, will also mix together to produce the desired output frequency. This causes an audible beat or tweet when tuning a receiver. These harmonics are formed in the actual mixing process, and hence are very hard to eliminate or reduce to low levels. In certain applications they can be essentially eliminated by the proper choice of frequencies in the mixing scheme.

Unwanted Response

By means of this chart, one can determine at a glance where these spurious responses (sometimes called crossovers) occur in a given frequency scheme, and what harmonics of the mixed frequencies are producing the unwanted response. The order of the spurious response is the sum of the two harmonic numbers, i.e., if the third harmonic of f_1 and the second harmonic of f_2 are involved, then this is called a 5th order crossover. Generally, the higher the order the lower the amplitude of the crossover. This chart gives all possible combinations from 0 to 9th order crossovers.

Examples for using the chart are based on common superheterodyne receiver mixing schemes. However, the chart applies to any mixing scheme in which two frequencies, f_1 and f_2, are mixed to produce $f_1 - f_2$ or $f_1 + f_2$. In this discussion and in the chart, f_2 is always the *lower* frequency.

Example 1:

$f_1 = 20$ MC (fixed crystal)
$f_2 = 4$ to 5 MC (variable frequency oscillator or signal)
$f_{if} = f_1 + f_2 = 24$ to 25 MC (intermediate frequency)

The numbers on the chart scales will be read directly in MC. Crossovers occur whenever a line running from ($f_2 = 4$, $f_1 = 20$) to ($f_2 = 5$, $f_1 = 20$) intersects one of the ratio lines (indicated by a ratio number at the extreme right of the line). The first intersection is with ratio line $f_2/f_1 = 1/5$, and occurs at $f_2 = 4$, $f_1 = 20$. The actual crossovers at this point are read from the upper left table opposite $f_2/f_1 = 1/5$. They are:

a. $4f_2 - 2f_1 = f_2 + f_1 = 24$ MC
6th order
b. $6f_2 - 0f_1 = f_2 + f_1 = 24$ MC
6th order

Note that only numbers for sum frequency mixing are read from the table. These crossovers can be easily verified by simple mathematics, i.e.,

a. $4 \times 4 - 2 \times 20 = 24$
b. $6 \times 4 - 0 = 24$

Tabulation of the lowest order crossover at each intersection for example 1 is shown in Table I.

A crossover will occur at $f_2 f_1 = 2/9$ as shown, but it will be greater than the 9th order. In general, a crossover of some order will occur at every frequency in a mixing scheme, but those above the 9th order are not usually of practical interest.

Example 2:

$f_1 = 1.0$ to 2.1 MC (variable frequency oscillator)
$f_2 = 0.5$ to 1.6 MC (signal frequency)
$f_{if} = f_1 - f_2 = 0.5$ MC (intermediate frequency)

If we take the scales shown to read directly in MC as in example 1, the region we are interested in is located in the crowded lower corner of the chart and cannot be read accurately. However, if we divide *each* frequency scale by 10, then this region is clearly shown. Scales can be divided or multiplied by any number so long as corresponding numbers on the two scales represent the *same frequency.*

Indication of Crossovers

Crossovers occur whenever a line running from ($f_2 = 0.5$, $f_1 = 1.0$) to ($f_2 = 1.6$, $f_1 = 2.1$) intersects one of the ratio lines. A transparent straight edge is convenient for this purpose. Tabulation of the lowest order crossover at each intersection for example 2 is shown in Table II.

Notice that numbers for difference frequency mixing are now read from the table.

This chart gives the designer a visual means for locating in advance the regions in a frequency mixing scheme that will be relatively free from spurious responses.

TABLE I

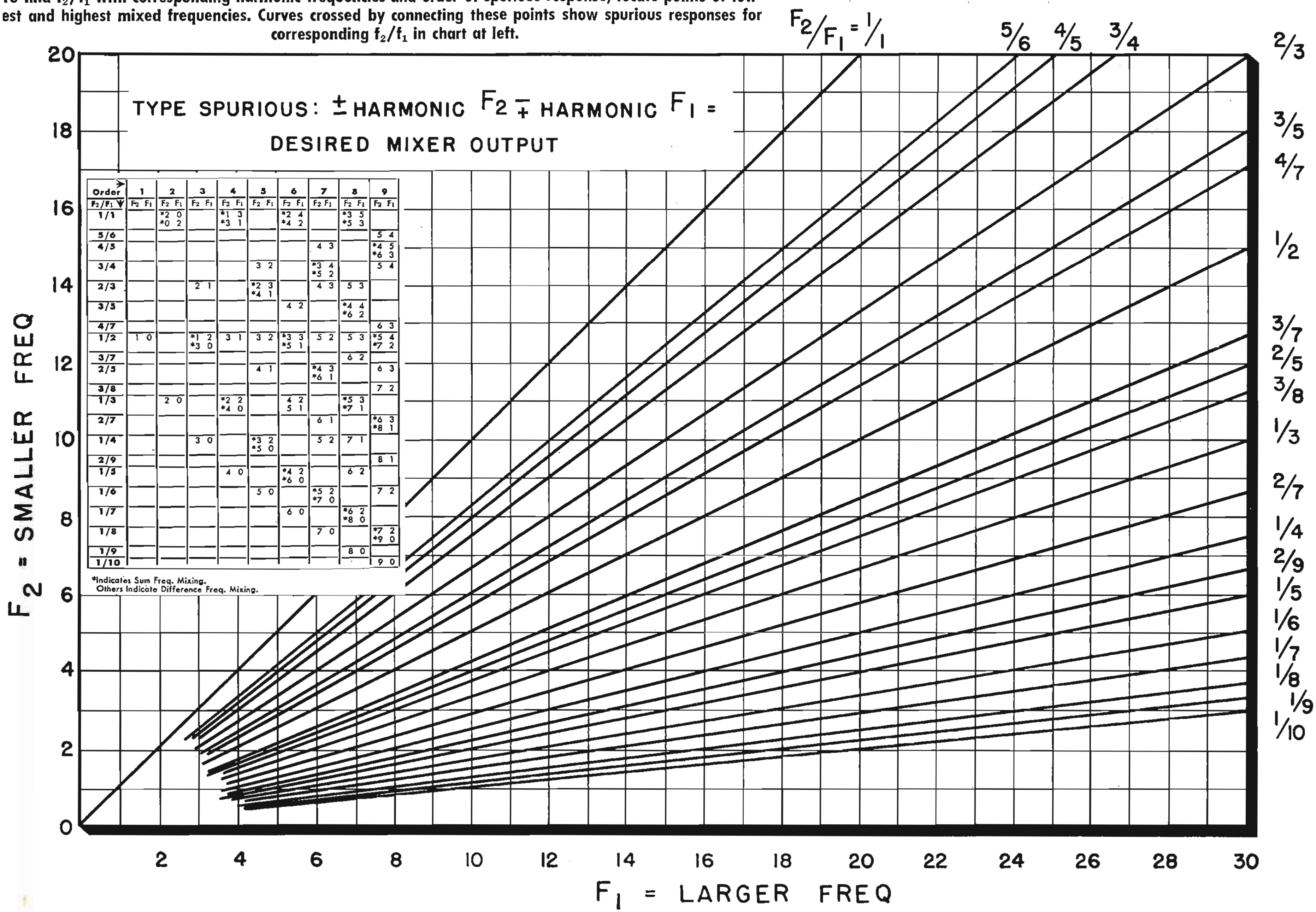
f_2/f_1	Lowest Order Spurious	f_2	f_1	Order
1/2	$1f_2 - 0f_1$	0.5	1.0	1st
4/7	$6f_2 - 3f_1$	0.6	1.1	9th
3/5	$4f_2 - 2f_1$	0.75	1.25	6th
2/3	$2f_2 - 1f_1$	1.0	1.5	3rd
3/4	$3f_2 - 2f_1$	1.5	2.0	5th

TABLE II

f_2/f_1	Lowest Order Spurious	f_2	f_1	Order
1/5	$4f_2 - 2f_1$	4.0	20	6th
1/5	$6f_2 - 0f_1$	4.0	20	6th
2/9	None below 9th	4.45	20	>9th
1/4	$3f_2 - 2f_1$	5.0	20	5th
1/4	$5f_2 - 0f_1$	5.0	20	5th

SPURIOUS RESPONSE CHART

To find f_2/f_1 with corresponding harmonic frequencies and order of spurious response, locate points of lowest and highest mixed frequencies. Curves crossed by connecting these points show spurious responses for corresponding f_2/f_1 in chart at left.



Order →	1	2	3	4	5	6	7	8	9
F_2/F_1 ↓	F_2 F_1	F_2 F_1	F_2 F_1	F_2 F_1	F_2 F_1	F_2 F_1	F_2 F_1	F_2 F_1	F_2 F_1
1/1		*2 0 *0 2		*1 3 *3 1		*2 4 *4 2		*3 5 *5 3	
5/6									5 4
4/5							4 3		*4 5 *6 3
3/4					3 2		*3 4 *5 2		5 4
2/3			2 1		*2 3 *4 1		4 3	5 3	
3/5						4 2		*4 4 *6 2	
4/7									6 3
1/2	1 0		*1 2 *3 0	3 1	3 2	*3 3 *5 1	5 2	5 3	*5 4 *7 2
3/7								6 2	
2/5					4 1		*4 3 *6 1		6 3
3/8									7 2
1/3		2 0		*2 2 *4 0		4 2 5 1		*5 3 *7 1	
2/7							6 1		*6 3 *8 1
1/4			3 0		*3 2 *5 0		5 2	7 1	
2/9									8 1
1/5				4 0		*4 2 *6 0		6 2	
1/6					5 0		*5 2 *7 0		7 2
1/7						6 0		*6 2 *8 0	
1/8							7 0		*7 2 *9 0
1/9								8 0	
1/10									9 0

*Indicates Sum Freq. Mixing.
Others Indicate Difference Freq. Mixing.

United Nations Communications Facilities

United Nations' $65,000,000 headquarters in New York City. The 39-story Secretariat Building (l), Conference Building (c) and General Assembly Hall (r) are located on an 18-acre tract

Headquarters feature impressive equipment installation for radio and TV broadcasting, simultaneous translation, inter-office communications, recording and public address

PART ONE OF TWO PARTS

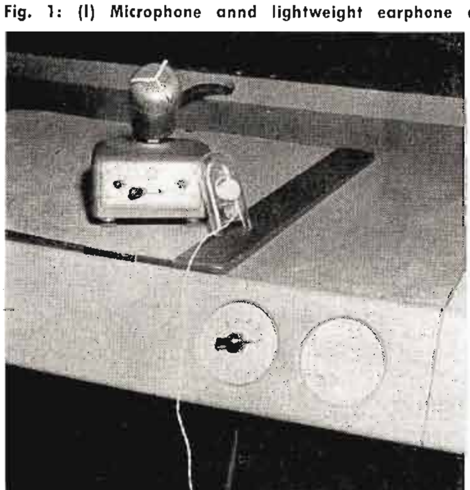
By H. B. RANTZEN, Director
Telecommunications Services Div., United Nations, New York

UNITED NATIONS plans for broadcast and electronic equipment for its new Headquarters in New York City started originally with a budget of over $2,500,000 to cover the provision of a great deal of TV, radio broadcasting, and recording and reproducing equipment, teletype and facsimile apparatus, an FM transmitter, etc. Sometime later, but after the building plans and the ducts had been designed for this range of equipment, it was found necessary to cut the budget to about one-third of the original figure by excluding from it practically everything except simultaneous interpretation and sound reinforcement, and by recovering and using again as much apparatus from Lake Success and Flushing as possible. During the last three years it has been possible to restore the position a little by introducing extensive systems simplifications, and by designing around components already commercially available rather than specially manufactured.

A number of important changes from Lake Success and Flushing practices have been introduced with the idea that services at the new Headquarters, expected to be one and one-half times as much as that at Lake Success and Flushing, could be run with the same staff. Briefly, some of these fundamental changes are:

1. All of the technical equipment for each meeting hall has been concentrated under the control of a single operator in a control room overlooking that meeting hall. For each of 12 meeting halls, a special control room with console has been equipped with apparatus racks carrying all of the sound reinforcement, switching, simultaneous interpretation, and line termination apparatus.
2. In the broadcasting studio booths, disc and magnetic reproduction apparatus has been grouped around the studio console so that the more complicated productions can be done by two technical operators, and simple speech transmissions by a single operator.
3. Original plans were for four TV cameras in each of the Plenary Hall and council chambers, and each of five conference rooms, and portable equipment available for any other location from which TV might be required. This had later to be dropped from the budget and still later when television was reintroduced, it was agreed that the producers would work "blind" in the oper-

Fig. 1: (l) Microphone annd lightweight earphone at President's table. Fig. 2: (r) Console in control booth overlooking council chamber



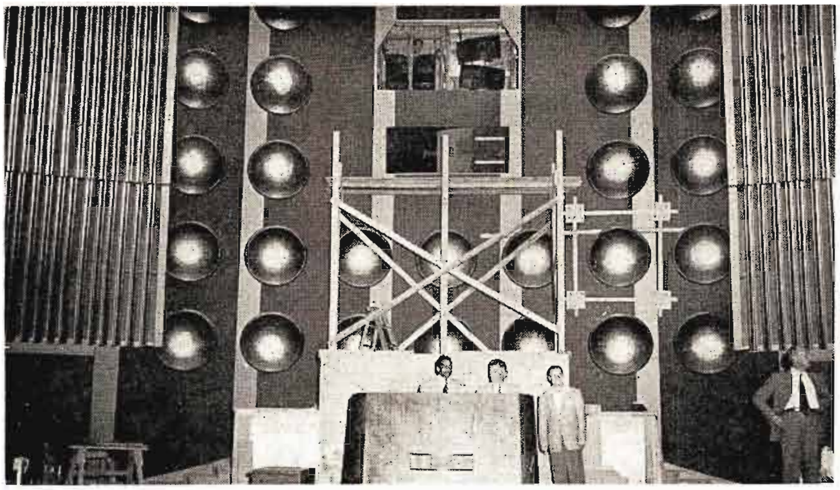


Fig. 3: Loudspeakers being mounted in their chambers above podium in the Plenary Hall

ating center where all of the camera channels and control equipment would be concentrated. From this TV center a large number of camera cables have been run through intermediate cubicles and patch panels so that routes can be established to any of the council chambers or conference rooms, or to the Plenary Hall. This has meant that fairly complete television coverage of the meetings is obtainable with three or perhaps four camera channels.

4. Apparatus in the central recording room has been laid out, so that at peak periods, it will be possible for as many as four machines to be grouped under the control of a single operator.

5. Two interview booths were provided quite close to the important council chambers and were to be wired so that simple interviews could be carried out without a technician in the booth. While operations of this type are fairly common practice abroad, it is believed that they are not in general use in commercial services in New York and the introduction of them into UN may, therefore, have to wait changes in the contractual arrangements under which technical operators are at present obtained for UN services.

6. The sound systems in the conference rooms and council chambers are such that the delegates and their advisers are served by a large number of small loud-speakers mounted unobtrusively in the edges of tables and the backs of chairs. The microphones are on the tables in front of the delegates. These arrangements give a much more even distribution of sound over the area of the "floor" occupied by the delegates than would have been possible had the more usual arrangement of loud speakers in the ceiling been adopted. The use of low level switching of microphones results in a very much simpler audio system with fewer amplifiers than would have been required had high level switching been adopted.

7. All simultaneous interpretation systems in the new buildings are of the "wired" type, and all chairs equipped with simultaneous interpretation are fixed, except for those of the delegates who obtain their simultaneous interpretation feeds from fixed tables in front of them.

Equipment Provided

In its present form the installation includes the following systems:

A. Simultaneous interpretation and sound reinforcement for the Plenary Hall, three council chambers, four large conference rooms and four small conference rooms. The Plenary Hall is just over 1.5 million cu. ft., and about 2,000 seats in it have been equipped with six-channel simultaneous interpretation; wiring has been run to thirty-four booths for radio, press, television, etc., overlooking the hall. The three council chambers each have simultaneous interpretation provided on 800 or 1,000 chairs, and there are about the same number of booths overlooking it as there are for the Plenary Hall. The eight conference rooms also have simultaneous interpretation systems.

B. Broadcasting studio equipment, including disc and magnetic reproducers have been provided for nine studios. Provision is being made so that two of the studios can be used for TV and film interviews as well as for sound broadcasting.

C. Seven or eight paging and intercommunication systems.

D. A TV installation consisting of three camera channels (a fourth, remote-controlled channel may be added) and associated equipment to permit taking pictures from any of 15 or 20 different locations.

E. 16 mm kinescope recording equipment, with rapid developer.

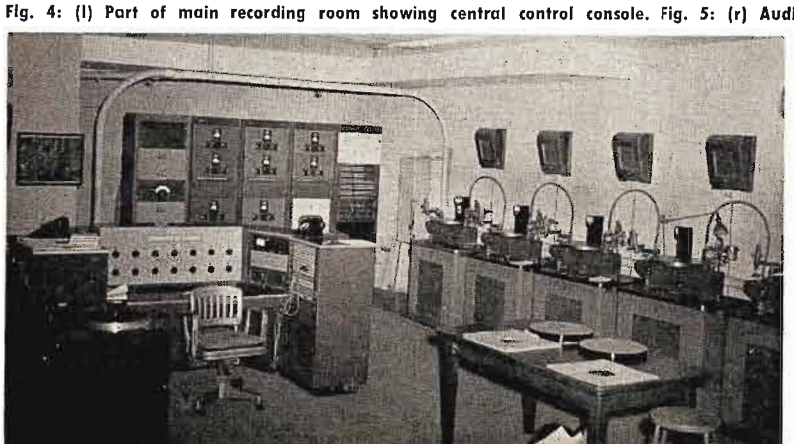
F. Fourteen channels of disc and magnetic recording in a central recording room and an associated dubbing room.

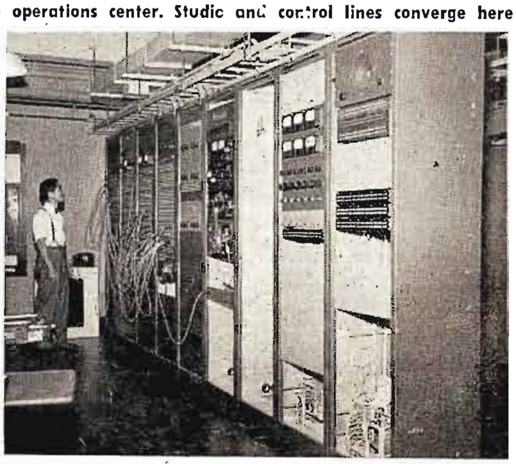
G. An office distribution system to enable about 150 staff to dial and hear on a small desk loudspeaker any of about 20 different outputs.

H. A number of auxiliary services, i.e. two controlled clock systems, an internal automatic telephone system for technical areas, a verbatim recording installation where proceedings of meetings can be recorded on magnetic tape and distributed in ten-minute sections to a number of typists so that a typed record is available a few minutes after the end of a meeting, etc.

Fig. 1 shows a typical installation on a table in front of a delegate, or rather, in this particular case, in front of the President. The switching in the base of the microphone is an arrangement developed only for chairmen or presidents of meetings. Normally, microphone switching is done in the control room by a tech-

Fig. 4: (l) Part of main recording room showing central control console. Fig. 5: (r) Audio operations center. Studio and control lines converge here





nician who looks through his window to see which speaker is being recognized by the chair. With the key in the base of the microphone in its central position, the chairman's microphone can be switched ON or OFF by the technician just like any of the other microphones. The other two positions of the key correspond to microphone ON and microphone OFF regardless of what the technical operator might do. Leaning against the base of this microphone is one of the light hearing aids (1 oz.) used by delegates in place of headphones. It is a standard hearing aid unit carried in a plastic mount which hangs on one ear.

Interpretation Switch

The two circles in the edge of the table are respectively the six-position simultaneous interpretation switch which controls the language heard in the hearing device, and one of the small loudspeakers reinforcing what is said by delegates on the floor.

Fig. 2 is a view of the console in the control booth overlooking one of the council chambers. The microphone switching keys are laid out in a pattern similar to that followed by delegates at their tables in the room below, and the two meters above them are respectively a compression meter and a volume meter for the main floor channel. Volume controls and meters for each of the simultaneous interpretation language outputs are on the right of the console, and there are five volume controls for the main floor channel itself. The microphones in front of the delegates

(*Continued on page* 124)

Fig. 6: Portable TV equipment. UN also has rapid-developing kinescope 16mm recording equip.

INERTIAL NAVIGATION SYSTEM

A military secrecy order of several years' standing has recently been lifted to allow public disclosure of a radically new and comprehensive device for air and space navigation. The new device is described in Patent No. 2,613,071 entitled "Navigation System, Including Acceleration Integration Means," granted on Oct. 7, 1952 to Paul G. Hansel.

Navigational quantities including position in space, absolute speed and direction of motion, distance from a starting point and total traversed distance are automatically computed and displayed within an aircraft or space vehicle. In addition, auto-pilot control signals are generated to provide guidance along any preset course or toward any desired destination. The device is completely self-contained and functions without reliance on ground radio facilities or on anything else external to the aircraft. It can therefore be used anywhere on the earth or in outer space without prior exploration or the installation of beacons or other facilities.

As shown in Fig. 1, the heart of the device is a gyro-stabilized multiple-axis accelerometer which senses all components of the inertial forces associated with changes in

(*Continued on page* 109)

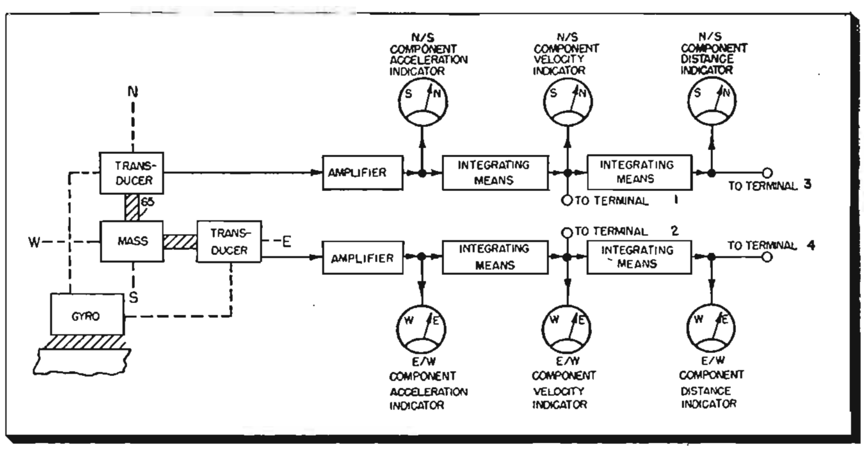
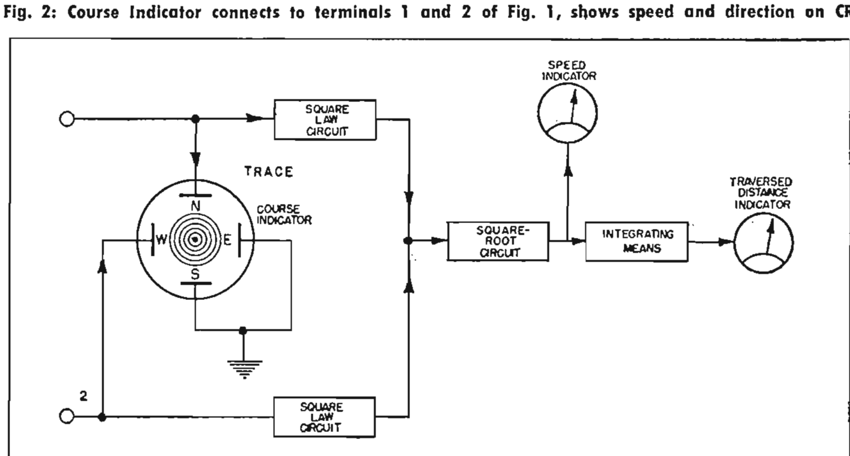


Fig. 1: Acceleration of aircraft mass accelerometer produces electrical impulses through transducers, proportional to N-S and E-W inertial forces. Integrating circuits give velocity and distance values

Fig. 2: Course Indicator connects to terminals 1 and 2 of Fig. 1, shows speed and direction on CRT



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Design Features of a

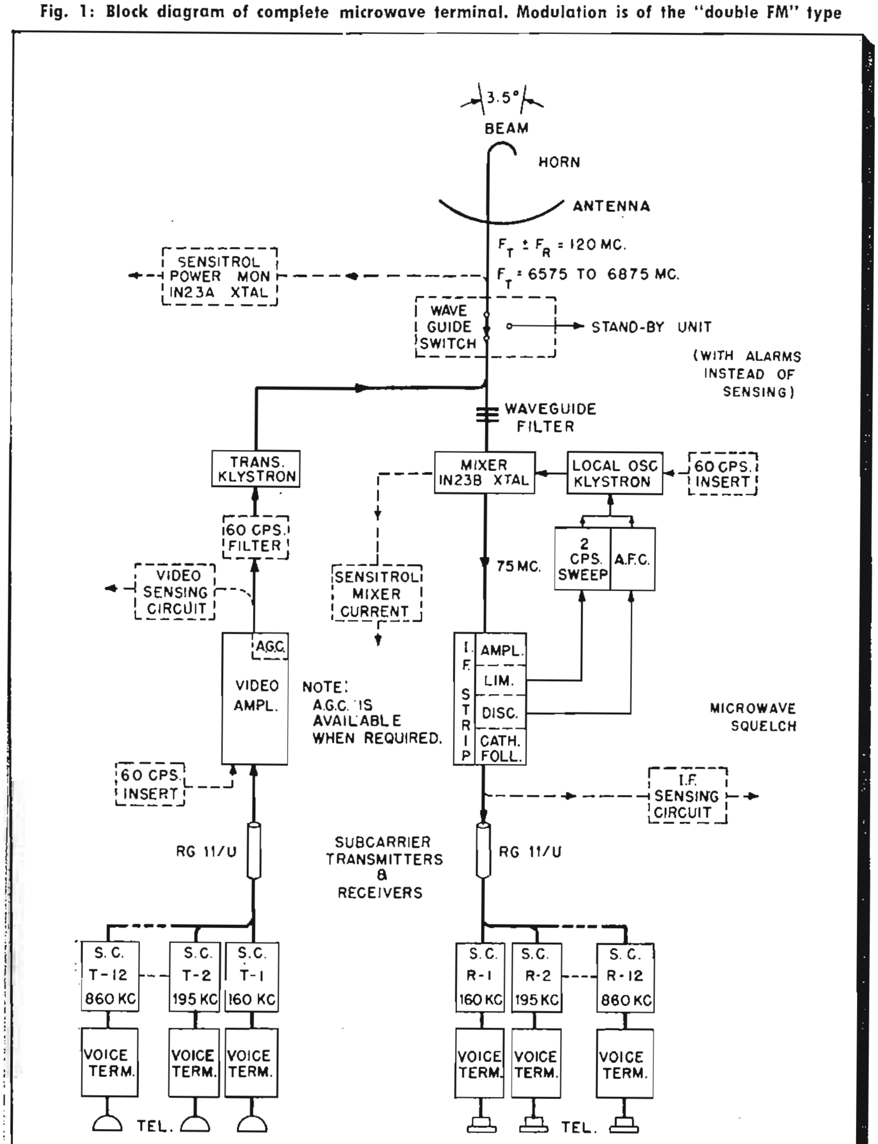
Many-faceted aspects of systems for pipelines,
scribed in detail. Packaging techniques, equip-

MICROWAVE relays (hereinafter abbreviated "MR") were originally planned to obtain radio communication with multi-channel or other wide band intelligence signals in an uncrowded part of the radio spectrum. Immediately upon completing laboratory prototypes, it was determined that these relays would be more economical than telephone lines, and would usually be more reliable because of the outages ordinarily suffered by the wire systems during severe weather. As the reliability of the MR circuit became well-known, many industries ordered systems which span distances from a few miles to a thousand or more, and such systems are now so well known that most of the generalities of system application will be avoided herein.

In approximate order of number of systems installed, the present operators of MR are oil and gas pipelines, common carriers for telephone and TV, civil and military government agencies, power companies, airports and railroads.

Fig. 1 shows the block diagram of one complete microwave terminal. Modulation is "double FM" (or sometimes "triple FM"). Each voice terminal frequency-modulates a frequency-shared subcarrier which in turn frequency modulates the microwave transmitter. As many as 24 multiplex channels are used in the double FM circuit. Modulation equipment includes telephone, circuits for voice, selective ringing, party line and conference lines; other circuits for teletype, telemetering, remote supervisory control devices; interconnections for UHF communication with patrol vehicles; alarms for remote indication at headquarters of any failure, burglary, or special phenomena which the operator wants to monitor; and in fact any conceivable signal. TV signals are also propagated, with only one or two subcarrier voice channels for supervision and maintenance.

Fig. 1: Block diagram of complete microwave terminal. Modulation is of the "double FM" type



Microwaves Preferred

Choice of Frequency: Microwaves are used in preference to lower frequency bands for quite a few reasons: Wide bandwidth is available for the communication of any presently known or desired intelligence; FCC allocations are readily available for all users, which is quite different from the present allocation problem in the lower frequency bands; and there are practically no geographical limitations on the microwave installations, except that ac power lines are ordinarily required. In some cases such as a fuel pipeline installation, such fuel is available for driving pipeline compressors and is similarly available for operating all electric equipment including MR. Microwave frequencies are entirely free from static, and no varieties of interference are likely due to the low power requirements of the microwave transmitter and to the highly directional quality of the antennas in use. At the higher microwave frequencies, waveguide is always used, and the cut-off effect prevents any lower frequency interference, regardless of its power. Right-of-way problems, pole installations, and wire line maintenance are of course entirely absent, and

Microwave Relay

PART ONE OF TWO PARTS

common carriers, government and utilities dement functions and design parameters presented

stormy weather problems which ordinarily are a hazard to wire line communications are of no consequence in the MR. Additional benefits on the military scene include the anti-jamming features of the directive antennas.

Effect of Rainfall

Fig. 2 shows the effect of rainfall on the different frequencies in the microwave spectrum. It is observed from this graph that the effect of rainfall on a station with fixed transmitter power and antenna size makes the frequencies from about 3000 to about 7000 MC the most useful in this respect. The operational (private commercial) frequency band from 6575 to 6875 MC is rapidly becoming the most widely used, along with the adjacent bands for special purposes down to 5925-6425 MC for common carrier operations. Also employed are 6425-6575 MC for mobile use, 6875-7125 MC for broadcast (TV) and 7125 through approximately 7425 MC (or Higher) for government use. This general frequency band is believed by the writer to have considerable advantage over lower frequency microwave bands.

Packaging

Fig. 3 shows a popular packaging technique. Notice that the framework channels are simultaneously a mounting for the r-f heads and other chassis, and a brace for the rigid support for the paraboloid antennas, tying the antennas to the concrete floor pad.

Fig. 4 shows a complete microwave relay station with the passive reflectors tilted to communicate along their respective paths to the next repeater or terminal stations.

Fig. 5 shows the r-f heads with control panel and a hand wheel for rapid disconnect. Each shelter contains duplicate frames as shown for West and East communications, and a duplicate set of equipment in each frame for main communication and standby communication, the standby being automatically connected whenever the main unit fails. Un-

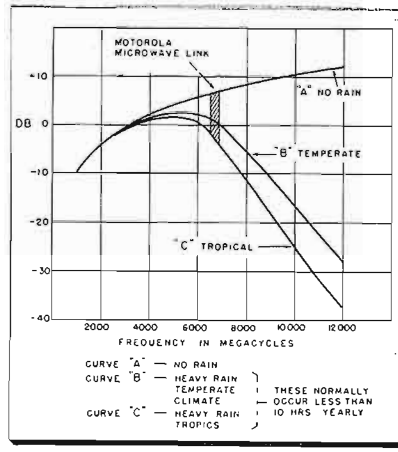


Fig. 2: Rainfall effect on microwave band

Fig. 3: Equipment layout shows packaging technique presently used for microwave stations

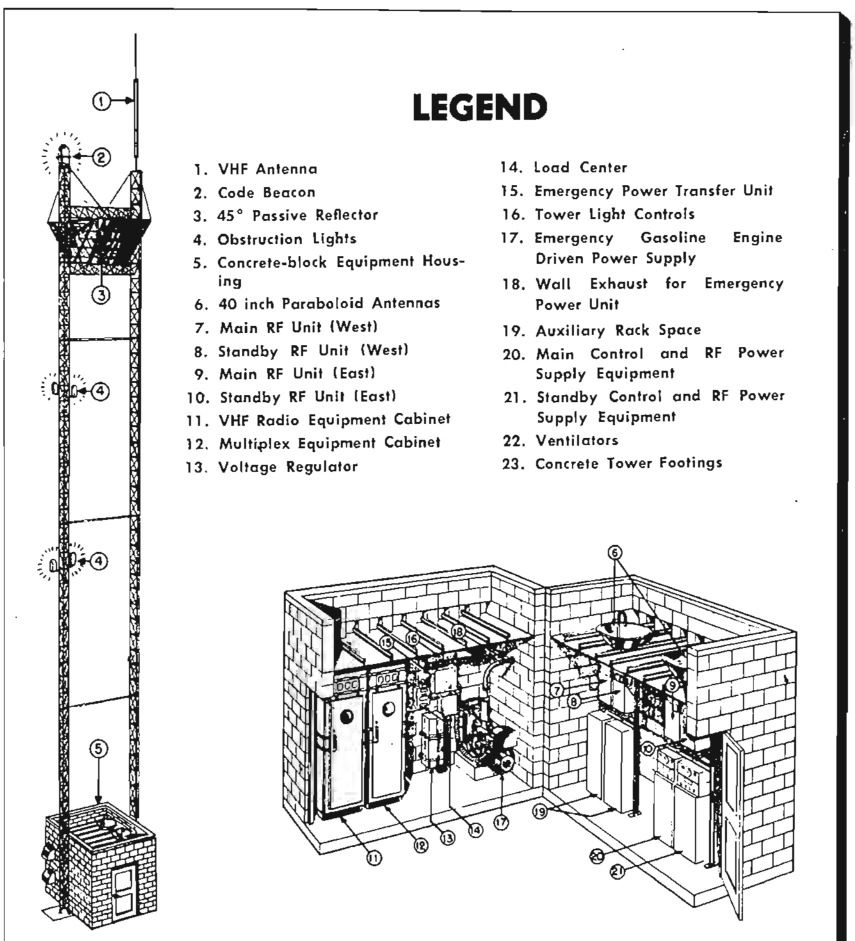
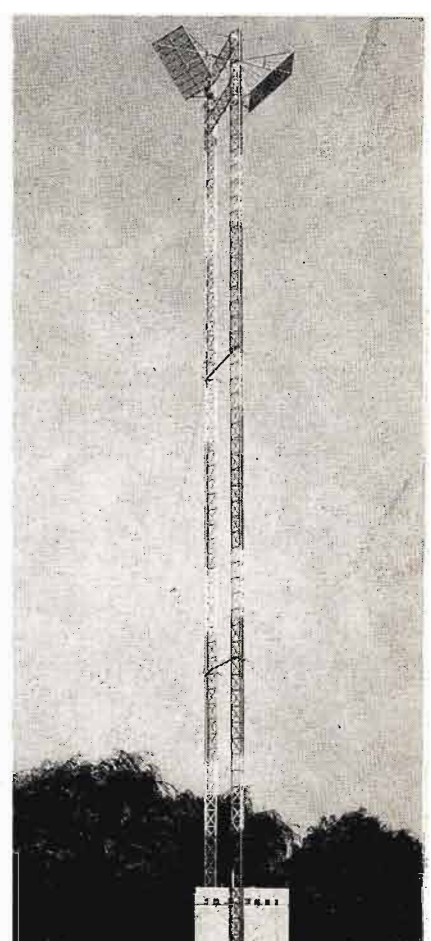
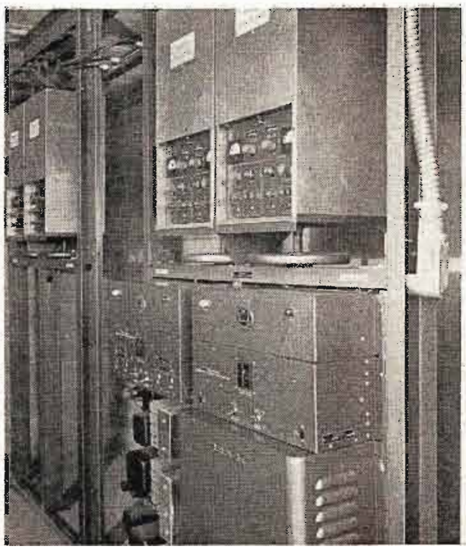
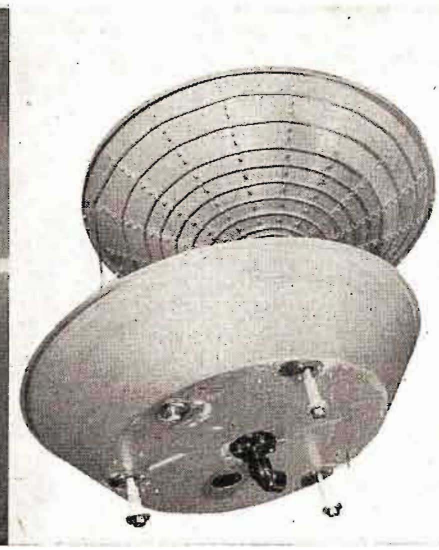


Fig. 4: Complete microwave relay station







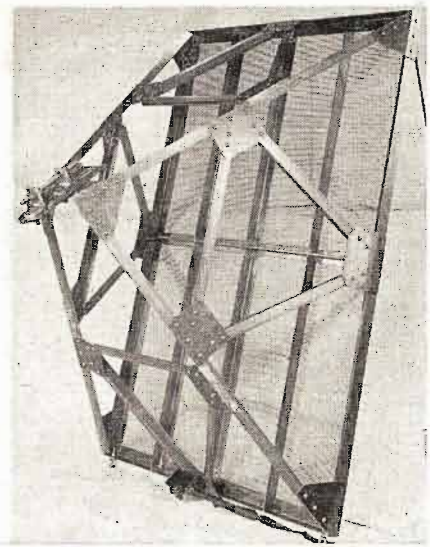


Fig. 5: (l) R-F heads with control panel. Fig. 6: (c) Antenna assembly and cradle. Fig. 7: (r) Reflector with concave paraboloid surface

der the r-f units are located ac junction boxes and switch chassis which also include the automatic switchover functions. Below these are the power supplies, those in the East rack being used also to power the West rack.

Antenna: The antenna assembly includes not only an accurate parabolic surface for focusing the radio waves, but a heater for de-icing, a drain for pouring out the melted snow, three tilt screws for accurately positioning the antenna, locking screws, weather-tight connections for energizing the heater, and a large cradle which is heavier than the paraboloid for the purpose of holding the entire assembly and strengthening the paraboloid. All this is shown in Fig. 6. The 400-watt de-icer is adequate for the 40-in. diameter, and for practically all climates. Larger dissipations are available, but have not been necessary. Part of the calrod heater is fed through the outgoing plastic duct in order that melted snow does not freeze again until it leaves the radio

Fig. 8: Paraboloid reflector prevents phase error which a flat reflector would produce

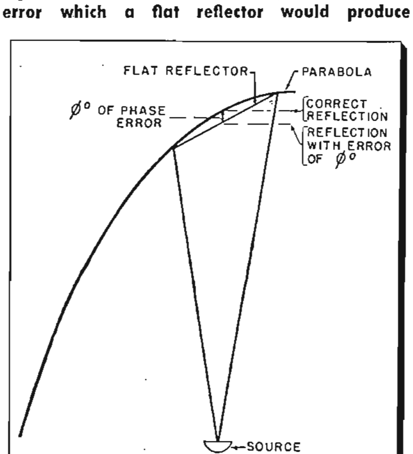
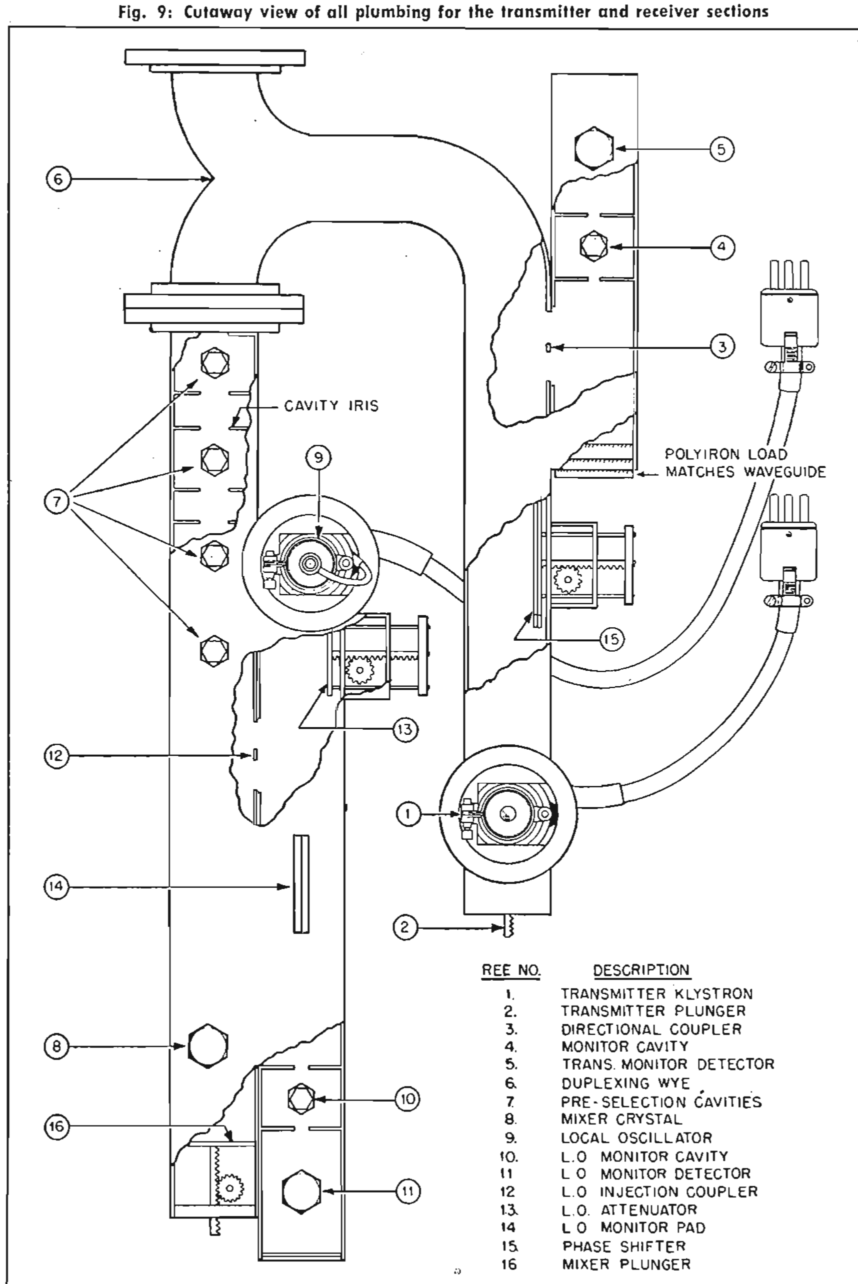
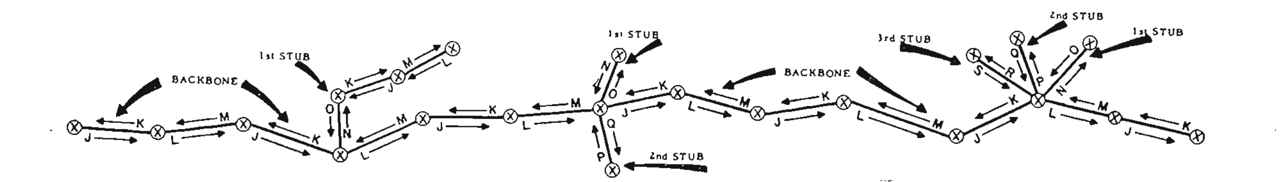


Fig. 9: Cutaway view of all plumbing for the transmitter and receiver sections





	COMMON CARRIER (5925 MC. - 6425 MC.)			COMMERCIAL (6575 MC. - 6875 MC.)			GOVERNMENT (7125 MC. - 9800 MC.)		
	Box Designation	Trans. Freq.	Rec. Freq.	Box Designation	Trans. Freq.	Rec. Freq.	Box Designation	Trans. Freq.	Rec. Freq.
BACKBONE	JC	6415 MC.	6295 MC	J	6585 MC.	6705 MC.	JG	7135 MC.	7255 MC.
	KC	6295 MC.	6415 MC.	K	6705 MC.	6585 MC.	KC	7255 MC.	7135 MC
	LC	6255 MC.	6375 MC	L	6745 MC.	6625 MC.	LG	7175 MC.	7295 MC
	MC	6375 MC.	6255 MC.	M	6625 MC.	6745 MC.	MC	7295 MC.	7175 MC.
1st STUB	NC	6215 MC.	6335 MC.	N	6785 MC.	6665 MC.	NC	7335 MC.	7215 MC.
	OC	6335 MC.	6215 MC.	O	6665 MC.	6785 MC.	OG	7215 MC.	7335 MC.
2nd STUB	PC	6235 MC.	6355 MC	P	6765 MC.	6645 MC.	PG	7315 MC.	7195 MC.
	QC	6355 MC.	6235 MC	Q	6645 MC.	6765 MC.	QG	7195 MC.	7315 MC
3rd STUB	RC	6275 MC.	6395 MC.	R	6725 MC.	6605 MC.	RC	7275 MC.	7155 MC
	SC	6395 MC.	6275 MC.	S	6605 MC.	6725 MC.	SG	7155 MC.	7275 MC.

SPECTRUM UTILIZATION

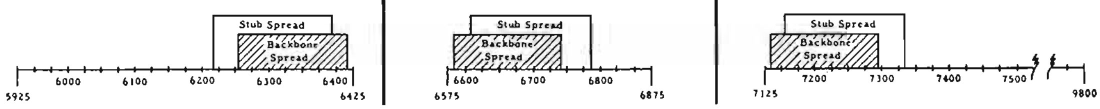


Fig. 10: R-F allocation plan for a microwave system allows for receiver selectivity, antenna configurations, and transmitter power

equipment. The three flanged bushings shown at the very bottom of the photograph are bolted to the supporting shelter or housing; hexagonal sections immediately above these bushings are rotated with a wrench to raise or lower any side of the assembly by means of screw threads within the bushings and a ball joint above the hex. The three small bolts visible above each hex are locked for permanently tightening the ball joint after the antenna adjustment is completed.

Thermostat for Heater

For economy, the de-icer should not be energized unless the atmospheric conditions are capable of forming snow or ice. For this reason, a thermostat is usually included in the antenna assembly to energize the heater when the ambient falls to freezing temperature. A better and more economical control is obtained by the use of a snow detector.

Wherever line-of-sight does not exist between two stations, the necessary elevation is provided by mounting a passive reflector on top of a tower and illuminating the reflector from the ground by means of the paraboloid. The beam from the paraboloid with a half-power width of 3½° (power gain of 35 db); rises with a cylindrical cross-section and a rather irregular phase front up to the end of the Fresnel zone. At this point, about 100 ft. from the paraboloid, the phase front has reached a fairly smooth spherical shape and the beam diverges with the characteristic 3½° until it hits the passive reflector. This 45° reflector is proportioned to intercept and reflect horizontally most of the energy, and does so in practice with negligible loss or some gain depending upon the particular station geometry. The reflector proper is faced with perforated sheet aluminum, this design having been tested in a wind tunnel and found to obtain a reduction in windloading proportional to its open area for all wind velocities up to at least 100 mph.

Figure 7 shows the details of a typical 45° reflector. The screw device at the left obtains vertical angles of tilt, while the pivot at the left end of this assembly and the corresponding one at the bottom form an axis for azimuth angles. To the two screw eyes at each side of the bottom surface are fastened guy wires which set and maintain the azimuth angle. Various models of this basic reflector have been made with riveted construction as shown, bolted construction for the whole assembly, welded construction, and in several different sizes for various tower heights. The reflector surface is 6 x 8 ft. for tower heights exceeding about 80 ft., and is 8 x 12 ft. for tower heights exceeding 200 ft. The surface of this reflector is not flat but is a concave paraboloid.

As may be seen from Fig. 8 a source at position A will radiate efficiently to the right of the reflector, if the reflector is a portion of a large parabolic curve. A flat reflector at the position shown would obtain phase errors which at the center of the illustrated beam would be of magnitude ϕ. In the practical case, ϕ will be only a fraction of an inch and therefore the parabolic shape of the reflector is not critical. However, it is shaped to approximate a paraboloid and thereby becomes part of the radiating system, obtaining an antenna gain in proportion to its total aperture; the beam which originally diverged 3½° will leave the curved reflector with a beamwidth narrower in proportion to the size of the reflector. The new beam which is formed is not as efficient as that which leaves the paraboloid because the illumination is not perfectly tapered, and because part of the illumination may miss the curved reflector. Considering both this inefficiency and the gain attributed to its aperture, the net gain may be small but at least the curved surface contributes to a lossless 45° reflector system. The reflector system is therefore not only extremely economical and convenient but it is available without any degradation of system performance.

Antenna Feed Termination

The antenna feed is terminated in an open ended "box horn" which is matched by an iris and by a small correction of the focal position of the aperture relative to the vertex of the paraboloid. This horn contains no weather sealing device at its aperture; it actually contains air molecules in the same state as the ambient around it. This system completely avoids condensation without

(*Continued on page* 145)

CUES for BROADCASTERS

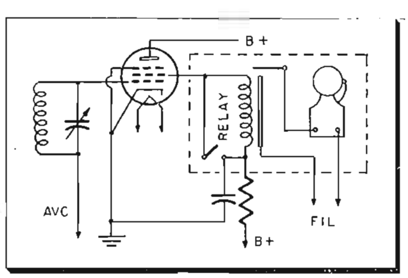
Practical ways of improving station operation and efficiency

Automatic Conelrad Alarm

CHARLES SJOSTROM, Chief Engineer, KOVC, Valley City, N. D.

THE basic unit of our automatic Conelrad alarm is an old table model receiver that has been knocking around our shop for a few years. The only cash outlay was for an ultra sensitive relay. (Advance 1200 series, 3,500 ohms.) The rest was junk box parts.

The relay was tested on the bench and found to be in the 2 ma. range. The receiver has a type 78 tube in the i-f section and this tube has a screen operating in the 2 ma. range



Screen controlled relay circuit for use in Conelrad alarm receiver from junk box

also. All that was necessary was to cut this relay into the screen circuit. When the station is tuned in, the avc bias holds the screen current down and the relay remains open; however if the carrier is removed, the avc bias is reduced, and the increased screen current actuates the relay.

The alarm bell works well in the filament circuit of the receiver and can be mounted anywhere in the receiver cabinet. A switch is used to short out the relay for release once it has been triggered. (If the relay is adjusted properly it will release when the carrier comes on but this is a delicate adjustment and we find it more satisfactory to throw the shorting switch.) This switch is mounted on the side of the cabinet.

$$$ FOR YOUR IDEAS

Readers are invited to contribute their own suggestions which should be short and include photographs or rough sketches. Typewritten, double-spaced text is requested. Our usual rates will be paid for material used.

Long Period Recording

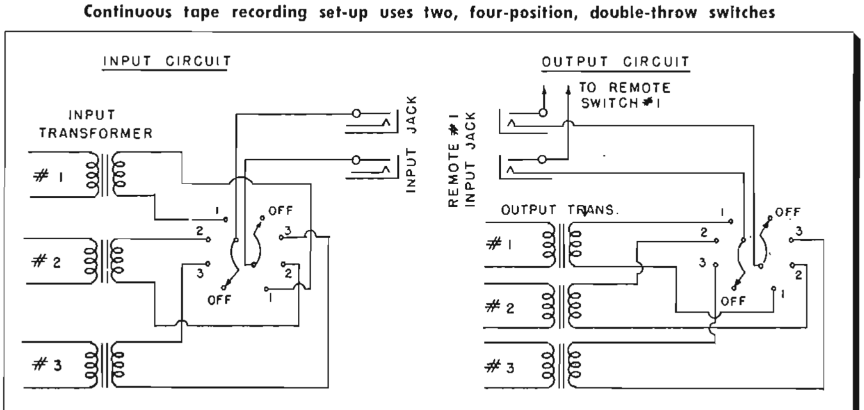
EUGENE S. CLARK, KGWA, Enid, Okla.

WE have a switching setup which is very useful for recording ball games or other long programs for delayed broadcast. It consists of two, four-position, two-circuit switches. One switch is for the input and the other for the output circuit.

A jack on our speech rack is connected to the arm of the input switch. By feeding a program from any line, such as net line, into this jack it is possible to record continuously for any length of time by transferring from one recording unit to another by the switch. The same arrangement is made on the output circuit, the switch arms being connected to one of the remote keys on the control board panel, so that no patching is needed for playback.

We also have separate input and output jacks for each recorder so that it is possible to record or playback more than one program at a time.

Continuous tape recording set-up uses two, four-position, double-throw switches



Eliminating Preamplifiers

J. DAVID BODELL, WCCM, Lawrence, Mass.

AT WCCM we are of the opinion that many stations now operating with turntable preamplifiers, can do without them. Our patience became exhausted with microphonic and noisy preamp tubes, hum, poor quality, constant trouble shooting, and messy turntable interiors. The trouble was traced to our preamplifiers and their associated pads, transformers, etc.

In an effort to end our trouble, the preamplifiers and everything else between the pickups and consoles—excepting the scratch filters—were eliminated. It was found that we still had plenty of gain, quality was faultless, no microphonics, and operation was simplified. There was, however, a small amount of hum, but this was entirely eliminated by not grounding either side of the pickup lead-in wire.

Artificial Echo Chamber

J. B. STRAUGHN, Box 364, Rt. #1 Laurel, Md.

A DEVICE for inserting echos into any type of signal source may be made as follows. Suspend a long flexible coil spring such as the type used by children for playthings from a suitable point. At the top of this spring attach the stylus of a crystal pickup element.

A driving unit made from the moving coil of an old loudspeaker is attached to the spring part way down. The exact position of this driving unit will depend upon the degree of reverberation required. The driving unit is connected to the signal source and the output of the pickup is connected back into the line. Reverberation is introduced mechanically by the compliance of the flexible spring. This type of artificial echo chamber is not too good for music but for speech and various special effects it works perfectly.

Remotely Controlled Tape Recorder

EDWARD BOYER, Chief Engineer, WBOB, Galax, Virginia

STARTING and stopping rack-mounted Magnecord tape recorders from the operator's position without purchasing high priced remote control equipment is a problem facing many small radio stations. We solved this by installing a two-way switch at the operator's position, and one on the rack near the recorder, which is connected to the motor power circuit.

It is only necessary to disconnect one lead from terminal #5 on the terminal strip located just to the left of the Jones plug on the tape transport chassis. Connect one side of the two-way circuit to terminal #5 and the other side to the lead that was removed from the terminal.

This makes it possible for the operator to cue up the recorder in advance and at the flip of a switch at the operator's position the recorder will start and stop without delay.

Aluminum from Platters

ROBERT E. BAIRD, Chief Engineer, KWSC, Pullman, Wash.

MANY stations use old platters to supply scraps of aluminum. Most technicians know that if the platter is boiled in hot water the emulsion will come off like a banana peel.

To save time we clean our discs as follows: Use any kind of saucepan partially filled with water. Place a disc on top, and sprinkle upper surface with water. Place a second discs on top of this and sprinkle again. Continue for six or eight discs. Boil the water in the sauce pan, the aluminum discs will conduct the heat and bring the layers of water between them to the boiling point. Continue boiling until you are sure the heat has reached the top of the stack. Fifteen minutes of constant boiling should do it. Remove the stack, and all but the top surface of the top disc and a portion of the bottom surface of the bottom disc will readily peel.

Cue Light-Box for Remotes

J. L. MOTT, Chief Engineer, KOKX, KOKX-FM, Keokuk, Iowa.

WHEN doing remotes, especially public gatherings, the only man who knows when the program is going on the air is the one at the remote amplifier, this sometimes causes confusion. Therefore, we built a portable "On Air" and warning light. It consists of a small control box and a light box, connected by a nine wire cable. The control box holds the fuse, filament transformer, off-on switch, pilot lamp, and band switch. The light box contains 45 #40 pilot lamps each behind a red lens.

While the off-on switch is in the "on" position and the band switch in position 1 the light box is dark. By putting the band switch in position 2 the figure "3" lights on the box, indicating 3 minutes before air time. The next position lights figure "2," the next figure "1." The fifth position lights the entire board, indicating "On Air." Three minutes before the program ends the man at the controls lights the 3, then the 2, then the 1. When off the air the board is turned off.

The light box is made of a piece of wood 5 in. wide, 8 in. high, and 1½ in. deep, covered by a piece of aluminum 5 in. wide, 9 in. high, and 3 in. deep. Mark the hole centers on the wood ¾ in. apart with 1 in. between the edge of the wood and centers of the outside rows of holes. Drill each hole with a ½ in. steel bit to a depth of 1 in. This is to give room to remove the bulbs with a bulb remover, and allow the shanks of the lens caps to butt down in the hole so that no light leaked to an adjoining opening. The sockets are miniature screw with the hanger removed. A small amount of service cement (speaker cement) is put around the sockets to keep them in place. (Screws securing the sockets will split the wood between the holes. The sockets are wired with solid wire.)

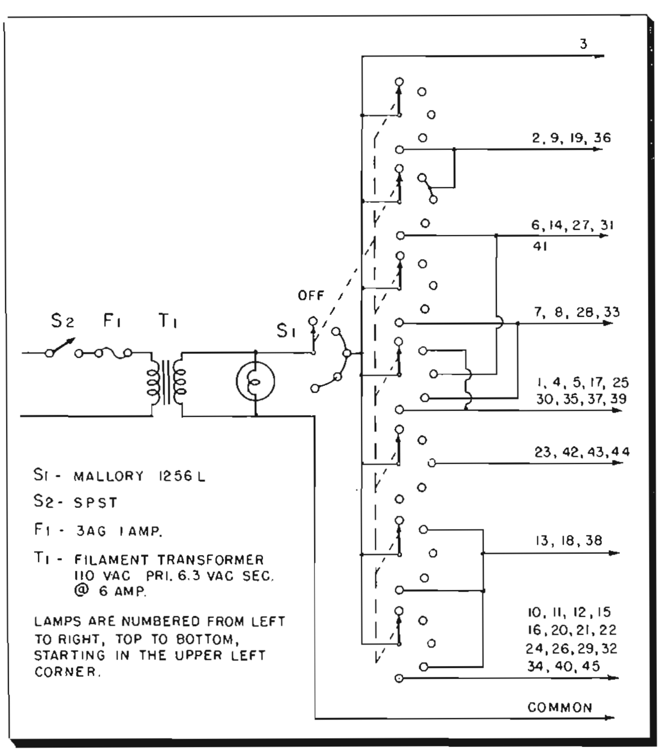
The metal cover has 45 holes in the front in the same positions as the holes. The sockets are wired at the bottom is to allow room for the cable. The holes are 7/16 in. in diameter, the lenses ½ in. red, with ⅜ in. shanks. Wood screws secure the cover to the board. For a neat job a nine wire cable should be used.

Non-Slip Method for Playing 45 RPM Discs

WILLIAM E. DIXON, Chief Engineer, WCHS, Charleston 24, W. Va.

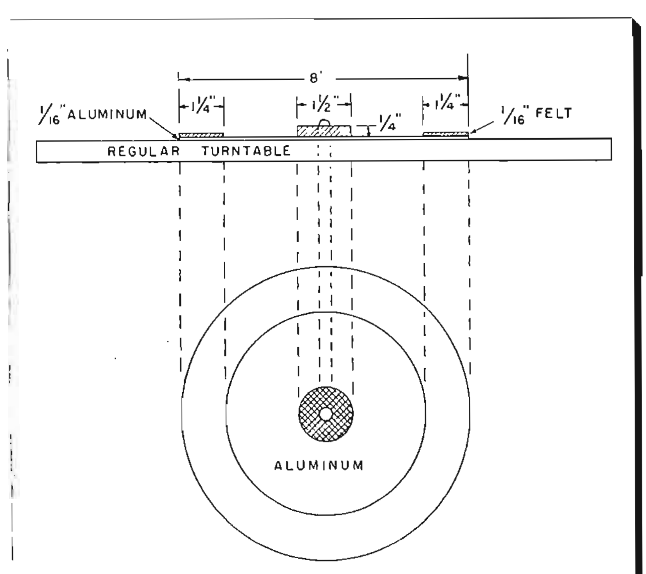
MANY broadcast engineers have wondered how to play 45 rpm records without slipping after they have adapted their standard transcription players to play this speed. An investigation as to the cause of the slippage at WCHS revealed that the record has only about 3½ in. of the disc making contact with the turntable and the part of the record where the transcription head rests

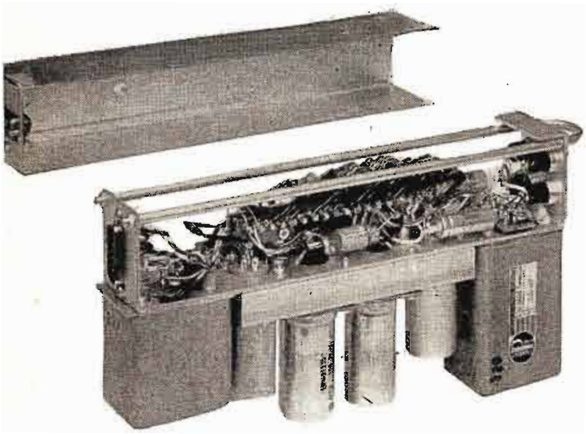
(Continued on page 122)



Multi-lamp box indicator for remotes (left)

Nonslip hubs for 45 rpm. discs made of aluminum (below)





Miniature Plug-in

Particularly suitable for TV installations, compact units single audio console. Easily-serviced amplifier shows

Fig. 1: Altec-Lansing A-428B miniature preamp with cover

By JOHN STORK
Altec-Lansing Corp.
9356 Santa Monica Blvd.
Beverly Hills, Calif.

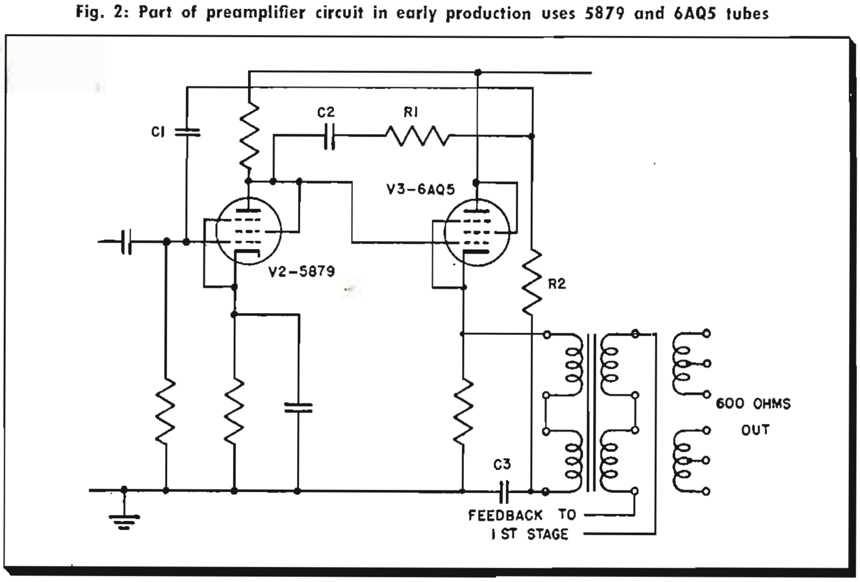
THE design of amplifiers for a broadcast console has as its objectives the attainment of low noise and nonlinear distortion levels over a wide dynamic range and excellent frequency response. Generally, the ideals of these objectives must be compromised with limited size, manufacturing economy, trouble-free operation, and ease of service and repair.

Small physical size of speech amplifiers has become increasingly important in TV broadcasting where many microphones are used on one set and where a single audio console may require as many as 30 amplifiers of the same type. It is apparent that where many identical amplifiers are used at one location, it is desirable to construct the amplifiers as separate plug-in units which may be quickly removed for repair and replaced if necessary with standby units. The basic design problem, then, was one of equaling, and if possible, exceeding the performance standards of the best available broadcast speech equipment, while at the same time developing a unit size much smaller than previously attained.

Summarizing briefly, the requirements in designing these Altec Lansing miniature speech input amplifiers were: (1) Use of only two amplifier types for a complete speech console, one type serving for both monitor and line amplifier functions, and the other for microphone amplifier and for any other relatively low level applications such as booster amplifier; (2) Use of few but easily obtainable miniature tube types; (3) Adjustable low impedance inputs and outputs on both amplifier types to match existing studio facilities; (4) Plug-in construction and means of metering tube currents while amplifier is in service.

The more specific design objectives of the preamplifier were that it be able to deliver +20 dbm output at less than ½% total harmonic distortion from 50 to 15,000 cycles and that it be capable of handling maximum input levels of −20 dbm. This, of course, restricts the gain to at most 40 db, which is sufficient, however, to maintain adequate signal-to-noise ratio at the mixer output when as much as 30 db mixing loss is encountered following the preamplifiers. Frequency response of each amplifier should be at least within 1 db from 20 to 20,000 CPS in order that a speech console, in which as many as three amplifiers, such as preamplifier, booster, and line amplifier, will be connected in tandem, may meet FCC response requirements without external or inter-amplifier equalization. In a satisfactory preamplifier, thermal-agitation noise of the input circuit should be considerably larger than the random noise contributed by plate current flow in the first stage. With commercially available low-noise tubes and well designed circuit, we may expect an equivalent input noise of −124 dbm or better over the entire audio frequency range.

Fig. 2: Part of preamplifier circuit in early production uses 5879 and 6AQ5 tubes



Low-Level Audio

Two miniature tube types which have been particularly designed for low-level audio service were tested. These are the RCA 5879 voltage amplifier pentode and the GE 12AY7 medium-mu twin triode. Our choice settled at first on the 5879 because of its availability and lower replacement cost. A number of samples of this tube were checked for microphonic, hum, and hiss noise by comparison with an RCA 1620 type tube which was known to have excellent noise characteristics. The noise voltages produced by the 5879 were on the average only slightly higher than those of the 1620. Later tests on the 12AY7 indicated equally good performance, although the 5879 has a slight advantage in better terminal arrangement for 6 v. ac heater operation.

With quiet miniature tubes available, it is obvious that the principle size limiting components of the preamplifier would be its input and output transformers. The latter must have sufficient core material to handle the specified maximum output of +20 dbm at 30 CPS, and the input

Broadcast Amplifiers

permit large number of microphone pick-ups through 0.5% harmonic distortion from 30 to 15,000 cps

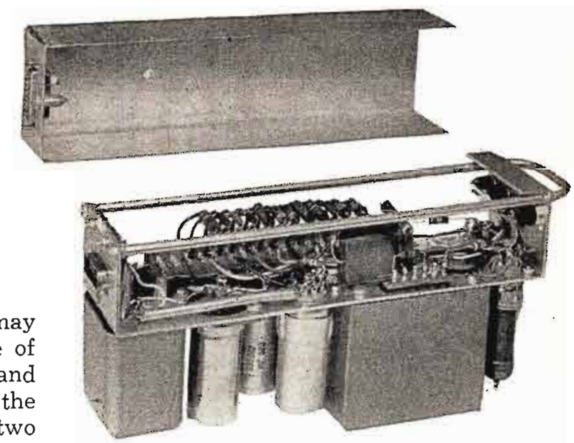


Fig. 5: Altec-Lansing A-429B miniature line-monitor amplifier shown with cover tray

transformer must have heavy shielding against external longitudinal currents on the input lines. In the final design, an input transformer was manufactured in a case size of 1½ x 2 x 2 in. which had 90 db of magnetic shielding, a balance of better than 50 db to longitudinal currents up to 45,000 CPS frequency response within 1 db from 10 to 30,000 CPS (including 22 µµf external capacity load), 84,000 ohms secondary impedance, and maximum signal level of +8 dbm at 30 CPS. The output transformer is in a case 1½ x 2 x 2⅞ inches. The electrical specifications are 12,500 ohms primary impedance, +20 dbm signal level at 30 CPS (without polarizing current), and frequency response within 1 db from 5 to 60,000 CPS. A tertiary winding was provided for feedback voltage.

Unbalanced Current

A limitation on unbalanced current in the output transformer requires the use of push-pull output stage, or shunt connection of the transformer with isolating capacitor to a single output stage, the latter incurring at least a 3 db power loss. Examination of characteristic curves of the 5879 tube will show, and experiments confirmed, that two paralleled 5879's operated within their current and voltage ratings, and with shunt connected output transformer, will not deliver more than about +18 dbm output power. To obtain our design objective of +20 dbm, a different output tube should be used. A logical choice in this case is the 6AQ5 tube, since this type may also be used in the output stage of the line and monitor amplifier and holds the tube complement of the total amplifier system to only two types.

Preamplifier Production

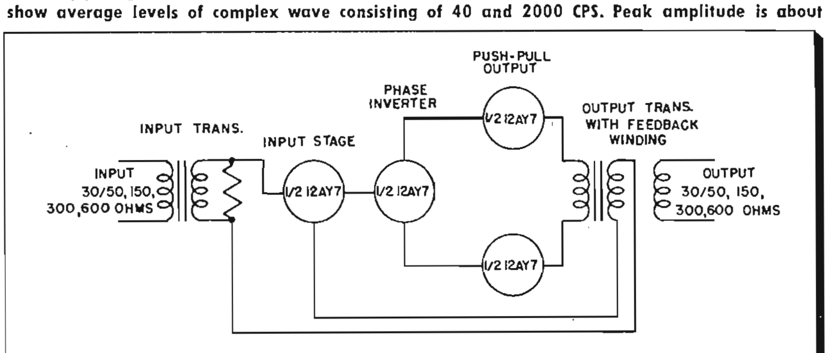
Details of part of the circuit used for early production of the preamplifiers are shown in Fig. 2. The 6AQ5 draws 10 ma current with a 16,000 ohm load resistor. Cathode-follower operation of this tube has several desirable qualities: (1) More linear operation reduces distortion contributed by the output stage; (2) Unity gain minimizes the problem of microphonics in the 6AQ5, which is not designed as a low noise tube; (3) Direct coupling permits the discarding of several coupling and biasing components. In this circuit where it is necessary to use a blocking capacitor, C3, to prevent the flow of polarizing current through the transformer windings, it is evident that at very low frequencies, depending on the size of C3, C3 and the primary inductance of the output transformer will contribute large phase shift to the feedback loop. This and the phase shift introduced by coupling and filter capacities will cause the amplifier to be unstable at a sub-audible frequency. Any large transient, either in the signal circuit or in the power supply system such as that caused by suddenly applied load to the 117v. mains, will excite the amplifier at this frequency and produce a "thump" or a few cycles of oscillation which may be of sufficient magnitude, through ensuing amplification, to open overload protectors at the transmitter.

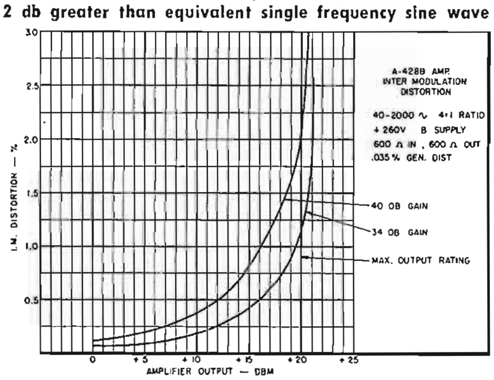
In practice, C3 is reduced in value, making the resonant frequency of C3 and the output transformer primary inductance sufficiently high to sharply attenuate amplifier response below the audio-frequency range. Control of phase shift in this region to prevent instability through the feedback loop is provided by R2-C1. This network may be considered as applying additional feedback for phase correction at frequencies where the reactance of C3 becomes appreciable. C2 and R1 serve as a stepping network for phase correction in the extreme high frequency range. These expedients, although complicating the circuit and construction of the amplifier, are necessary because of the great amount of feedback used to ensure stable gain and very low distortion.

Some time after production started on the speech input equipment amplifiers, the 12AY7 tube became more readily available for commercial use. Because of the circuit simplification and the increased space obtained by the use of fewer

(*Continued on page* 132)

Fig. 3: (L) Diagram of A-428B preamplifier shown in Fig. 1 employs 12AY7 tubes. Fig. 4: (R) Intermodulation distortion s. power output characteristics show average levels of complex wave consisting of 40 and 2000 CPS. Peak amplitude is about 2 db greater than equivalent single frequency sine wave





High-Q Measurements

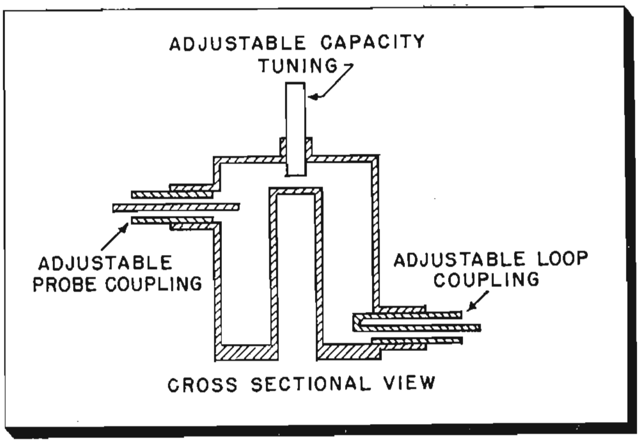


Fig. 1: Cavity with electrostatic (probe) and magnetic (loop) coupling

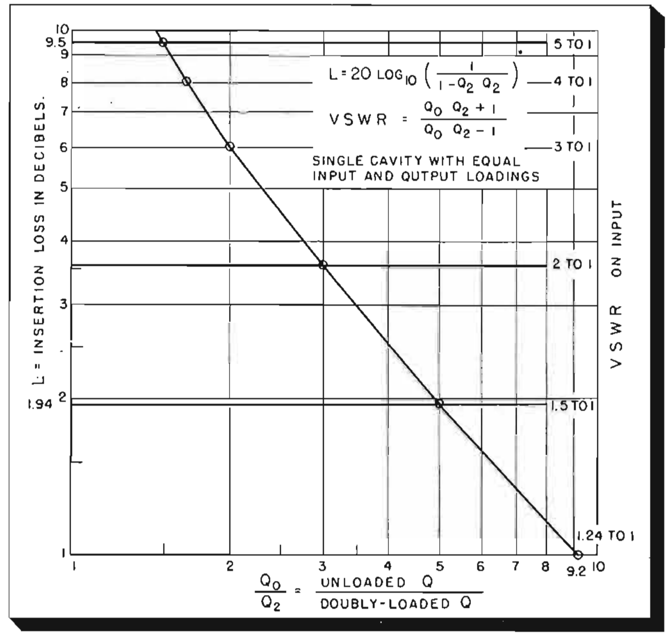


Fig. 2: Insertion loss and Q-ratio characteristic of a single cavity

By ***ALEX HORVATH***
Federal Telecommunication Labs., Inc.
An I. T. & T. Associate
500 Washington Ave.
Nutley 10, N. J.

THE problem of measuring the unloaded Q of various cavities is one that requires several precautions that are often neglected. A typical cavity is shown in Figure 1. If the unloaded Q is high, the errors in measurements may be as large as 50% from the true value. In this paper, several procedures are given from which an appropriate choice may be made. depending on the Q to be measured. The errors in results appear to be in the order of 4%.

The usual method of Q measurement involves a signal source with a vernier adjustment of frequency, a receiver at the same frequency with a calibrated output meter, and isolating pads. Connecting cables are 50 ohm coaxial to insure shielding. The pads, one between the receiver and cavity, and the other between the cavity and generator, are used to prevent resonances and to make the impedances looking into the receiver and generator such as to produce less than a 1.2:1 standing-wave ratio on a 50 ohm line. If the receiver and generator impedances are 50 ohms, then the pads are not necessary unless the high standing waves produced by the cavity can detune either or both instruments. The measurements of SWR require the use of an additional piece of equipment such as slotted line, reflectometer or impedometer.

The need for pads to prevent frequency pulling of the instruments by the cavity is obvious. The need for a low SWR as just indicated is also understood when the detuning effects of the cavity by the instruments are considered. This is especially true if lossy cable is used as a pad. Reflections to the cavity result in very rapid changes in reactance with frequency due to the long length of line. Such reflections may originate at either or both the receiver and generator and will detune the cavity appreciably at the half-power points. If the reflections are due to a short or open, at least 15 db attenuation by each pad is required to minimize the effects.

Measuring Unloaded Q

When measuring unloaded Q it is quite common to reduce the couplings in and out of the cavity to small values and to assume that the measurement is a conservative figure of the unloaded Q. A natural error follows. While looking for resonance it may be found that the generator is not powerful enough to give an indication on the receiver because of its own internal attenuation, plus the 15 db attenuation of each of the two pads, plus 30 to 50 db insertion loss in the cavity. If the pads are reduced or eliminated, or if the coupling is increased, then the answer may have a large error. If the pads are not used the indicated Q may be too high by as much as 50%.

The proper procedure is to couple rather closely at both the input and output of the cavity. Resonance is then clearly indicated by a peak 20 to 40 db above any leakage. After resonance is found, both couplings are made equal as indicated by the minimum SWR of each. The comparison is made by interchanging the input and output.

The loaded Q and insertion loss are now measured and remeasured for several other equal coupling settings. The unloaded Q is determined each time from the graph of Fig. 2, which is a plot of the insertion loss against the ratio of unloaded to loaded Q according to the equation (2) below. For a particular insertion loss such as 6 db, the value of the ratio is found to be 2. The unloaded Q is therefore twice the loaded Q. A cross check on the test setup may be made

Fig. 3: Two-terminal method for measuring Q

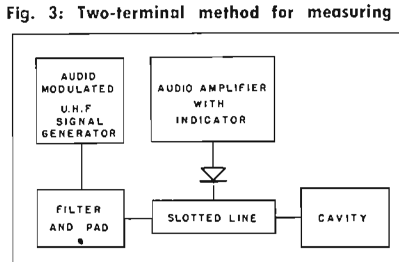
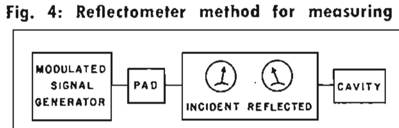


Fig. 4: Reflectometer method for measuring Q



in the 1000-MC Range

New testing techniques for microwave circuitry prevent errors which often run as high as 50%. Mathematical relationships of SWR, impedance, insertion loss and Q presented

by comparing the minimum SWR at the input at resonance with the insertion loss. The two should be within 0.5 db of the values of Fig. 2, which is a plot of (1) below.

As soon as consistent answers are obtained, further measurements at narrower band widths are not necessary. The accuracy is three to four times that of unloaded Q made directly.

Adjustable Cavity

Matching the input and output of a cavity might be a sizable chore in itself unless some consideration is given beforehand to the design of an adjustable type. Probes which slide in and out of tubes as in Fig. 1, or loops which slide or turn, or diaphrams which slide or turn are fairly easy to adjust. The size of each should be such as to permit various degrees of overcoupling. This differs with Q but is not difficult to ascertain. The form of coupling will be

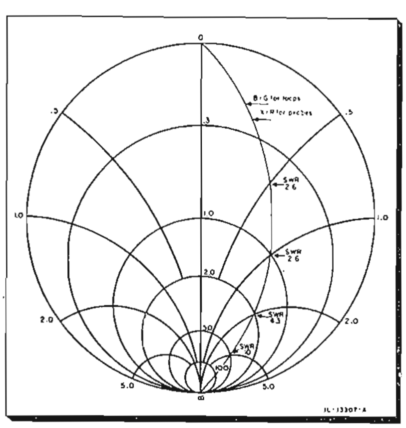


Fig. 5: Smith Chart indicates cavity input impedance. SWR point determines test frequency

determined by individual requirements.

One variation in the Q measuring set-up is often made. The signal generator is modulated with audio and the receiver is replaced with a detector and an audio amplifier having a calibrated output. The task of tracking the receiver with the signal generator is then removed.

For best results, the detector should be 50 ohms at the r-f input end, in order to eliminate the need for a pad between the cavity and detector. If the detector is a bad match, padding will be required to reduce the SWR to less than 1.2:1 as indicated previously.

The power law of the detector and amplifier combination should be checked to insure correct indication of the half-power points when making bandwidth measurements. The method described on page 555 of *Microwave Antenna Theory and Design* (vol. 12, Rad. Lab. Series) may be followed in which the detector assembly is used as a probe in a slotted line. A high SWR is created on the line. The wavelength is measured, the distance between half-power points is measured and the ratio of the two readings obtained. For a ratio of 0.25, the detector is square law. Variations in the power law from 1.9 to 2.1 are not harmful insofar as there is some cancellation of errors when band width and insertion loss measurements are used together and when SWR measurements are made.

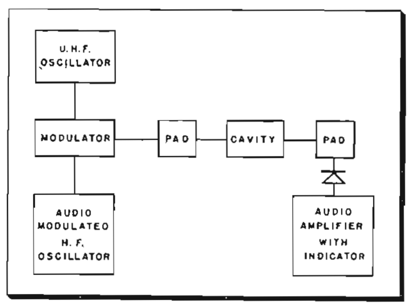


Fig. 6: Four-terminal, two-generator measurement technique for determining high Q values

Two-Terminal Method

In contrast to the four-terminal method of measuring Q just described, there is a two-terminal method which may be derived from an unpublished report on input impedances of resonators by Chodorow and Cooke of the Sperry Gyroscope Co. A block diagram is shown in Fig. 3. This method of measuring Q is done with an audio modulated signal generator, an isolating pad, a slotted line with its crystal probe, and an audio amplifier. Measurements are made of the changes in SWR and in null position caused by the cavity as the frequency is changed through resonance by known increments. The changes are described in detail in Chapter 5 of *Microwave Electronics*, by J. C. Slater. Resonance itself is indicated and located by a comparitively rapid shift of the null position. While checking the lowest SWR possible which is at the resonant frequency, the cavity is detuned momentarily to determine whether the impedance at the input is greater or smaller than 50 ohms. If detuning is impractical, then the same information may be obtained later by varying the frequency to both sides of resonance until very little coupling to the cavity exists. Impedances larger than 50 ohms are indicated when the null is at the same place in both tuned and untuned conditions with electrostatic or probe coupling and 90° apart with electromagnetic or loop coupling. Less than 50 ohms is indicated by the nulls being in the same position with loop coupling and 90° apart with probe coupling.

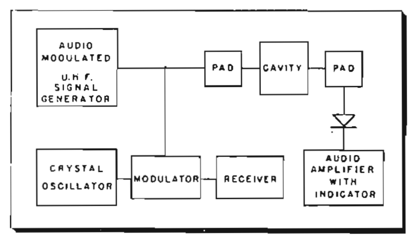


Fig. 7: Alternate two-generator test set-up

Smith Chart

Each point measured is then plotted on the Smith Chart as an admittance if electromagnetic coupling is used, or as an impedance if electrostatic coupling is used. The reference point is the position of the null at the minimum SWR at resonance. For conductance or resistance values higher than 50 ohms, the normalized reference portion will be between one and infinity on the Smith Chart, and for lower values will be between one and zero. Data on both sides of this point will be found to follow closely the conductance or resistance circle established by the standing wave ratio at the resonant frequency. Furthermore, it will be found that the frequency variation is linear with the susceptance indicated on the chart. Thus

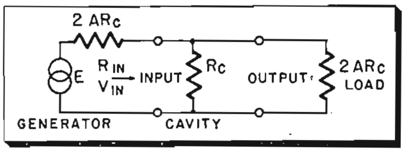


Fig. 8: Doubly loaded cavity at resonance

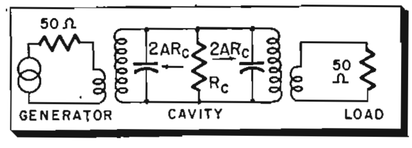


Fig. 9: Cavity coupled at input and output

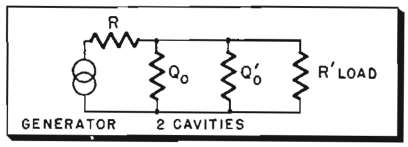


Fig. 10: Two cavities, critical or overcoupled. Values at peaks are: $Q'_0 = Q_0$ and $R' = R$

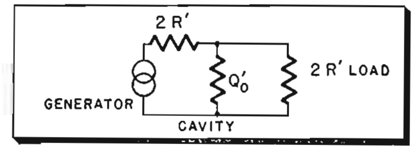
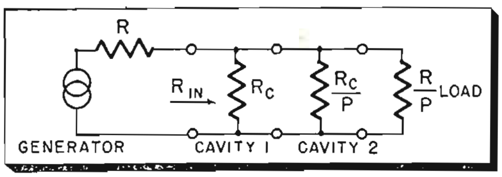


Fig. 11: Single cavity equivalent of Fig. 7 has same SWR and loss as circuit of Fig. 10



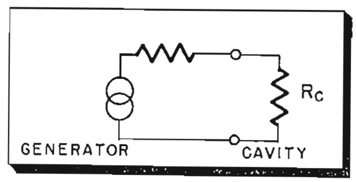


Fig. 12: (L) Two cavities at resonance. Fig. 13: (R) Single cavity, singly loaded at resonance

these circles may be calibrated in terms of frequency, and the frequency where the susceptance or reactance is equal to the conductance or resistance may be determined with good accuracy. The band width between these frequencies is the 3-db bandwidth of the unloaded cavity and is used to obtain the unloaded Q.

Overcoupled Conditions

A large variation of the input coupling is acceptable. It is preferable to use values such as to give a minimum SWR at resonance of less than 5 to 1. Within this range the overcoupled conditions are easiest to handle insofar as the null and SWR shift more slowly with frequency. Extreme overcoupling should be avoided to minimize the effect of the reactance of the coupling itself.

In actual practice two-terminal measurements are made by first finding resonance, either by a four-terminal method or by locating a rapid shift in a null position as the frequency is changed. If the null shifts 180° along the slotted line within a few megacycles it indicates an overcoupled condition. If the null shifts first 90° in one direction, and back to the original position, the 90° in the other direction, and back again, an undercoupled condition is indicated. If the undercoupling exists, the coupling is increased until it is overcoupled by about 2 to 1. This may be checked at resonance by detuning momentarily, which should indicate an impedance of larger than 50 ohms. The position of the null at resonance is checked at the same time. This position should be the same as that of a maximum in a detuned condition. The SWR at resonance and the frequency are then recorded.

The frequency is now shifted in one direction and the change in position of the null followed until the total shift in the null is about 75°. The frequency, null position, and SWR are again recorded.

The two points are plotted on the Smith Chart and the frequencies used to calibrate the susceptance or reactance circles. Half the unloaded bandwidth is then the difference in frequency between resonance and a 3-db point as previously defined. Accurate values of unloaded Q as high as 4000 may be obtained.

Two-Terminal Measurements

Two-terminal measurements may be made also by replacing the slotted line of Fig. 3 with an instrument such as the Federal impedometer which measures both the incident and reflected waves. A block diagram of the method using a reflectometer with internal amplifiers is shown in Fig. 4. Resonance is found by varying the signal generator frequency until a minimum SWR into the cavity is found. This is determined in terms of the incident and reflected waves, or $SWR = (I+R)/(I-R)$, where I is the meter reading for the incident wave, and R is the reading for the reflected wave.

The magnitude of the cavity input impedance with respect to the 50-ohm connecting cable is determined next either by following instructions for use of the impedometer, or by varying the cavity coupling and noting the change in SWR. For probe coupling the impedance varies from large to small as the probe is moved into the cavity, and the SWR varies from large to unity to large again. For loop coupling the impedance varies from small to large as the loop is moved in, and the SWR varies from large to unity to large again. Thus if the SWR is 2 with probe coupling, and it becomes smaller by moving the probe into the cavity, then the probe is undercoupled and higher than 50 ohms.

Cavity Input Impedance

The cavity input impedance is now located on the proper resistance or conductance circle of the Smith Chart illustrated in Fig. 5. The SWR at the point where the resistance or conductance is equal to the reactance or susceptance is found on the chart and the frequency of the signal generator is varied to obtain this value. The difference between the initial and the latter frequencies is half the 3-db bandwidth of the unloaded Q. For greater accuracy a second point can be found by varying the frequency of the signal generator to give the proper SWR on the other side of resonance.

As Q becomes higher, the need for the precise determination of two frequencies very close together becomes greater. The average signal generator does not have the required vernier adjustment and it becomes necessary to provide additional equipment to measure the 3-db bandwidth. One such system is shown blocked out in Fig. 6. The outputs of a UHF oscillator and an HF oscillator with audio modulation are mixed in a modulator and the resultant frequencies are fed through a pad to the cavity. The output of the cavity is detected and amplified at audio to give an indication on a calibrated meter.

With the outputs of two generators being mixed, the frequencies fed into the cavity are the UHF, and the two side band frequencies modulated with audio. The sideband frequencies are kept at least three bandwidths away from the center frequency. Measurements are made with a sideband frequency which is varied by changing the high-frequency generator. Modulation, signal output of this generator, and the output of the modulator should all remain con-

(Continued on page 141)

Servo System Comparators

Comparison of error signals in communications systems used in three measurement methods: phase detection in servo motor, electronically-gated phase detection, and pulse coincidence comparison

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SERVOMECHANISMS and regulators are feedback control systems in which the comparison of reference and controlled quantities provides the measure of readjustment of the output required to establish a desired state. In the typical system shown in Fig. 1, a continuous comparison is made to provide an error signal when a difference between input and output exists. Being constantly aware of such errors and trying to reduce these errors to zero, the closed-loop system presents automatic and continuous self-calibration. In many systems, however, the quantity under control has a composition entirely different from that of the reference, making a direct comparison impossible. Where this is true, a modifying element may be introduced into the feedback path to obtain the desired form.

Often in communication systems, where automatic mechanization of some function is desired, the comparison operation can take the form of a phase measurement between periodic electrical signals. Circuitry of this kind can be designed to provide a high degree of precision with stability of balance over wide variations of signal levels and circuit parameters. The three circuits to be described are of this type and are useful with ac, or carrier servo systems.

These circuits are for (1) phase detection in the servo motor, (2) electronically-gated phase detection, and (3) pulse-coincidence comparison. The first and third are, to our knowledge, novel although based on accepted principles. The second is not presented as being new but it was investigated experimentally in these laboratories with reportable results. In each case the circuits provide directly an ac error signal at power-line frequencies, thus obviating the need for either dc amplification or any intermediate conversions from dc to ac.

Phase Detection in Motor

To accomplish the actual phase detection of the servo loop advantage is taken of the characteristics of a two-phase motor. The two sinusoidal signals to be compared for phase differences are fed into a network, as shown in Fig. 2, and the sum and difference signals appear at the output. If the two signals compared are equal in amplitude, and displaced in phase by any amount, the sum and the difference signals will always be 90° apart. This relationship is illustrated by the voltage vector diagrams of Figs. 3a and 3b (for leading and lagging phase conditions, respectively).

Analytically, this may be shown by specifying the two signals,

$$e_1(t) = E \sin \omega t$$

$$\text{and } e_2(t) = E \sin(\omega t + \phi),$$

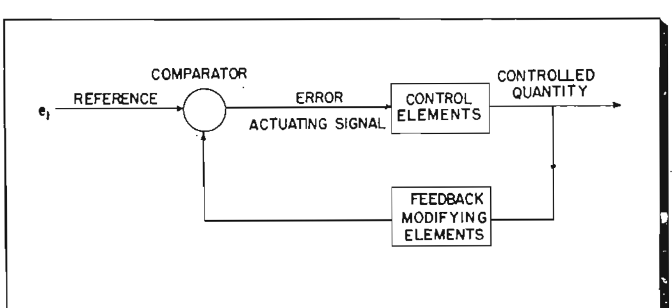
where ϕ is the phase angle between the signals. From the input network we get (1) by trigonometric substitution and equation (2).

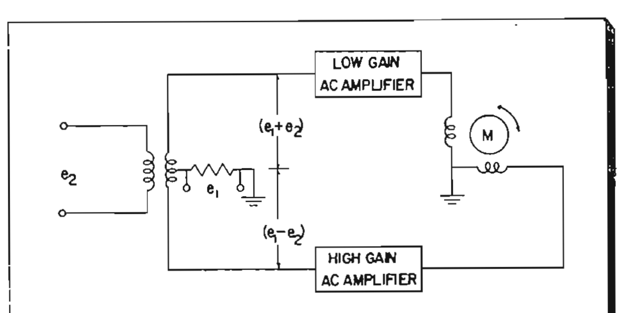
Equations (1) and (2) are seen to be in time quadrature with amplitudes described by the cosine and sine functions of the phase angle. Consequently, except for a phase error of $\phi = 90°$, signals (1) and (2) are of unequal level. In fact, the disparity in signal levels normally experienced in practice would be considerable; for in dealing with a servo loop only small phase shifts could take place before phase correction would begin to be introduced. Another important property of these two functions is exhibited when the phase angle changes from leading to lagging as in the vector diagrams of Figs. 3a and 3b. Note that in a leading phase angle condition the difference voltage vector leads the sum voltage vector (considering clockwise rotation as positive) and an interchange of relative positions results from a lagging phase angle. This can be demonstrated with equations (1) and (2) by substituting $-\phi$ for ϕ. The last property of concern is demonstrated when no phase error exists (Fig. 3c). From equations (1) and (2) it is obvious that for a phase term equal to zero the difference signal becomes zero and the sum signal is a maximum.

Phase Error

If the sum and the difference voltage signals are each impressed across a winding of a two-phase motor, by virtue of the above considerations the required phase detection is accomplished. When a phase error exists, the motor winding voltages will be electrically as well as mechanically in quadrature and a rotational torque will be developed by the motor. In addition, when the phase shift changes from a leading to a lagging angle, the demonstrated interchange of relative position of the quadrature sum and difference signal voltages will effect a reversal of direction of the torque developed. This results in motor action in the

Fig. 1: (l) Simple servo loop block diagram. Fig. 2: (r) Phase detection in the servo motor from sum and difference signals





opposite direction and provides the necessary bi-directional motor control. When the two signals are in phase, only one motor winding is excited, no rotational torque is available, and motor action ceases. If the motor shaft position is translated into a phase correction of one of the signals, motor action will continue only long enough to correct for the phase differences.

Adding Network

The analysis to this point has been developed for conditions of equal amplitude comparison signals (e_1 and e_2) into the adding network. This case has been used because of the ease with which the basic principles can be set forth. This is not to be construed to mean that equal amplitudes are a necessary condition. Actually this case is the limiting one, and unequal amplitudes only represent a condition of reduced sensitivity. The vector diagram, Fig. 3c, shows that it does not matter if the comparison signals are unequal when zero phase shift exists. When unequal amplitudes are used, and a phase shift occurs, the sum and difference signals will not be in quadrature, but at a smaller angle (3), motor torque will still be developed but will be reduced in proportion to the sine of the angle in equation (4). Although a loss of sensitivity is suffered, inasmuch as the zero-phase-angle condition of the comparator is insensitive to amplitude variations, and since this is a zero-seeking servo system, the accuracy of the system is unaffected by amplitude changes of the compared signals.

In the previous explanation of the ac-motor phase detection, consideration of the widely differing sum and difference, or motor voltage levels, was neglected. Since the motor rotational torque is proportional to the product of the amplitude of the motor-winding voltages for greater sensitivity the difference voltage receives considerably more amplification than the sum voltage signal. The net result is substantially equal voltage levels on the motor windings for small angular phase shifts.

Electronically-Gated Phase Detection

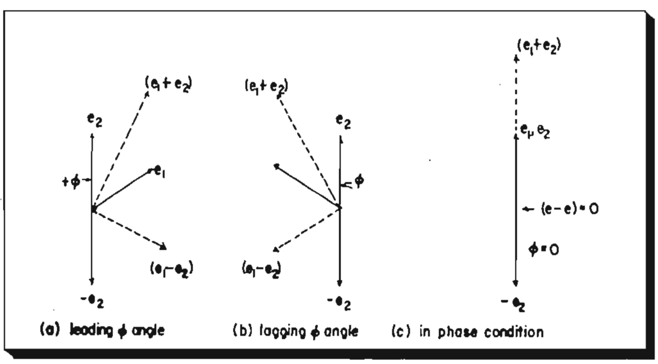
The circuit for electronically-gated phase detection illustrated in Fig. 4 is limited in application to systems where the frequencies of the signals to be compared are very much higher than the power-line frequencies. In this instance, phase measurements are made at 20 KC after the controlled signal has been modulated with a 60 cps square wave derived from the power line. The modulated signal, a packet of 20 KC sine waves at a recurrent rate of 60 cps, is transformer-coupled into the input network of an unbalanced phase detector. When a quadrature cw reference signal is added at the center tap of the secondary, the detector produces a 60-cps output signal having an amplitude proportional to the magnitude of the phase error. Also, no output is obtained when the error is reduced to zero, and a 180° phase reversal occurs when the error changes from leading to lagging. After suitable amplification, the error signal impressed across the control winding of a two-phase servo motor provides bi-directional rotation and proportional speed control.

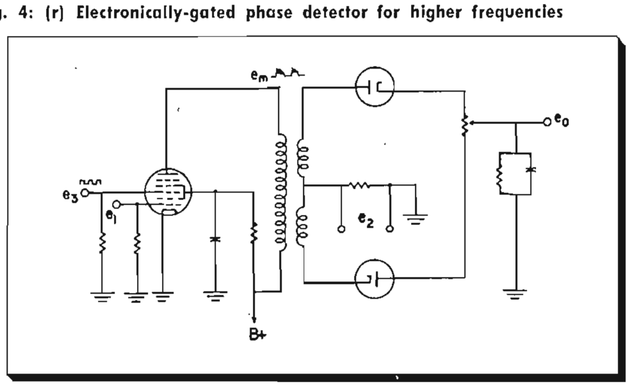
Mathematical Description

A mathematical description of the circuit operation provides additional information as to performance and design factors of interest. Consider the signal to be processed (5), where ϕ is the phase error to be measured. The square-wave modulating signal may be described by the Fourier series (using an even function) shown in equation (6). From the modulation of e_1 by e_3 the signal (7) is obtained, where C_1 is a proportionality constant having the dimension one/volts. The above signal is both linearly subtracted from and added to the reference signal in the input circuit of the phase bridge (8). The detection of the sum and the difference signals is accomplished in the separate diodes. Since only the fundamental component of the signal (ω_m) is of interest, the low-pass filter constants are so proportioned as to provide effective cut-off below the second harmonic. The signal contributed by the sum term from the diode is as in equation (9), where C_2 is again a proportionality constant with dimensions one/volts, or, by use of trigonometric identities, equation (10). The other diode provides the negative of the signal described by equation (10). Thus the difference appearing across the output is shown in (11). From equation (11) the output is seen to contain a dc and an ac term. Both terms have magnitudes expressed by the sine function of the phase error. The individual signal amplitudes are only scale factors and do not influence the null or zero of the servo system. The unused dc term, also a measure of phase, is the only term that would appear in the signal across the low-pass filter if no modulation were employed, as in the more commonly encountered circuit configuration. Had a random phase term been introduced in the modulating signal, the analysis would have shown that incoherence between the rf and modulation does not alter the output. It is to be noted particularly that because of the "narrow banding" by the low-pass filter, the complex structure of the square-wave modulating signal did not enter into the usable output. However, by gating the modulator tube, independence of output-level variations from input-amplitude changes was achieved. In practice, it was found to be adequate to overdrive the grid with a high-level sine wave.

The two comparators considered previously provide error signals with amplitudes described by sinusoidal functions of the phase angle. Therefore, for the small angles generally

Fig. 3: (l) Vector relations for phase detection in the servo motor. Fig. 4: (r) Electronically-gated phase detector for higher frequencies





$$e_1(t) + e_2(t) = 2E\cos(\tfrac{\phi}{2})\sin(\omega t + \tfrac{\phi}{2}) \quad (1)$$

$$e_1(t) - e_2(t) = 2E\sin(\tfrac{\phi}{2})\cos(\omega t + \tfrac{\phi}{2}) \quad (2)$$

$$\psi = \tan^{-1}\left[\frac{E_1 \sin\phi}{E_1\cos\phi + E_2} - \tan^{-1}\frac{E_1\sin\phi}{E_1\cos\phi - E_2}\right] \quad (3)$$

$$T \propto E_1 E_2 \sin\psi \quad (4)$$

$$e_1 = E_1 \cos(\omega t + \phi) \quad (5)$$

$$e_3 = E_3\left[1 + \sum_{n=1}^{\infty}\frac{\sin(n\pi/2)}{(n\pi/2)}\cos n\omega_m t\right] \quad (6)$$

$$e_m = C_1\frac{E_1E_3}{2}\left[\cos(\omega t + \phi) + \sum_{n=1}\frac{\sin(n\pi/2)}{(n\pi/2)}\{\cos(\omega t + n\omega_m t + \phi) + \cos(\omega t - n\omega_m t + \phi)\}\right] \quad (7)$$

$$e_2 = E_2 \sin(\omega t) \quad (8)$$

$$C_1C_2E_1E_2E_3\left[\sin\phi + \frac{1}{\pi}\{\sin(\omega_m t - \phi) - \sin(\omega_m t + \phi)\}\right] \quad (9)$$

$$C_1C_2E_1E_2E_3\left[\sin\phi + \frac{1}{\pi}(\sin\phi)\cos(\omega_m t)\right] \quad (10)$$

Tabulation of equations referred to in text

of interest in closed-loop operation, the slope of the sine function defines the comparator sensitivity which is approximately 0.0174E volts/degree. For systems operating in the presence of noise and interference signals, the limit of phase-error resolution will be defined by this slope and the signal-to-noise ratio. To overcome these limitations, methods of pulse-time measurements may be used to take advantage of the steep wave fronts.

Measurement Procedure

The manner in which the measurements are carried out is illustrated in the block diagram of Fig. 5 and the wave forms of Fig. 6. A 120-cps square wave is generated from each of the 60-cps sine-wave signals and then fed into a coincidence stage designed to produce an output only when both signals go positive. When no time delay phase error exists (Figs. 6a, 6b) the square waves are 180° out of phase and no output is obtained. For a leading phase error (Figs. 6a, 6c) the two signals are both positive for an interval of time and produce a 60-cps pulse in the output (Fig. 6d). A lagging phase error (Fig. 6e) produces a similar pulse displaced by half the period (Fig. 6f.) In triggering a "Flip-Flop" with these pulses, a 60-cps square wave is developed which can then be filtered to obtain the fundamental. This signal, when amplified, excites the control winding of the servo motor.

It is to be noted that the required 180° phase reversal of the motor signal with a change from leading to lagging phase errors is achieved (Figs. 6d, 6f). Actually the signal reversal is less than 180° by the amount of the pulse duration, but performance is little altered by this small difference.

In many applications the relay-like characteristic of this system (i.e., only zero or full voltage on the motor control winding) would be objectionable. An approximation of proportional control might be introduced by taking cognizance of the pulse width at the output of the coincidence tube. A study of the waveforms shows that the pulse width is proportional to phase error. Integration of the pulse would result in a dc voltage also proportional to the error. The gain of the motor amplifier could then be regulated, using the voltage as an agc to increase gain with increasing error.

In evaluating the comparators considered previously the factors of limit of angular resolution and stability of balance must be weighed against the relative circuit complexity encountered in the mechanization of each. Viewed in this fashion each would probably fare well among counterparts currently finding application in practice. To point out more simply the advantages and limitations of the comparators under discussion, it seemed desirable to make a relative evaluation among these three.

The servo-motor phase-detection method is particularly attractive because of the degree of circuit simplicity with which it can be effected. Satisfactory stability of null position has been demonstrated with a 2 : 1 change in input signal level. Resolution of angles less than 1.5° has been limited by the distortion components of the signals and the noise appearing in the high-gain ac amplifier channel.

Circuit Simplicity

Even greater circuit simplicity is offered by the electronically-gated method of phase detection. The need for driving only a single motor winding with a control signal is counterbalanced, however, by the inherent instabilities of the diodes employed in the bridge circuit. Error resolution in a servo loop of 1.5° was achieved here too.

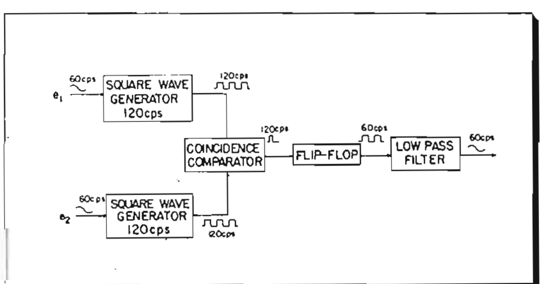
In the pulse coincidence comparator precision of error measurement is made available at the expense of circuit complexity. The problem of generating pulses coincident with the crossover of the sine-wave signal can be solved in numerous ways, but none of them are simple. In addition, adequate circuit bandwidth is required to provide pulse rise times consistent with the degree of accuracy required. An experimental system demonstrated error resolution of better than 0.3° with an apparent system bandwidth of one megacycle.

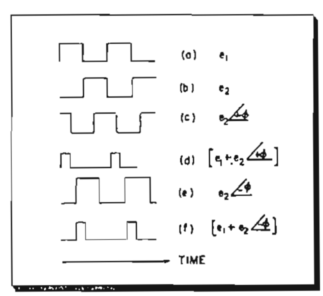
ACKNOWLEDGMENT – The investigations and development program upon which this paper is based were developed under contract W28-009-ac465, Rome Air Development Center, U.S. Air Force.

The development of the comparators was jointly carried on by Mr. R. Alexander and the author. The suggestions of Mr. D. W. Cawood are gratefully acknowledged.

This paper was first presented at the 1952 National Electronics conference held in Chicago, Sept. 29-Oct. 1.

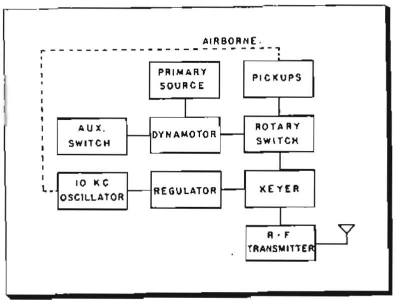
Fig. 5: (l) Pulse coincidence comparator. Fig. 6: (r) Waveforms for pulse coincidence comparator





Miniature Airborne Telemetering

Compact equipment for aircraft and missile test fits in container 16.27 in. long by 3.26 in. diameter. FM, AM and PM transmission systems evaluated



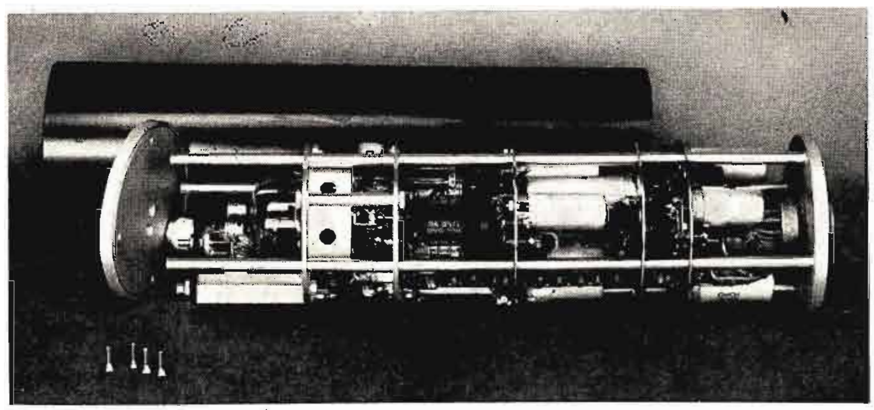


Fig. 1: (l) Block diagram of PDM-FM airborne telemetering system. Fig. 2: (r) Transmitter-keyer-oscillator and cylindrical container

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THE flight testing of modern high speed aircraft, rockets, and jet-propelled missiles has resulted in the development of radio telemetering systems having various degrees of information handling capacity and overall accuracy. Both frequency division and time division multiplexing are used. Transmission methods vary considerably. The most widely used frequency division method is FM-FM, wherein a number of (up to 15) comparatively low frequency subcarriers are frequency modulated by data pickup outputs, and in turn FM a r-f carrier. Time division methods currently used include PPM-AM (pulse position modulation on an amplitude modulated r-f carrier), PDM-FM (Pulse duration modulation on a frequency modulated r-f carrier), and PDM-PM, a comparatively new method to be described here, involving pulse duration modulation on a phase modulated r-f carrier.

The choice of a telemetering system for a given application depends, in general, upon the number and types of measurements to be made, the required frequency response per channel, the overall accuracy desired, the required transmission range, and the space and primary power available for the airborne unit. In applications where relatively large numbers of medium frequency response channels are required, a PDM-FM system has been used with notable success.[1]

The prime object of the work described here was to improve and miniaturize the airborne unit of this currently used system. A second objective was to compare the relative merits of PDM-FM and PPM-AM as applied to a miniature medium capacity time division radio telemetering system.

Currently Used System

Fig. 1 is a simplified block diagram of the airborne portion of a presently used PDM-FM telemetering system. The modulation system used is one in which duration modulated pulses are used to FM a r-f transmitter. Each pulse represents an instantaneous sample of the information from a single channel. The equipment has a capacity of 30 channels and a sampling rate per channel of 30 CPS. Two of the 30 channels are left unused in order to provide for synchronization of the ground equipment. Airborne channel calibration may be accomplished by reserving one or two of the remaining 28 for the purpose.

Time division is accomplished by a special high-speed mechanical switch which samples the channels in time sequence, producing AM pulses which are electronically converted to constant amplitude pulses of varying duration.

The airborne equipment includes the following components:

1. Dynamotor
2. Mechanical Multiplexing Switch
3. Auxiliary Switch
4. Keyer
5. Regulator
6. R-F Transmitter
7. 10-KC Oscillator

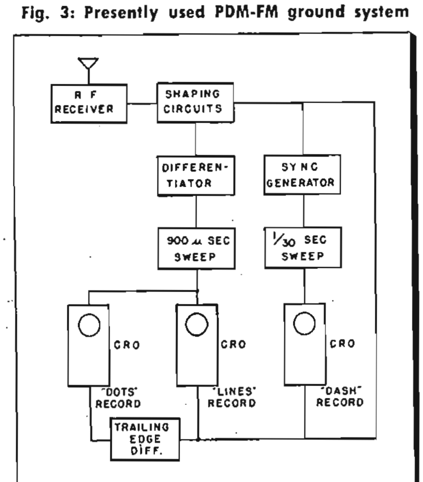
These components have the following functions:

Dynamotor: Supplies plate power for the electronic circuits and drives the mechanical multiplexing switch and the auxiliary switch through a gear reduction.

Mechanical Multiplexing Switch: Samples the pickups in time sequence.

Auxiliary Switch: An adjustable

Fig. 3: Presently used PDM-FM ground system



System

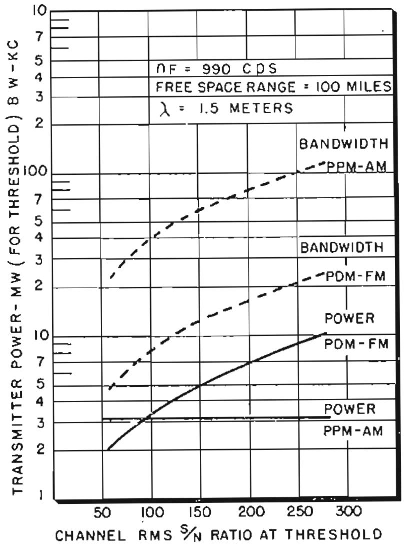
duty cycle SPST switch on a 30 CPS shaft, allows operation of an external device in synchronism with the sampling process.

Keyer: Converts the PAM signals produced by the Multiplexing Switch into PDM signals.

Regulator: Electronically regulates the plate voltage supply for the Keyer, 10-KC Oscillator, and R-F Transmitter Oscillator.

R-F Transmitter: Accepts the duration-modulated pulses from the keyer and transmits a r-f signal which is frequency-modulated by these pulses.

10-KC *Oscillator:* Provides regulated driving power for certain types of pickups.



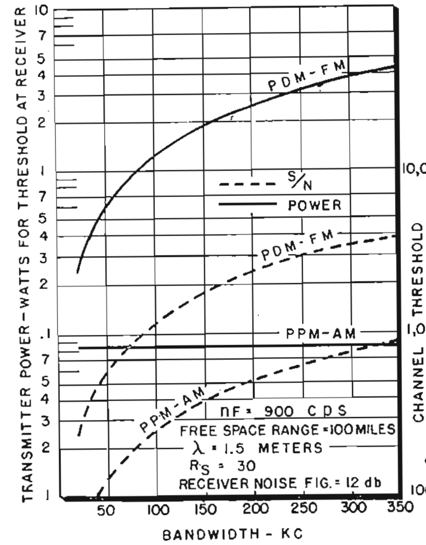


Fig. 4: (l) Power and bandwidth characteristics. Fig. 5: (r) System performance comparison

Cylindrical Containers

The airborne equipment is housed in two cylindrical containers which are hermetically sealed. The total volume of the two packages is approximately 350 cu. in. Fig. 2 is a photograph of the transmitter-keyer-oscillator equipment as manufactured by the Applied Science Corp. of Princeton.

The present ground system (see Fig. 3) includes a r-f receiver and suitable circuitry to shape the pulses and produce CRO sweeps for three photographic displays. A short functional description follows.

The first display is produced by using the leading edges of the channel pulses to trigger 900-μsec CRO sweeps which are intensified for the duration of the corresponding pulses. An optical record is made with a continuously moving camera film. The resulting record consists of a series of lines, one for each channel, each frame being denoted by the omission of two lines in succession. This display is known as a "Lines Presentation" and is the most accurate of the three employed.

The second display involves the generation of a 1/30-second sweep produced from the omitted two pulses. The individual channel pulses intensify this sweep, producing a "dashed" horizontal line on the CRO screen. Each "dash" represents the signal amplitude for a certain channel. A continuously moving film camera is used as before. This provides a compact record from which qualitative information may be obtained in a short time.

A third method is used where it is desirable to obtain a quickly produced and fairly accurate record of a few channels. A gate is produced from the framing circuit. This gate allows only five channel signals to pass through. The trailing edges are differentiated to produce intensifying pulses at the end of the channel pulses. Each leading edge triggers a 900-μsec sweep as in the "Lines" method. The resulting record consists of channel readings in the form of closely spaced "dots" superimposed on each other.

Miniaturization of Airborne Equipment

The first consideration of miniaturization is its possible effect on overall system accuracy. It is relatively easy to decrease size by eliminating parts of the original system and taking a resulting decrease in accuracy. Such a change, practically, results in the elimination of tubes and components which, in a sense, represent accuracy safety factors. The work done was based on the assumption that the present accuracy was to be maintained or improved.

Another consideration is that of system versatility. The elimination of unnecessary parts of the equipment should be carried out to the maximum possible extent. On the other hand, such eliminations should not result in drastic curtailment of versatility.

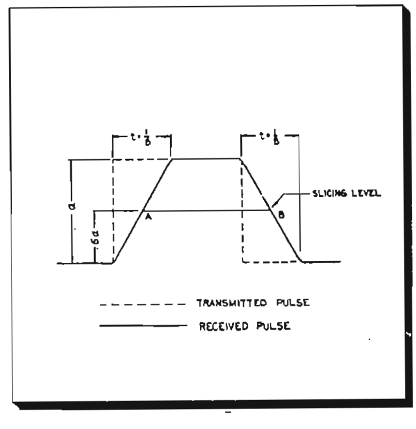
In most applications, the use of a 10-KC oscillator for driving pickups was not necessary. It was decided to eliminate this in the new equipment in favor of miniaturization.

The extent of miniaturization is also a function of the required transmission range, largely determined by the minimum possible r-f transmitter size. The required transmission range of the miniaturized airborne equipment was assumed to be equal to that of the existing equipment. Preliminary work showing that this is possible, using lower r-f power output and narrower bandwidth had been done previously.

A serious package design limitation, where minimum volume is a paramount objective, is that of heat dissipation. Heat considerations dictate a minimum number of tubes and the use of quality components having good high temperature performance characteristics. Physical placement of tubes and components must be such that no serious "hot spots" are produced.

The performance of subminiature tubes is another consideration where miniaturization is required. Electrical performance of these types is equivalent and, in some cases, superior to that of larger types. Uniformity in production of characteristics of given subminiature tubes is rapidly approaching that of miniatures due to continued improvements in manufacturing techniques. They are, in general,

Fig. 6: Effect of receiver bandwidth on the timing accuracy of a transmitted pulse shape



superior to larger types in their ability to withstand vibration and acceleration.

Factors considered in the choice of a power supply for use in a small PDM-FM equipment included the type of primary source, and the size, versatility, and performance of the supply itself. When the source power is supplied by 28-volt batteries, the choice narrows down to either a dynamotor or vibrator. A survey of existing vibrator supplies resulted in volumes of from 0.35 to 0.7 cu. in. per watt output for various manufacturers' designs. A dynamotor was available requiring 0.5 cu. in per watt. When a vibrator is used, additional volume is required for a motor to drive the sampling switch. This fact alone made the use of a dynamotor supply superior.

The miniaturization design should have no adverse effects on simplicity and ease of operation during testing and flight. As a matter of fact, if at all possible, any new system should include features which simplify field use.

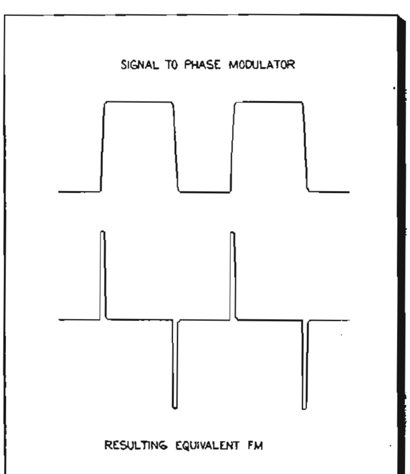
Potted Subassemblies

The use of replaceable potted subassemblies was considered and found to be impractical for use in this type of equipment. Encapsulation saves space by eliminating terminal boards, lugs, and other assorted hardware. This is of significance where very complex circuitry requiring many connections is involved, and where there are many potted units. Miniaturized PDM telemetering equipment does not belong in this category.

A potted unit becomes unusable when one component within it fails. When there is a small number of units in the equipment, this represents a high loss in terms of proportional cost.

The most straightforward and efficient construction design was considered to be one where separate units (unpotted) could be removed and replaced quickly through the use of plug-in features. Any defective unit can then be repaired at leisure for additional use.

Fig. 7: Waveforms illustrating PDM-PM system



Radio Link

Both PDM-FM and PPM-AM systems can provide good performance in a medium capacity telemetering system when the operating parameters are chosen correctly. Practical considerations modify the theoretical results, and final decision on the more appropriate system must take them into account.

The free space range between two dipoles is:

$$R = 0.118\lambda (P/P_t)^{1/2}$$

where:

P = Power output of the transmitter

P_t = Required signal power into the receiver at threshold

λ = Carrier wavelength

The required received power at threshold, P_t, is a function of the threshold bandwidth, B_t for PDM-FM and is independent of bandwidth for PPM-AM, the duty factor of the pulse train must be taken into account.

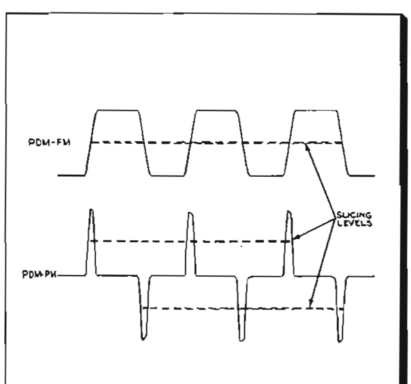


Fig. 8: Initial treatment of PDM-FM and PDM-PM pulses after detection process is completed

For PDM-FM[2]:

$$P_t = .512 \times 10^{-18} B_t \text{ watts}$$

This relation includes a proportionality factor based on a peak carrier amplitude equal to the peak noise pulse amplitude at threshold.

For PPM-AM[2]:

$$P_t = 4.1 \text{ nF} \times 10^{-18} \text{ watts}$$

where n = number of channels, and F = channel sampling rate in CPS.

This assumes minimum duration pulses and a threshold peak carrier amplitude equal to the noise peaks multiplied by two. It also assumes that synchronizing pulses are transmitted along with the channel pulses.

The receiver noise bandwidth at threshold for a given channel signal-to-noise ratio is as follows:

For PDM-FM[2]:

$$B_t = .26 \text{ nFR}_t \text{ CPS}$$

For PPM-AM[2]:

$$B_t = 1.22 \text{ nFR}_t \text{ CPS}$$

where R_t = channel S/N ratio at threshold.

The relations above enable calculation of theoretically required transmitter power and receiver bandwidth for various required S/N ratios and ranges. Fig. 4 shows results for the two systems plotted for a range of

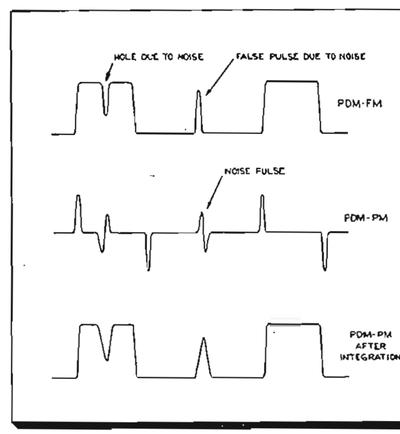


Fig. 9: Noise effect on PDM-FM and PDM-PM

100 mi. at a carrier frequency of 200 MC. (the approximate wavelength used in a large number of telemetering applications). The nF product is 900 CPS as used in present PDM-FM equipment.

Certain conclusions regarding system performance may be drawn from these curves. The curves are presented on a purely theoretical basis, no practical considerations being involved.

The required transmitter power for threshold operation shows no significant advantage for either system at rms S/N ratios from 50 to 150. Above this range, PPM-AM shows superiority. A rms S/N of 100 to 150 is sufficient for many telemetering applications. Higher S/N ratios may not be advantageous because of other sources of inaccuracy in some telemeters.

PPM-AM uses approximately five times the bandwidth that PDM-FM requires for the same signal-to-noise ratio. This, however, may be of little consequence where low and medium capacity systems are involved.

It will be seen from Fig. 4 that

PDM-FM requires a small bandwidth for low required transmitter power. Available telemetering receivers operating in the 217 MC range usually have overall bandwidths of from 300 to 500 KC. An estimate of the lowest practical bandwidth (assuming a single r-f of 10 MC) might be 50-60 KC. Good r-f selectivity is

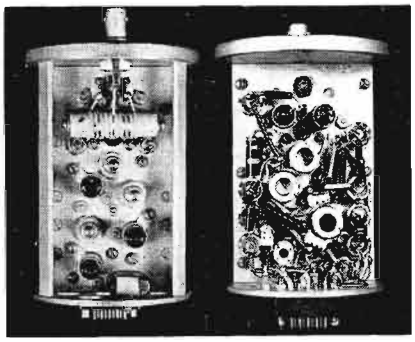


Fig. 10: R-F transmitter for PDM-PM system

required for a receiver with a single r-f of 10 MC in order to obtain passable image rejection in the region of 200 MC. A double heterodyne system is sometimes used to decrease image response, although it introduces more spurious responses due to the increased number of cross-products generated in two mixers. It should be understood that full advantage of a PDM-FM system cannot be taken without a suitable narrowband receiver.

Carrier Drifts

Narrow bandwidths cause difficulty due to transmitter carrier drifts. AFC can be used, but becomes difficult due to the decreased ratio of bandwidth to drift. Under such conditions, loss of signal for a short period causes "pull-out" and a corresponding loss of information until the receiver is manually readjusted. Crystal control of transmitter frequency corrects this situation, but has not been used in miniature PDM-FM equipment because of the space required for sufficient frequency multiplication to produce the required frequency deviation.

Equivalent FM noise due to microphonics is another factor which plays a considerable part in determining bandwidth. Experience with existing PDM-FM equipment has shown that carrier deviations of from 50 to 100 KC are usually necessary to override FM noise caused by vibration and acceleration. Crystal control is of great advantage in this respect.

Fig. 5 shows system performances for different values of available bandwidth. The power scales represent theoretical values multiplied by a

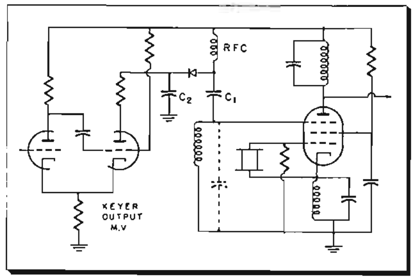


Fig. 11: Tri-tet oscillator and modulator

safety factor, K_s, based on attenuation caused by various effects which are present under practical conditions. The factor used was derived from field test data from known transmission systems having specified parameters. A receiving antenna gain of 10 db is included. The receiver noise figure is conservatively chosen as 12 db.

PPM-AM is somewhat superior to PDM-FM when commonly encountered receiver bandwidths must be utilized, although its S/N ratio for a given bandwidth is lower.

Pulsed carrier systems require modulators capable of producing adequately high voltage transmitter pulses to obtain the necessary high peak power. Modulator and transmitter tubes and components became bulkier as a result. A bulkier power supply is also required.

Due to the higher voltage field produced around the antenna, high altitude PPM-AM operation may be accompanied by quite serious voltage glow. Attenuation of the signal may necessitate higher transmitter power than the curves indicate. The safety factor mentioned above is based on practical experience with continuous wave systems and might have to be increased for high altitude PPM-AM use.

PDM-FM appears to be more practical than PPM-AM for a miniature medium-capacity telemetering system. This is especially true if the stability of the PDM-FM transmitter can be made to approach that of a crystal controlled PPM-AM transmitter. While PDM-FM requires more transmitter power when used with commonly available receivers, a transmitter capable of producing the required power is easily made small enough for its inclusion in a miniature package.

Radio Link Bandwidth

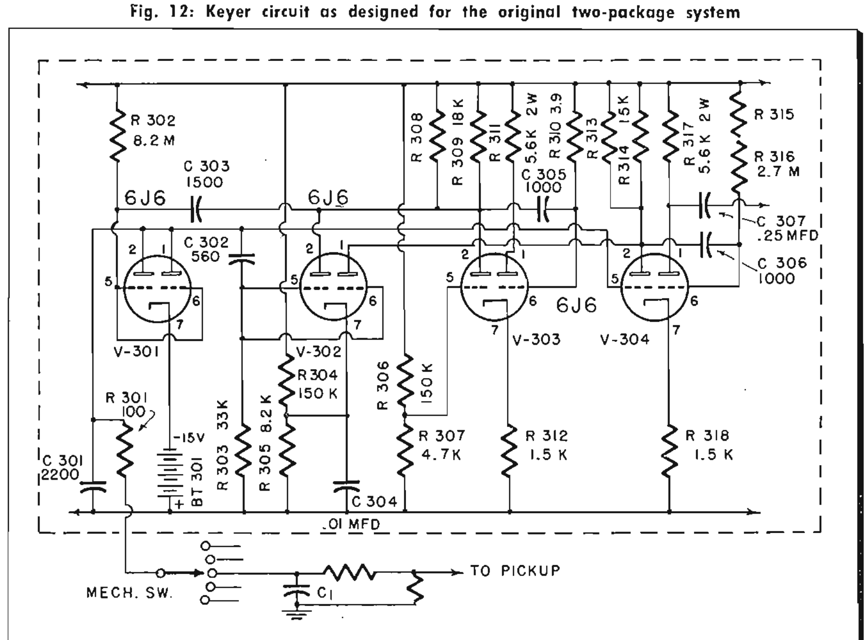
PDM-FM, as explained above, must be used with a small radio link bandwidth if fullest advantage is to be taken of its inherent possibilities for low required transmitter power.

Where miniaturization of airborne equipment is required, it is necessary to keep the size of the transmitter small. Hence, an investigation of any basic means for restricting system bandwidth had to be pursued.

One of the main problems, assuming a restricted bandwidth, is the effect on timing accuracy. The curves of Figs. 4 and 5 assume that bandwidth effects on overall timing accuracy are nil. Practically, however, this may not be possible.

The usable information contained in a pulse at the receiver detector output is a function of the times of start and stop of the pulse, i.e., its leading and trailing edges. For sim-

Fig. 12: Keyer circuit as designed for the original two-package system



plicity, assume that pulses applied to the transmitter modulator have negligible rise and fall times. Assume further that the system is operating far above threshold at a S/N ratio where fluctuation (and impulse) noise is negligible. Under these conditions the accuracy of the recovered information will depend only on the rise and fall times of the received pulses. For negligible rise and fall times (wide bandwidth) the accuracy as limited by bandwidth will be a maximum. As these times become longer (reduction in bandwidth), it becomes more difficult practically to define the start and stop points in time such that the recovered information is an exact replica of that which was transmitted.

Pulse at Modulator

Fig. 6 shows a pulse as delivered to the modulator and the same pulse after being transmitted over a radio link which has caused its rise and fall times to be increased. The sides of the received pulse are represented as straight lines, a legitimate approximation for the purpose of discussion.

The diagram shows that the duration of the original pulse at the modulator is represented by the line AB which is drawn horizontally at 50% of its maximum amplitude. Thus, suitable circuits may be arranged in practice to slice a thin section out of the pulse at this amplitude to produce a pulse with short rise and fall

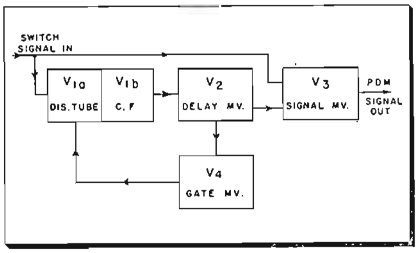


Fig. 13: Diagram of improved miniature keyer

times. The amplified output from such a system is then a very accurate replica of the original pulse. While this process has been used and is now new, it is described here as a necessary part of this explanation.

The effect of radio link bandwidth on pulse shape for FM transmission is approximately as in AM, that is, to increase the minimum possible rise or fall time to a time duration equal to approximately 1/B, where B is the link bandwidth[3].

Thus, with a FM receiver bandwidth of only 100 KC, for example, the minimum possible rise or fall time will be 10 μsec. This is a very acceptable figure for practical slicing circuitry and could, in fact, be at least twice as much and still result in accurate performance. This would result in a minimum rise or fall time of 20 μsec and a bandwidth of only 50 KC.

PDM-PM System

Up to this time, two commonly used modulation methods, PDM-FM and PPM-AM have been discussed. It has been stated that a crystal-controlled PDM-FM transmitter would enable narrowband transmission using this method without the practical disadvantages arising from the use of unstabilized oscillators. An investigation was made, therefore, with the object of determining the practical feasibility of a miniaturized crystal-controlled FM transmitter for PDM type modulation. It was known at the outset that such a transmitter could certainly be produced, but at a great sacrifice to volume. Various methods of phase modulation were considered. The simplest was considered to be a method where an amplifier tank circuit is detuned by a reactance tube or reactance switch. In order to produce an equivalent frequency deviation of only 50 KC under conditions where half the duration modulated pulses are at a minimum modulation and half are at maximum (the most unfavorable condition), a carrier frequency multiplication of approximately 100 times is necessary. This, of course, would require a large package, totally unsuitable for miniaturized equipment.

A unique modulation system was used, taking advantage of the high frequency components present in a PDM pulse train. As is well known, the equivalent FM produced by phase modulation of a carrier is directly proportional to the modulation frequency.

When a rectangular wave having steep sides is impressed on a phase modulator, the resulting equivalent ΔF wave takes the form shown in Fig 7. This wave is the derivative of the rectangular wave. its amplitude being proportional to the slope of the rectangular wave sides.

Calculations showed that a deviation of 100 KC could be obtained using an input pulse rise time of 10 μsec which is easily attainable in practice, and a frequency multiplication of only four times.

An investigation of PDM-PM for signal-to-noise ratio showed that it is roughly equivalent to PDM-FM. While an exact formula is difficult to obtain and was not justified within the scope of this work, some specific conclusions may be drawn. Noise can

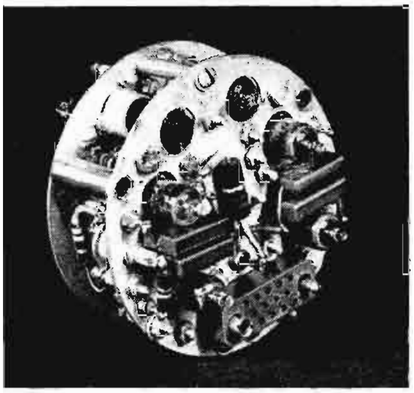


Fig. 14: Keyer unit shows plug-in construction

only be effective in either system by changing the time of beginning or end of the rectangular wave as seen by the receiving circuits. This change would be approximately the same in the two cases.

The best performance through fluctuation noise is obtained for either system under conditions where the received pulses are sliced at half amplitude as described previously for timing accuracy. When this is done, noise of less than 50% signal amplitude can have no effect unless it occurs simultaneously with a signal pulse at the slicing point. The result of this is to cause a slight error in the interval to be measured. On this basis, the S/N for PDM-PM is just as good as that for PDM-FM, and perhaps somewhat better. Fig. 8 shows PDM-FM and PDM-PM pulses as they should be treated after detection.

Integrator

In order that the PDM-PM pulses may be used with existing ground equipment, it is necessary to provide an integrator after the receiver detector. The question arises as to performance obtained with a regenerative type device (for example, flip-flop circuit) as compared to a simple integrator.

On the basis of fluctuation noise considerations discussed above, the PDM-PM pulses could be applied equally well to a regenerative device or a non-regenerative integrator. A regenerative device will cause trouble only when noise pulses are large enough to trip it. It is apparent that under the noise conditions de-

(Continued on page 84)

WASHINGTON
News Letter

Latest Radio and Communications News Developments Summarized by TELE-TECH's Washington Bureau

DIFFICULT DECISION—Having wrestled for two years with color television and also endeavoring to implement educational TV organizations to launch their video stations on the air, the FCC now has commenced a lengthy proceeding to crack another "tough nut"—the desire of the motion-picture industry to have a segment of the spectrum of 420 MC in the area below 7125 MC. Critical attitudes towards such an allocation of this substantial portion of the spectrum come from a different direction primarily than the television broadcasting field—the telephone and telegraph systems and the industrial mobile radio services and aviation. However, the Commissioners themselves, as was exemplified in the questioning of the motion picture engineers and counsel by Chairman Paul A. Walker and Commissioner Frieda B. Hennock in the initial hearings, showed their concern as to whether motion-picture theatre television aimed to take away programs from home video, particularly in sporting events. But the film industry spokesmen declared there was no such threat.

READY TO SERVE—The Bell System had emphasized in the conferences prior to the start of the FCC theatre TV hearings that it wants to serve the motion-picture industry through the microwave transmission of film television to the motion picture theatres. But the equipment for the broad bandwidth to relay televised color motion pictures, the Bell Laboratories scientists stress, is not yet ready for manufacturing and actually is only in the advance development stage with full field testing still unfinished. There was a general feeling in FCC circles that this situation as to the needed equipment is entirely accurate. But as in the color-television proceedings the motion picture industry legal proponents are engaging in considerable sparring in advocating their proposals. Their barrage will come up in full array, it is thought, when the FCC hearings are resumed Jan. 12.

MOBILE RADIO WATCHING—The most important services in mobile radio—petroleum, utilities, together with aviation—have not yet interposed their views before the FCC on the motion-picture industry's frequency assignment proposal to classify theatre television as an industrial radio service using two large bands on a shared basis in the 6575-6875 MC and 6425-6576 MC areas. But the mobile radio services with their position of having their services as a vital medium of the operations of their industries—and safety of flight in aviation,—all very important to the nation's economy, will wield a most potent influence in the thinking of the FCC and also in any possible presentations to Congress. In the orderly development of these services which have rather saturated their lower bands' usage, it has been viewed for some time past that upper frequencies were the logical location for the mobile services to occupy. Communications common carrier operations such as remote control for the international radiotelegraph companies and shorthaul fixed radiotelephone services of the telephone companies are also rapidly filling up the 3700-4200 MC band so the next place to go is the 5925-6425 MC area.

TV INTERFERENCE POTENTIAL—The FCC has been warned by the two major industry organizations in the radio-television field that its proposed new policy governing the assignment of the 72-76 MC frequencies to operational fixed stations and fixed stations in the domestic public radiotelephone service has the definite possibility of detrimental interference to television reception. These views were strongly presented to the Commission by the Radio-Television Manufacturers Association and the National Association of Radio and Television Broadcasters, together with the National Broadcasting Company, Sylvania Electric Products, Inc., and the Philco Corporation and the Minneapolis television station WCCO-TV. The opponents of the FCC proposal urged that all such assignments if this frequency plan becomes permanent should be made on an experimental basis and that there must be adequate geographical separation between the television and the domestic public service transmitters.

TECHNICAL EXPERTS—The American railroads which are steadily expanding their radiocommunications systems with a present total of more than 11,000 authorized base and mobile stations and inductive carrier installations as compared with 3800 in 1949 need a large number of communications engineers and technical experts, the FCC has been informed in reports from the Communications Section of the Association of American Railroads. The railroads now have well in excess of 100,000 persons employed in communications work. Potentialities of the transistor and microwave are being given intensive study by the railroads as the next sphere of radio communications expansion.

ESSENTIAL SERVICE—The petroleum industry has been classified as essential to Civil Defense communications. Since its radio-radar services are so vital to the petroleum industry's operations, the Federal Government had the industry establish a special 14-member committee to make a study of the use of radio and radar so as to determine the possibility of use of alternatives in event of a war emergency and in the event the armed services might have to take over some of the petroleum frequency assignments.

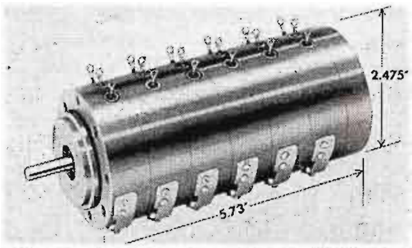
National Press Building
Washington, D. C.

ROLAND C. DAVIES
Washington, Editor

NEW EQUIPMENT for Designers and Engineers

Potentiometer

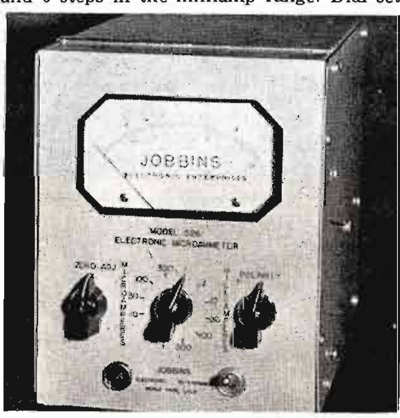
Vernier phasing ganged potentiometer, known as Gangpots, are available with from two to six individual sections. Assembly is



without external clamps or bolts. Mechanical rotation is 360° continuous; electrical rotation may be 360° or less. Sections are available in resistances from 2,000 to 300,000 ohms and each will dissipate 4 watts continuously at 25°C. Sections may have linear or non-linear outputs, one or two brushes, and taps as desired. A simple screwdriver vernier phasing for each section permits phasing to 0.2° over an angle of 22°.—**G. M. Giannini Co., 287 W. Colorado St., Pasadena, Calif.**—TELE-TECH

Microammeter

Model 526, a new electronic microammeter incorporates 6 steps in its microampere range and 6 steps in the milliamp range. Dial set-



tings are 3, 10, 30, 100 and 300 microamps and 1, 3, 10, 30, 100, and 300 in the milliampere range. Two meter scales, 0-1 and 0-3, permit rapid interpretation of electrical readings. Polarity switch is also included.—**Jobbins Electronic Enterprises, Menlo Park, Calif.**—TELE-TECH

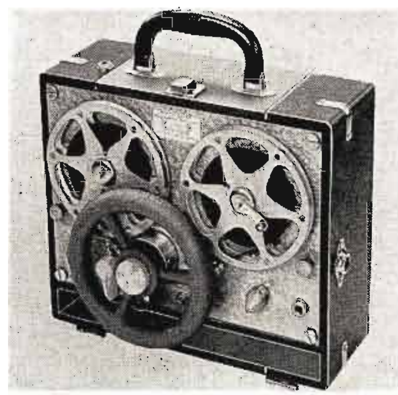
Relay

A hermetically sealed relay unit is well-adapted for use with transistors and germanium diodes. The hermetic seal may be either air or inert gas. Sensitivity runs as low as 10 milliwatts (0.010 watts) and it will operate as low as 0.0008 amps. Contacts are single pole, double throw to 3 amps, 24 volts dc; 115 v. ac, non-inductive. Coil resistances are available from 4 to 20,000 ohms. Standard temperature range is −55°C to +85°C (High-temperature units may be ordered to cover range from −65°C to +200°C). Environmental characteristics: vibration 20G

to 60 cycles, 10G to 200 cycles; shock and acceleration in excess of 50G. The unit operates as rapidly as 2 to 3 millisec., depending somewhat upon coil inductance. The dimensions are: 1 in. x 2⅜ in. It is available as a plug-in or solder hook unit with a variety of mounting brackets.—**Neomatic Corp., 9010 Bellanca, Los Angeles 45, Calif.**—TELE-TECH

Portable Tape Recorder

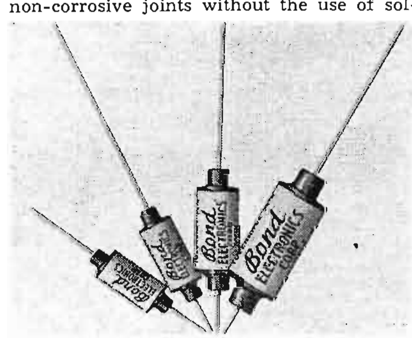
Broadcaster model 610-SD is a new battery-powered portable tape recorder with spring-wound motor, offering performance ratings in complete accordance with NARTB specifications. Measuring only 11½ x 10 x 7½ in., the Magnemite Broadcaster



weighs 15 lbs., including its self-contained inexpensive flashlight type dry cell batteries that last 100 operating hours without replacement. Constant tape speed, with flutter content within ±0.1% over the full winding cycle of six minutes, is achieved by means of a patented centrifugal flyball governor on the spring motor. The motor may be rewound during operation without any effect on recording or playback. A triple purpose indicator light signals 30 seconds before rewinding is necessary, shows if the switch is accidently left on, and also instantly indicates any variation in tape speed. The Broadcaster operates at a tape speed of 7½ i.p.s. furnishing 15 minutes of playing time on a standard 5 in. diameter 600-ft. reel of sound recording tape. A special single-track record head with double-gap (for double life) is used. Recordings may be played back on any ac-operated studio equipment at equivalent tape speed. A supplementary speed control provides ±5% tape speed adjustment. Recordings can be made while the instrument is in motion or being carried. Earphone monitoring while recording is possible, as well as immediate playback either through earphones, or into an auxiliary amplifier or speaker, or into telephone transmission lines. Standard phone jacks are used for the high impedance microphone input and output terminals.—**Magnemite Div., Amplifier Corp. of America, 398 Broadway, New York 13, N. Y.**—TELE-TECH

Resistors

New axial lead resistors with completely non-corrosive joints without the use of sol-



ders or fluxes are completely protected from chassis or mounting surface, affording greater dielectric path. They are guaranteed to exceed the requirements for Jan. R-B-51. Available on all standard tolerances, they are wound in a wide range of alloys to meet requirements of varying resistance values.—**Bond Electronic Corp., Springfield, N. J.**—TELE-TECH

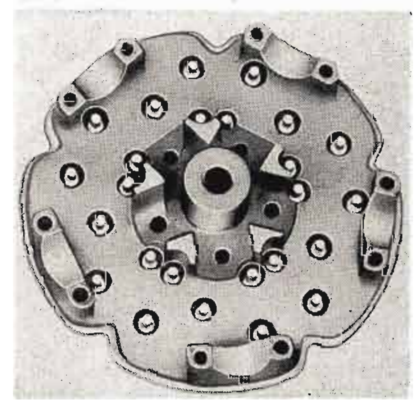
Resistors

For maximum stability two carbon film resistors are sealed in glass envelopes, evacuated, baked at high temperature under

vacuum, and finally sealed in helium of spectroscopic purity. These units are stable to .01% under all environmental conditions, and have long time drift of .01% per year or less. They can be supplied in networks with ratios and temperature coefficients held to very close tolerances. Less expensive units are made by solder-sealing resistors in ceramic tubes with metallized ends. The stability of these is less than that of the glass-helium sealed resistors, but much better than that of varnished resistors, particularly under conditions of high humidity and temperature.—**Chase Resistor Co., 9 River St., Morristown, N. J.**—TELE-TECH

R-F Tuner Plate

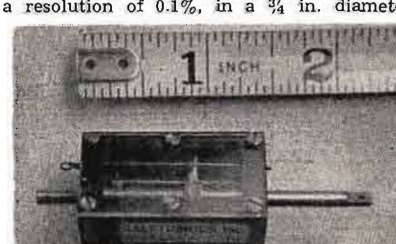
Precision tuning of five r-f channels is provided by a high frequency contact plate. Although the circuits tuned operate at high frequency, permanently accurate tuning is attained. The part described is injection-molded of Mycalex 410 glass-bonded mica dielectric, molded to close



tolerances and incorporates a series of coin silver contacts, stainless steel distributing rings, and an integral center hub. The use of Mycalex insulation results in extremely low dielectric loss, long-term dimensional stability, and permits precision molding with resultant dimensional uniformity of all pieces. This process also reduces the unit cost considerably as compared to other materials and methods of fabrication. In this application moisture is also an important factor. Mycalex, being non-hygroscopic, solves this problem completely.—**Mycalex Corporation of America, Clifton Blvd., Clifton, N. J.**—TELE-TECH

Potentiometers

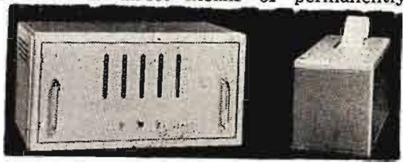
Rotary Type RC subminiature potentiometer can be furnished up to 320,000 ohms with a resolution of 0.1%, in a ¾ in. diameter



case. Type LE, a rectilinear potentiometer, in a case 1⅜ in. long, can be supplied up to 1,000,000 ohms with a resolution of 0.05%. The manufacturer places particular emphasis on custom-engineering potentiometers to the user's specifications.—**Galetronics, Inc., c/o Eastman-Pacific Co., 2320 E. 8th St., Los Angeles 21, Calif.**—TELE-TECH

Digital Recorder

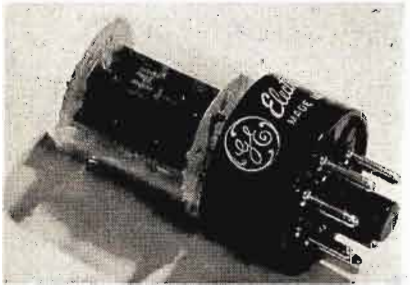
Digital Recorder (series 1550) is a printed readout for high-speed electronic counter. It provides a direct means of permanently



recording sequential count information in Arabic numeral form on a standard adding machine tape and is designed to operate from electronic counters, time interval meters, events-per-unit-time meters, nuclear scalers, and other electronic totalizing devices at a maximum cycling rate of one printout every 0.8 sec. The series 1550 is composed of a readout and a printing recorder. The first unit consists of a band of readout decimal counting units essentially paralleling the totalizing function of the basic counting instrument from which they operate, and a selecting relay matrix to channel information from the counting circuit to the printing recorder. The second unit presents a sequence of total counts in direct reading digital form on a standard adding machine tape. The readout unit is available in three, four, five and six bank units.—**Berkeley Scientific Division of Beckman Instruments, Inc., 2200 Wright Avenue, Richmond, Calif.**—TELE-TECH

Triode

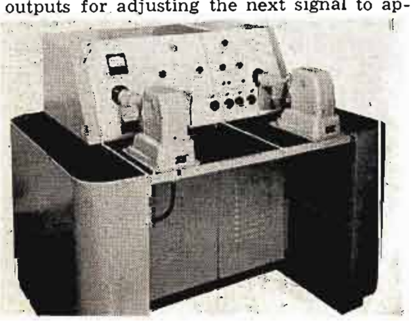
A high-perveance triode (6AH4-GT) for vertical output service in television receivers utilizes relatively low plate voltages at



high plate currents to fully deflect wide-angle picture tubes. It is capable of withstanding the high pulse voltages normally encountered in this application. Typical operating characteristics with 250 v. on the plate include: heater voltage 6.3 v.; grid voltage, —33 v; plate current, 30 ma; transconductance, 4,500 μohms; amplification factor, 8.0; and plate resistance, 1,780 ohms.—**General Electric Co., Tube Department, Schenectady 5, N. Y.**—TELE-TECH

Dual Flying Spot Scanner

An improved version of the Poly-Efex Scanner, FTL-93A is now available for television station application. Incorporating advanced circuits and expanded operational features, the Scanner allows a single operator to take complete charge of a station's program sources. Basically a dual flying spot scanner, the unit has, in addition to its two self-contained slide sources, a four-channel video switcher, and a special effects section. This special effects or montage section permits a variety of picture presentations, such as "split-screens," corner or center insertions, superimposed patterns, etc., of any two signals, plus automatic or manual fades, lap dissolves, and wipes. The two high-resolution slide sources may be fed by automatic slide magazines that hold as many as 72 slides which may be fed in or out of sequence. In addition, a preview output has been added to the usual line and monitor outputs for adjusting the next signal to appear on the program line. An integral gamma correction circuit has been built into the unit to compensate for the non-linearity of the raster produced by the cathode ray tube. This important new circuit development permits a greater number of gray steps in the range from black to white, resulting in a much sharper and clearer picture, with an overall effect of greater contrast range.—**International Telephone and Telegraph Corp., Nutley, N. J.**—TELE-TECH



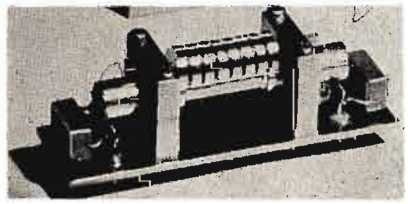
Microphone

A unidirectional dynamic microphone finished in satin and maroon, features a multi-impedance transformer and impedance

selector switch. Tradenamed the "Dynabar" model DR-11 (DR-11S with off-on switch), the new microphone employs Astatics sintered metal method of acoustic phase shifting. This is said to accomplish a front-to-back pickup differential of approximately 15 db, which makes the microphone, for all practical purposes, dead to extraneous noise and drone. The internal dynamic element is floated in rubber. The impedance selector switch provides operating impedance of 50, 200, 500 and HZ and is located at back of the microphone housing, flush with surrounding grillework to prevent accidental turning. Output level of the Dynabar is —54 db (1 v. per microbar); range is 40 to 10,000 cps. Standard equipment includes Amphenol cable connector and 18 ft. of 2-conductor shielded cable.—**Astatic Corp., Conneaut, Ohio**—TELE-TECH

Mechanical Filter

A mechanical filter magnetostrictively driven for intermediate frequency application, is composed of three sections: the input transducer, the resonant section and the output transducer. Input and output section are identical and function to convert the electrical signal to a mechanical form and vice versa. In the resonant section, discs composed of special alloy metal have a very sharp resonance and excellent frequency stability. By means of magnetostrictive action, mechanical vibration are converted into a varying magnetic field. A coil intercepts this field and supplies the output voltage. The entire unit is housed in a hermetically sealed case smaller in size than a normal intermediate transformer. At the present time the mechanical filter is being incorporated in the new Collins 75A-3 Amateur Receiver. The unusual selectivity of this filter and its miniature size make it readily applicable to both military and commercial transmitter and receiver designs.—**Collins Radio Co., Cedar Rapids, Iowa.**—TELE-TECH



Variable Inductance Coils

A new series of variable inductance coils covers the complete 2-180 μhenry range. Designed for such applications as video peaking, r-f and i-f amplifiers, and filter networks, these coils feature compact plastic forms, four rugged terminals (two of which may be used as separate tiepoints), and durable windings. Convenient for development and production use, Series 102 Coils are individually boxed and labeled.—**North Hills Electric Co., Box 427, Great Neck, N. Y.**—TELE-TECH.

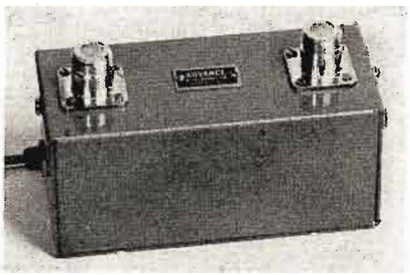
Program Equalizer

Type 4031-B program equalizer may be used in very low-level portions of a system without danger of extraneous noise and

hum pickup. All inductances are toroidally wound. The controls may be set to any position in an active channel without causing clicks or noises; without changes in the average program level. No power supply or other accessories are required. The detented action of the controls permits recording of the exact dial settings for reference and future duplication of desired characteristics even years later. Long term stability is assured by the use of only passive circuit elements. Easy operation of the two control knobs allows a wide range of over 395 available curve combinations; selective for both high and low frequencies over the entire audio spectrum; equalization in high frequencies at any of the 3 peak frequencies. The 4031-B may be pre-set and switched in or out of the line upon cue without affecting the overall level. A fixed pad compensates for insertion loss. The controls provide for independent adjustment of the high and low frequencies in 2 db steps.—**Cinema Engineering Co., 1510 West Verdugo Ave., Burbank, Calif.**—TELE-TECH

Variable Delay Line

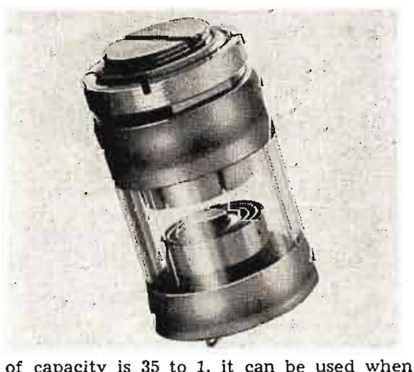
Type 601 variable delay line consists of 44 sections of lumped-parameter L-C networks. Each section is specially designed to



give (1) linear phase shift up to 70% of its cutoff frequency, and (2) the frequency responses curve being Gaussian in shape. As a result, type 601 step variable delay line produces essentially zero over-shoot and has a very rapid rise-time. Light weight, small size, and rigid construction make this device suitable for incorporation with any instruments where variable time delay is needed. Time delay is variable in steps of 0-2μ sec up to 2.2μ sec. Characteristic impedance is 190 ohms nominal for both input and output. Maximum rise time is less than 0.1μ sec at any step.—**Advance Electronics Co., P. O. Box 394, Passaic, N. J.**—TELE-TECH

Capacitor

A new concentric high ratio capacitor has a maximum capacity of 35μμf, and a minimum capacity of 1μμf. Because its ratio



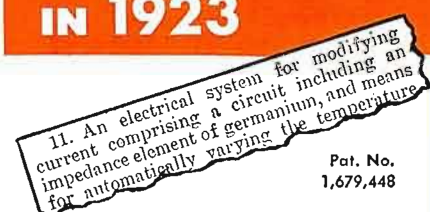
of capacity is 35 to 1, it can be used when capacitive adjustments need to be made over a wide range with great accuracy. Construction is of silver-plated brass and Pyrex glass. It is said to have excellent performance characteristics at the higher frequencies and is a high Q condenser at and above 200 MC. A friction spring locks the rotor, assuring stable characteristics.—**Johanson Manufacturing Corp., Boonton, N. J.**—TELE-TECH

RAYTHEON and TRANSISTORS

A *Thirty-Year Record* OF

Germanium Product Research, Development and Manufacture

IN 1923



Pat. No. 1,679,448

Raytheon's Dr. C. G. Smith applies for patent on a germanium current amplifier.

IN 1929

Raytheon designed and produced this Germanium *Photo Transistor.*

IN 1948

the Raytheon CK-703 *Point Contact Transistor* is perfected and put in production, now superseded by the improved type, CK716, currently available.

IN 1949

Raytheon inaugurates large scale production of *Germanium Diodes.*

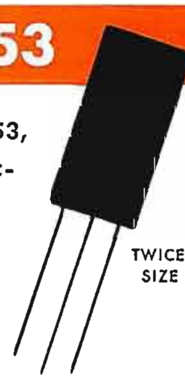
IN 1950

TWICE SIZE

Raytheon develops the CK710 *Germanium Diode Mixer* to replace silicon diodes. UHF television receiver circuits now use the CK710.

IN 1953

by early 1953, Raytheon Junction Transistors and New Point Contact Transistors will be available in sample quantities.



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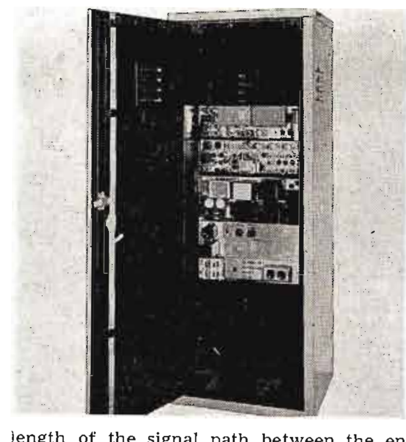
Automatic Relay Station

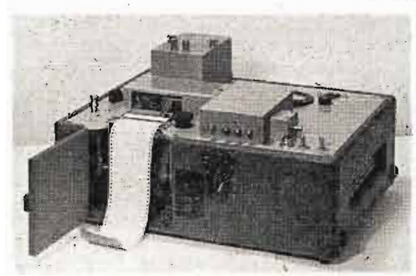
A new automatic relay station to increase the area of operations of a base-to-mobile communications system or to extend the



length of the signal path between the end points of a point-to-point radio relay system operates in the 450-470 MC range. The equipment is also used when it is to be installed in a location some distance from the point of audio termination. Such a condition might be dictated by a high ambient noise level or poor signal propagation characteristics at the most convenient location. Proper location of receiver and transmitter may increase the effectiveness of a system many times. The new base station is housed in a weather-proof cabinet suitable for pole mounting, the same cabinet successfully employed in conjunction with Motorola's 25-50 MC and 152-174 MC remotely controlled base station.—**Motorola, Inc., 4545 Augusta Blvd., Chicago, Ill.**—TELE-TECH.

High Speed Level Recorder

Recent design changes in the high speed level recorder Model HPL have resulted in improved frequency response and increased



sensitivity which can be adjusted from 7 to 12 mv. A new semi-automatic electronic damping is provided which controls the writing stylus and is particularly useful when the input potentiometers or writing speed are changed. The electronic chassis is an integral part of the recorder and can be easily substituted with circuits of different functions. Mechanical changes have been made for a more convenient chart roll insertion and manual chart setting. Chart rewinding mechanism has been added. Knobs formerly protruding from the side of the instrument case have been eliminated.—**Sound Apparatus Co., Stirling, N. J.**—TELE-TECH

DC Generator

A miniature dc generator is similar to the Globe "Moto-Mite," a permanent magnet motor. The design has been refined specifically for generator applications to provide units of high voltage output per unit of speed. Effort has also been made to reduce the "slot-lock" effect and to reduce inherent friction to obtain minimum starting torque. Since these generators are permanent magnet units, slot lock and voltage output are proportional to magnetization. Therefore, maximum output is incompatible with minimum slot lock or starting torque. As an example, a specific unit can provide 0.7 volts per 100 rpm with a starting torque of 0.15 oz. inches, or can produce 1.7 volts per 100 rpm with a starting torque of 0.5 oz. inches. All outputs are based on high impedance loads (approximately 1000 ohms per volt minimum) and must be correspondingly reduced if appreciable current is required. Most units can be loaded to 50 milliamperes or higher, depending on the winding.—**Globe Industries, Inc., 125 Sunrise Place, Dayton 7, Ohio**—TELE-TECH

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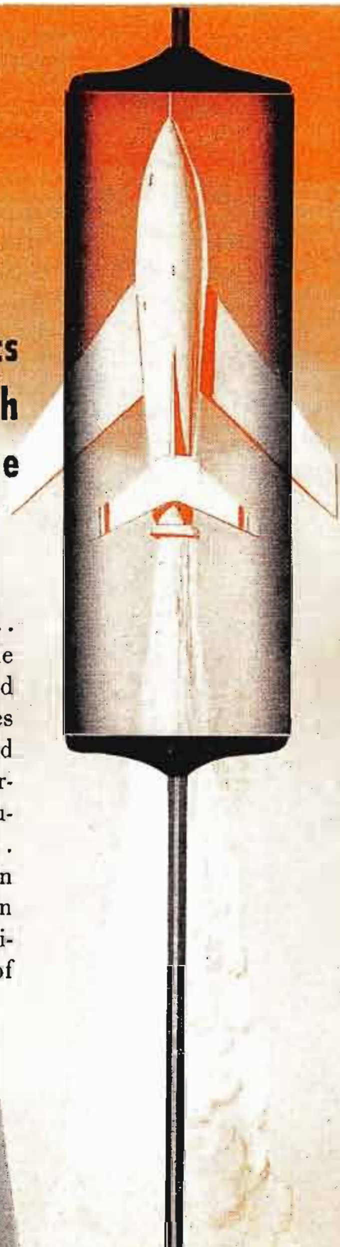

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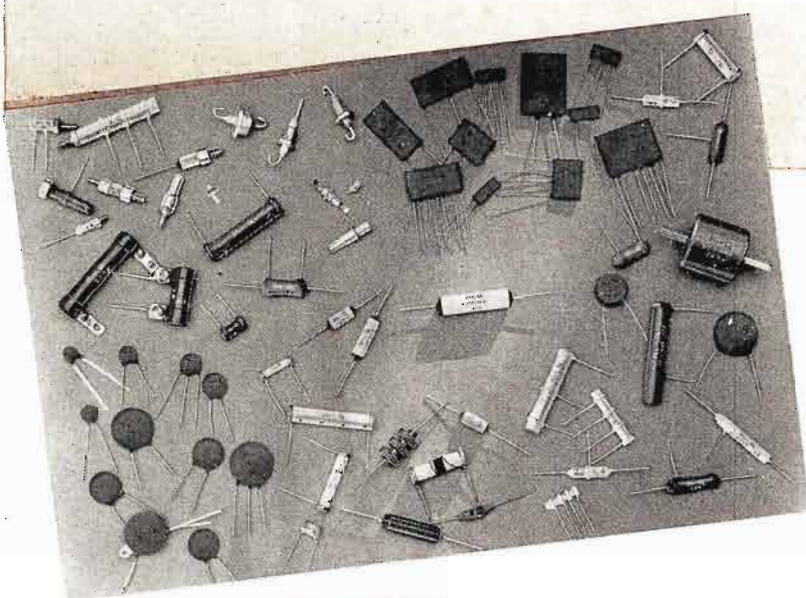

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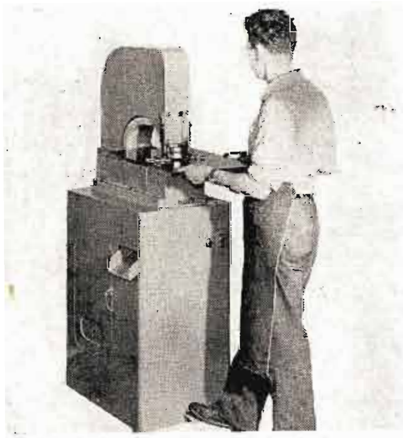
Plugs and Jacks

A new line of silver-plated banana plugs and jacks can be used in military, industrial and commercial equipment requiring very

low contact resistance. The No. 428 plug has a straight threaded shank 1⅛ in. long. The No. 429 has a combination shank 3.4 in. long with a knurled collar for force-fit in a panel hole and a threaded section in addition. Both plugs have contact springs of beryllium copper. The No. 431 banana jack is machined of solid brass, also heavily silver-plated. It has a knurled shoulder and a threaded body. The hex head is 7/16 in. across flats, and the shank is 3.4 in. long.—**Insuline Corp. of America, 3602 35 Avenue, Long Island City 1, N. Y.**—TELE-TECH

Punch Presses

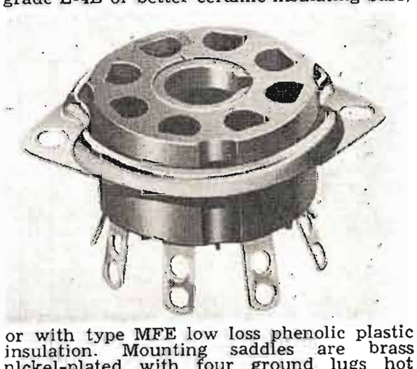
The new power operated Punch Presses, each with a rated capacity of five tons, will punch a 4 in. diameter hole in 16 gauge



(.062 in.) sheet steel or a ⅜ in. hole in 3/16 in. steel plate. Called Di-Acro power punch press No. 1 and No. 2, a feature of these machines is their deep throat. They are capable of making 180 strokes a minute. A foot control frees both of the operator's hands for work handling and positioning. A complete line of punches and dies are available. The flywheel on these machines is driven by a half-horsepower electric motor. Choice of a single-phase 110-220 volt, or a three-phase 220-440 volt, ac motor is offered. —**O'Neil-Irwin Mfg. Co., 624 Eighth Avenue, Lake City, Minn.**—TELE-TECH

Octal Sockets

Designed to specification JAN-S.28A, a new line of octal sockets are available with either grade L-4B or better ceramic insulating base,



or with type MFE low loss phenolic plastic insulation. Mounting saddles are brass nickel-plated with four ground lugs hot tinned for solderability. Saddles are available with 0.156 in. diameter mounting holes or with threaded extrusions for 6-32 screws. Contacts are available in either phosphor, bronze or beryllium copper, silver plated. They are hot tin dipped after assembly for better solderability.—**Sylvania Electric Products Inc., 1740 Broadway, New York 19, N.Y.**—TELE-TECH

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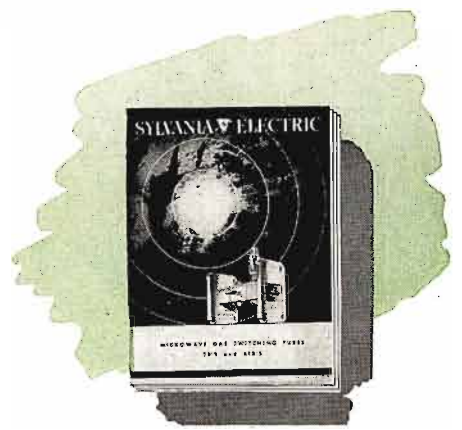

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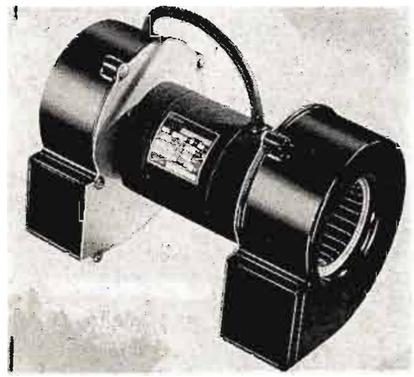
Motor Blowers

Two fractional hp motor blowers for cooling aircraft electronic equipment and microwave relay equipment, are available. Model



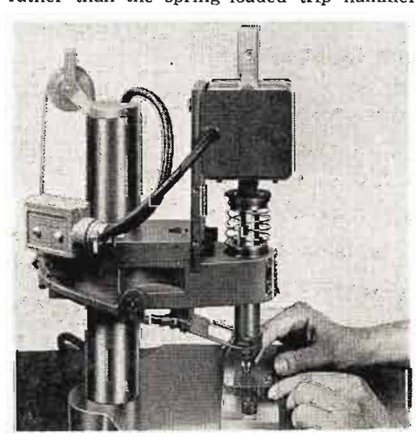
100 dc motor is rated 1/50 hp at 27½ v. Designed for aircraft, this model operates at 4500 rpm at sea level, 6500 rpm at 50,000 feet with a relatively constant air delivery of 40 CFM. Ambient temperature range is −65°C to +70°C. Model 2914 is a Cyclohm induction motor rated from 1/100 to 1/15 hp. Currently used for microwave relay equipment and other electronic applications, this motor operates at 1650 rpm with an input voltage of 90-120 v. Motor is self-ventilated and is available with ball or sleeve bearings. Air delivery of double blower is 37 CFM each head at 95 volts ac. —**Howard Industries, Inc., 1760 State St., Racine, Wis.**—TELE-TECH.

Rectifiers

A new type of ac to dc regulated rectifier known as the "MagniVolt" is said to be better than 1% from no load to full load with ±10% ac line variation. Response is faster than 0.2 sec. even under extreme contrast of load conditions. RMS ripple is less than 1%. It is designed to operate on 115 v., single phase, 60 cycle current and is built in standard models ranging from 1.2 v. to 28.0 v., and from 2.5 amps to 30.0 amps. The manufacturer attributes the equipment's ruggedness to the Inet-developed Magnetic Amplifier which is incorporated in it.—**Inet, Inc., 8655 South Main St., Los Angeles 3, Calif.**—TELE-TECH

Staking Machine

An all-electric staking machine called "Electrostake" is powered by a solenoid rather than the spring-loaded trip hammer



used on most conventional stakers. It reduces operator fatigue and makes possible 25 to 50% increase in production. Both the hold-down pressure and the staking blow are fully adjustable. Portable machine operated by foot treadle is used for any assembly-line operation where two or more assembled parts must be pressed firmly together and then staked or riveted with a sharp blow. Staking, riveting, eyeletting, upsetting and rolling can all be accomplished. Hold-down pressure can be preset from a few ounces to 10 lbs. and does not vary during the staking operations. Basic construction consists of an adjustable bracket mounted on a base and column. The bracket supports the solenoid which automatically delivers the power stroke. It weighs 45 lbs., occupies 1 sq. ft. of bench space and plugs into any 115 v., ac outlet.—**Black and Webster, Inc., Dept. N99, 445 Watertown St., Newton 58, Mass.**—TELE-TECH

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Miniature Telemetering

(*Continued from page* 72)

scribed above, this cannot occur.

The performance of such a system under conditions of strong impulse noise of greater than 50% signal pulse amplitude is a different matter. For PDM-FM such noise pulses result in either short extra pulses or "holes" in the signal pulses, depending on their time of occurrence.

For PDM-PM it is important to realize that the impulse noise pulse must result in a bi-directional pulse if it occurs between signal pulses[4]. Thus, an integrator becomes superior to a flip-flop circuit under strong impulse noise conditions. The integrator provides result equivalent to or better than the existing FM system. Fig. 9 illustrates this fact.

R-F Transmitter

The crystal-controlled r-f transmitter developed for the miniature PDM-PM airborne unit is shown in Fig. 10. Five subminiature tubes are used. The power output into a 50-ohm load is 4 watts minimum at a plate supply drain of 75 ma (250 v.).

The modulator circuit devised for use with this transmitter is of interest because of its simplicity, and is considered to be rather novel.

A crystal tri-tet type oscillator-tripler is employed. The modulator network, consisting of a crystal diode, a coil and two capacitors, is connected to the suppressor grid of the tube as shown in Fig. 11. This circuit is used for the combined functions of oscillation, frequency tripling, and phase modulation.

The triode shown represents the second section of a monostable multivibrator used as the PDM signal source.

When the triode is non-conducting, the diode is non-conducting and the suppressor-ground impedance consists of the reactance of the coil and stray capacitance, resonant frequency of which may be above or below the tripled signal frequency. The flow of current in the suppressor load circuit causes an r-f voltage to appear at the suppressor. When the triode conducts, the diode conducts and the reactance to ground is greatly decreased, causing phase modulation of the plate current. The r-f choke provides a dc path of high r-f impedance.

The use of this modulator results in an adjustable dtviation value of from ±10 KC to ±150 KC after a frequency multiplication of four times. Amplitude modulation is less than 8%.

(*Continued on page* 86)

The conversion of the AM pulse train from the mechanical switch into duration modulated pulses must be accomplished with a high degree of accuracy, stability, and a minimum of circuit complexity.

Fig. 12 shows the keyer circuit as designed for the original two-package system. This circuit has been used extensively and its performance has been generally satisfactory. A brief description of its operation follows.

The 0-5 v. dc pickup outputs are applied to the mechanical switch contacts through RC filters. The switch wiper applies the channel pulses to keyer input in turn. The tube V_{301} is used as a discharge tube which is kept non-conducting for a time longer than the full scale duration of the keyer output pulse. Capacitor C_{301} is a storage capacitor which holds the voltage for a time after the switch breaks and also prevents any switch contact noise from causing triggering uncertainties.

Monostable Vibrators

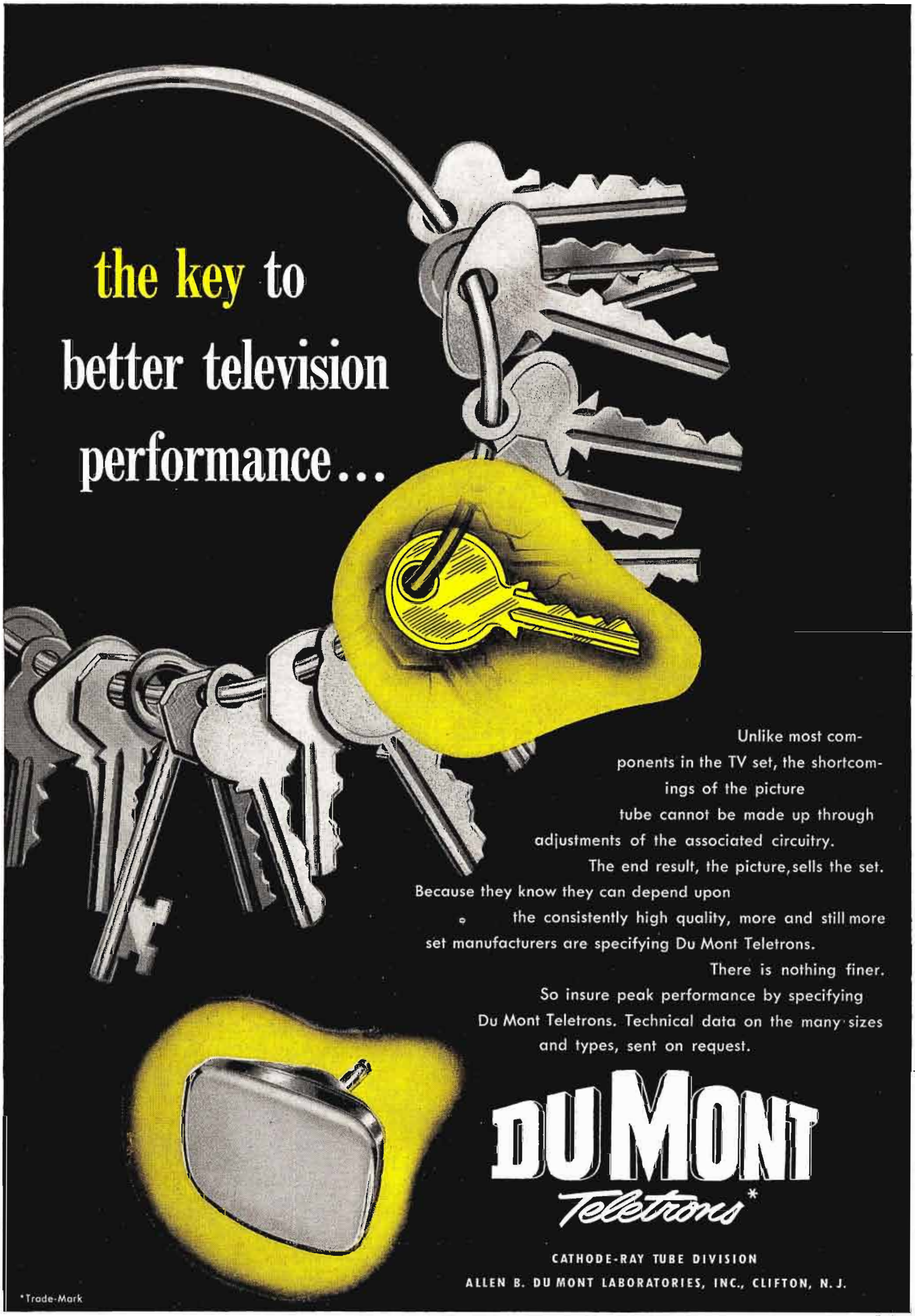
The circuit must trigger for zero voltage input from the switch. The tube V_{301} is returned to -15 v., thus providing a minimum of 15 volts swing when the switch makes contact to a zero volt channel. This 15-v. pulse is differentiated and applied to the two monostable multivibrators through buffer sections. The operating conditions of V_{303} are made to be such that a pulse having a duration longer than the maximum keyer output pulse duration is produced.

This pulse (negative) is applied to the grid of the discharge tube through C_{303}, causing it to be cut off for the pulse duration.

Simultaneously, the output multivibrator V_{304} receives both a trigger pulse through its buffer section and a dc voltage from the switch on its first grid. The constants of this multivibrator are chosen such that the duration of its output pulse is linearly related to the dc voltage at the first grid. A positive pulse is taken from the second plate.

The filters at the switch input provide compensation for errors introduced when various pickup source resistances are used. C_{301} must be charged fully by the time the output multivibrator triggers if maximum accuracy is desired. While the error encountered might be included in the keyer calibration, this is generally unsatisfactory where different source resistances are used. The large capacitor C_1 causes the keyer to see a very low impedance source,

(*Continued on page* 90)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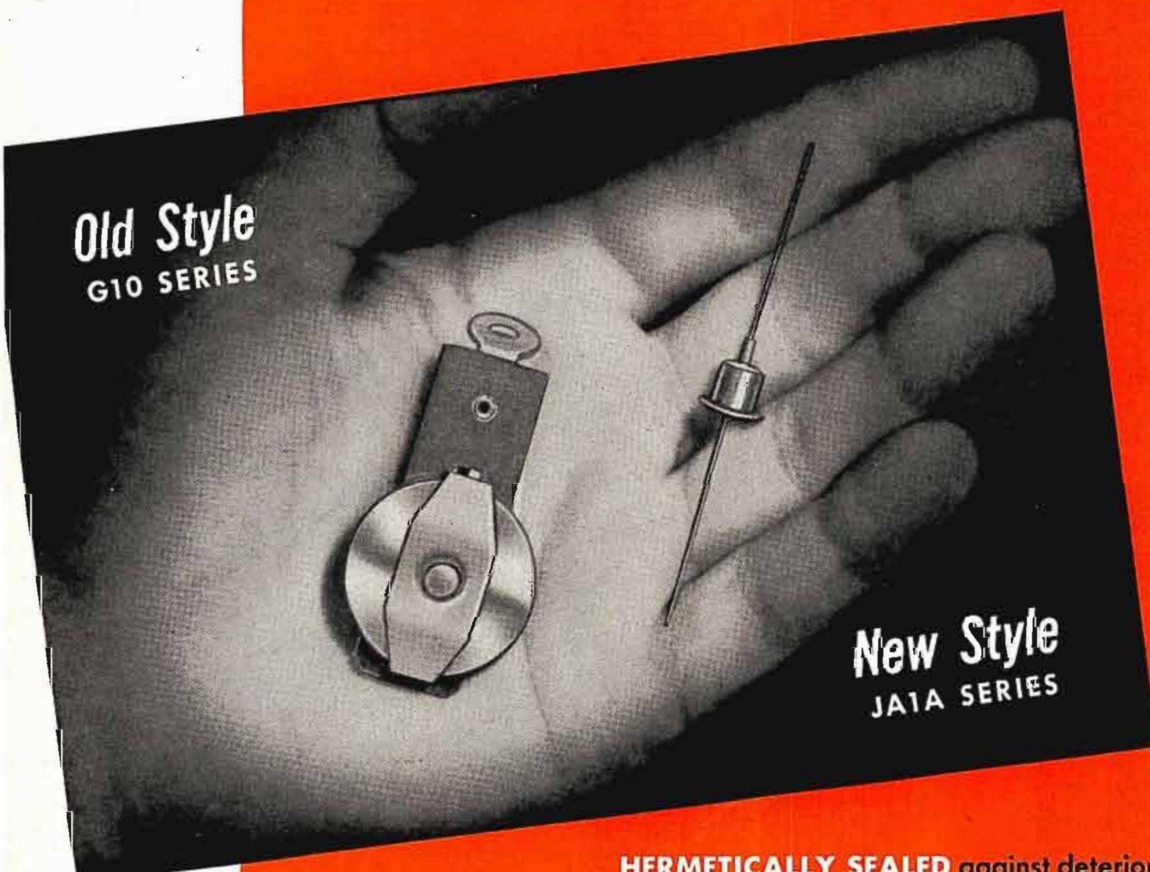

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HERMETICALLY SEALED against deteriorating elements. Glass-to-metal seals throughout.

MINIATURE SIZE to facilitate use in all electronic equipments, yet heat losses are dissipated efficiently.

REDESIGNED to meet all military humidity tests and shock and vibration requirements.

HIGH OUTPUT VOLTAGE and improved back current characteristics.

MODEL 4JA2A4 designed for use in TV power supplies. DC output voltage is 10 to 15 volts higher than with comparable selenium rectifiers in a typical voltage doubler circuit.

Germanium Rectifier

AT 55°C!

ABSOLUTE MAXIMUM RATINGS • T-55°C • RESISTIVE LOAD				
DIFFUSED JUNCTION RECTIFIER	4JA1A1	4JA1A2	4JA1A3	4JA2A4
PEAK INVERSE VOLTAGE* (volts)	100	200	300	400
PEAK FORWARD CURRENT (amps)	0.47	0.31	0.25	1.57
D.C. OUTPUT CURRENT* (Ma)	150	100	75	500
D.C. SURGE CURRENT (amps)	25	25	25	25
FULL LOAD VOLTAGE DROP (volts peak)	0.5v	0.5v	0.5v	0.7v
FORWARD RESISTANCE AT FULL LOAD (ohms)	1.1	1.5	1.9	0.5
CONTINUOUS REVERSE WORKING VOLTAGE (volts D.C.)	30	30	30	185
FREQUENCY OF OPERATION (kc)	50	50	50	50
STORAGE TEMPERATURE (°C)	85	85	85	85

*Typical absolute maximum ratings. For other combinations refer to Fig. 1.

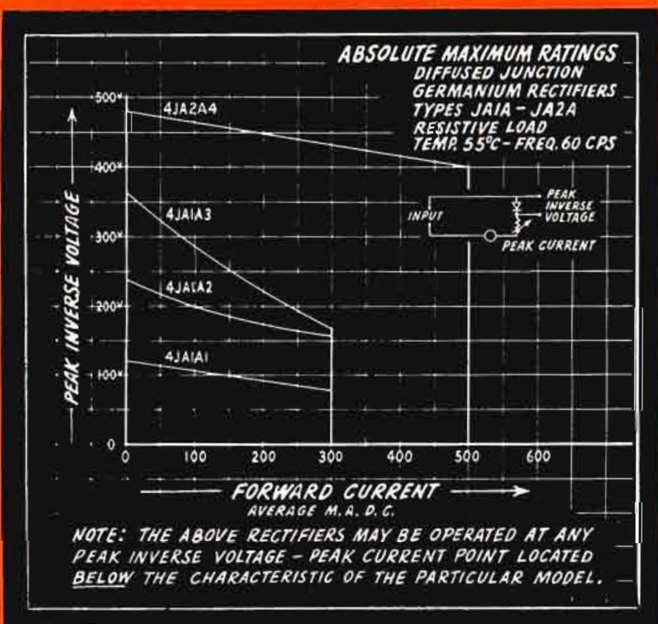
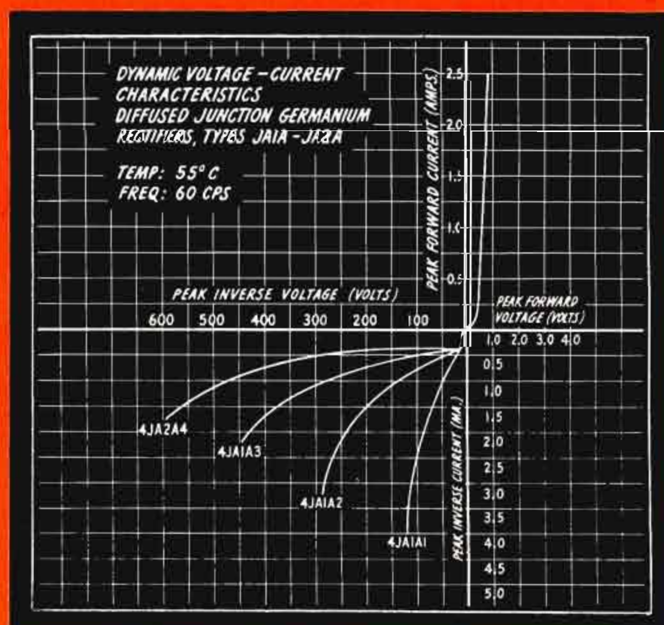


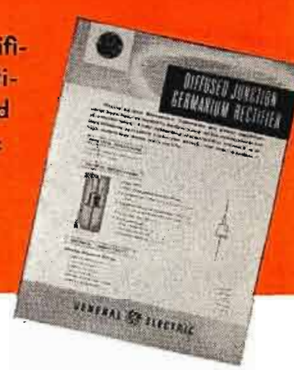
Fig. 1



Suggested Application Fields

Originally developed for military use, the new JA1 and JA2 Rectifiers may be adaptable to fields other than radar and military communications. Among them are the following: Computers, magnetic amplifiers, TV receiver power supplies, telephone switchboards. Application information on other uses can be supplied. Write or wire us!

NEW BULLETIN—Complete specifications on the diffused junction rectifiers are contained in this illustrated bulletin. It's yours on request. Write: General Electric Co., Section 48122, Electronics Park, Syracuse, N. Y.



GENERAL ELECTRIC

causing the storage condenser to attain maximum charge very rapidly.

Miniaturization of the keyer had to be accomplished without impairing system accuracy, simplicity, or stability. The keyer is the most likely source of system error among the circuits in the airborne equipment. Because of this, the original keyer design included somewhat elaborate arrangements to reduce its susceptibility to factors causing inaccuracies. A separate electronically regulated plate supply and the commutator input filters are examples of such techniques. The filter assembly required more space than the keyer deck itself, and, if eliminated, would provide a marked decrease in total volume.

A study showed that if a switch producing clean PAM pulses was possible, there is no reason to include a storage capacitor and hence, filters. The absence of a storage capacitor eliminates error due to its charging time constant, making filters unnecessary.

Research and development on high speed mechanical switches by The Applied Science Corp. of Princeton has produced commutators which satisfy PDM keyer requirements without the use of a storage capacitor, providing the trailing edges of the switch pulses can be kept from triggering susceptible circuits. The leading edges of the pulses produced by the switching action are extremely clean. The trailing edges, while usually acceptable, cannot be controlled to the degree required for 100% keyer reliability unless a circuit is arranged to eliminate their effects.

Such a circuit is used in the original keyer, namely, the monostable multivibrator which is used to cut off the discharge tube until after the longest keyer output pulse.

Switch "Break"

The problem is that of preventing any variations in contact at the switch pulse trailing edge from causing large high frequency voltage jumps which may cause triggering of the PDM multivibrator. If the discharge tube is held non-conducting during the switch "break" the voltage variations caused by unclean switching cannot exceed the signal input voltage. The monostable multivibrators do not respond to such low voltage pulses and hence, nc unwanted triggering occurs.

The absence of a storage capacitor makes it necessary for the switch "on time" to be as long or longer

(*Continued on page* 94)

MICROTRAN®

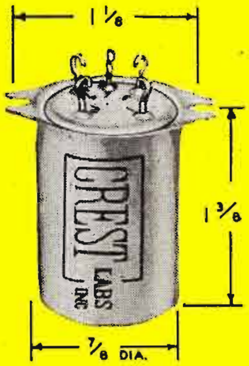
hermetically sealed transformer

available as stock items

These ruggedized military type units were developed to meet demands of a growing miniaturization program.

All units are available from stock in hermetically sealed cans, although open frame units may be ordered. Open frame units are Resin impregnated to provide thorough protection from adverse climatic conditions and are supplied with flexible 3" color coated leads.

Also available on special order for MIL applications are standard MIL type cases.

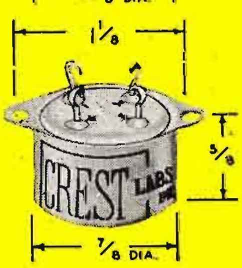


MINIATURE TRANSFORMERS

PART NO.	MIL TYPE	APPLICATION	PRIMARY IMPED. Ω	SECONDARY IMPED. Ω	RESPONSE ±2 db. (C.P.S.) MAX. LEVEL 10 db.	LIST PRICE
M1	TFIA10YY	Mike pickup or line to 1 grid	50, 200, 500	50,000	20-20,000	$15.40
M2	TFIA10YY	Mike pickup or line to 2 grids	50, 200, 500	50,000	20-10,000	15.40
M3	TFIA10YY	Dynamic mike to 1 grid	7.5, 30	50,000	20-20,000	14.30
M4	TFIA15YY	Single plate to 1 grid	15,000	60,000	20-15,000	12.10
M5	TFIA15YY	Single Plate to 1 grid	15,000 4MA.D.C.	60,000	200-20,000	12.10
M6	TFIA15YY	Single plate to 2 grids	15,000	95,000	20-15,000	14.30
M7	TFIA15YY	Single plate to 2 grids	15,000 4MA.D.C.	95,000	200-20,000	14.30
M8	TFIA13YY	Single plate to line	15,000	50, 200, 500	20-20,000	15.40
M9	TFIA13YY	Single plate to line	15,000 4MA.D.C.	50, 200, 500	150-20,000	15.40
M10	TFIA13YY	Push pull plates to line	30,000 ohms P.-P.	50, 200, 500	30-50,000	15.40
M11	TFIA10YY	Crystal mike to line	50,000	50, 200, 500	20-20,000	15.40
M12	TFIA16YY	Mixing and matching	50, 200	50, 200, 500	30-40,000	14.30
M13	TFIA20YY	Reactor 300 HYS. - No D.C.: 50 HYS - 3MA. D.C.		6,000 ohms D.C. res		11.00
M14	TFIA10YY	50: 1 mike or line to 1 grid	200	1/2 Megohm	80- 3,000	15.40
M15	TFIA15YY	10: 1 single plate to 1 grid	15,000	1 Megohm	100-2,500	15.40

SUB MINIATURE TRANSFORMERS

PART NO.	MIL TYPE	APPLICATION	PRIMARY IMPED. Ω	SECONDARY IMPED. Ω	RESPONSE ±2 db. (C.P.S.) MAX. LEVEL 6 db.	LIST PRICE
SM1	TFIA10YY	Input	200, 50	250,000, 62,500	80-10,000	$12.90
SM2	TFIA15YY	Interstage 3:1	10,000	90,000	100-10,000	12.90
SM3	TFIA13YY	Plate to line	10,000(3MA.)-25,000(1.5MA.)	200, 500	150-10,000	12.90
SM4	TFIA13YY	Output	30,000 1MA.D.C.	50	70-10,000	12.90
SM5	TFIA20YY	Reactor 50 HY at 1 mil. D.C.	4,000 ohms.D.C. res.			10.90
SM6	TFIA13YY	Output	100,000 .5MA.D.C.	60	100-10,000	12.90



MICRO MINIATURE TRANSFORMERS

PART NO.	MIL TYPE	APPLICATION	PRIMARY IMPED. Ω	SECONDARY IMPED. Ω	RESPONSE ±2 db (C.P.S.) MAX. LEVEL 0 db.	LIST PRICE
MM1	TFIA10YY	Input	200, 50	250,000, 62,500	200-10,000	$12.90
MM2	TFIA15YY	Interstage 3:1	10,000	90,000	150-10,000	12.90
MM3	TFIA13YY	Plate to line	10,000(3MA.)-25,000(1.5MA.)	200, 500	150-10,000	12.90
MM4	TFIA13YY	Output	30,000 1MA.D.C.	50	150-10,000	12.90
MM5	TFIA20YY	Reactor 50 HY at 1 mil D.C.	3,500 ohms.D.C. res.			10.90
MM6	TFIA13YY	Output	100,000 .5MA.D.C.	60	200-10,000	12.90

Open Frame Construction

TRANSISTOR TRANSFORMERS

PART NO.	MIL TYPE	APPLICATION	PRIMARY IMPED.	SECONDARY IMPED.	LIST PRICE M	LIST PRICE SM & MM
*T1	TFIA10YY	Input-Line to emitter	500	500	$14.50	$14.15
*T2	TFIA10YY	Input-Hi impedence mike to emitter	50,000	500	15.70	14.15
*T3	TFIA15YY	Interstage-collector to emitter	50,000	500	15.70	14.15
*T4	TFIA13YY	Output-collector to line	50,000	500	15.70	14.15
*T5	TFIA13YY	Output-collector to speaker	50,000	6	14.50	14.15

* Add M Prefix to indicate miniature size, SM for sub-miniature size, MM for micro-miniature size. Size to be used depends on D.C. current, frequency response and power output requirements. Write for full details.

Immediate delivery of stock items!

Our circuit design department can assist you in your miniaturization problems. Our recent developments of HI "Q" audio transformers for single frequency applications have permitted substantial reduction in equipment complexity.

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RCA UHF

AGAIN, RCA sets a record in UHF technical leadership—by delivering to KPTV the entire UHF transmitter plant that put the FIRST commercial UHF signals on the air.

Out of the experimental field into the practical, *RCA transmitter-antenna combinations* like those shown here make UHF planning a practical reality. They enable you to obtain the most coverage at minimum investment.

◀ **RCA UHF PYLON ANTENNA.** The high-gain TV antenna that includes a vertical beam-tilt arrangement—enabling you to cover specific areas more effectively. Horizontal radiation pattern of the Pylon is virtually circular.

10-KW TYPE TTU-10A (FOR ERP* TO 270 KW). This UHF transmitter, and a UHF Pylon Antenna, will produce from 240 to 270 kw ERP on channels 14 to 83. The combination is capable of serving almost any metropolitan area with strong signals. Type TTU-10A is designed for straight-line or block "U" arrangements.

*Effective Radiated Power

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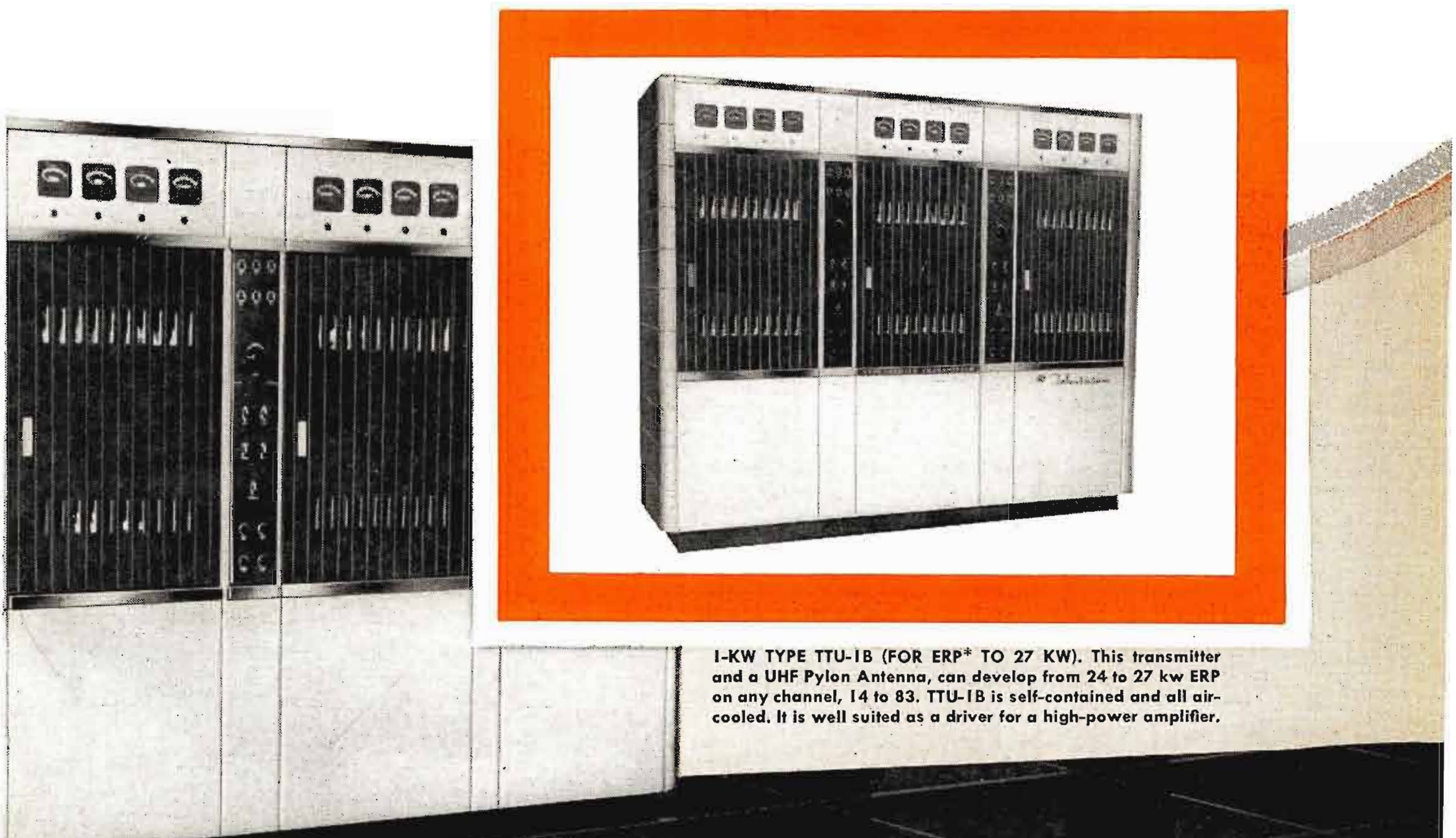
For example, in low-power operation, RCA's low-cost 1-kw UHF transmitter and a high-gain Pylon Antenna combination is the most economical choice. Or, if you require higher power, RCA's "10-kw" UHF and a high-gain Pylon combination *approaches the ultimate in useful coverage.*

In addition to transmitter-antenna combinations, RCA also has the UHF accessories you need to go "on air"; transmitter monitoring equipment, transmission line fittings, towers, consoles, UHF loads and wattmeters, Filterplexers, etc. Everything is "systems matched" to work together for maximum performance. All equipment is available from ONE responsible transmitter manufacturer—RCA.

Make sure YOU get your UHF equipment when you need it. Your RCA Broadcast Sales Representative is ready to take your order—*and show you what you need to go UHF at lowest cost.*



1-KW TYPE TTU-1B (FOR ERP* TO 27 KW). This transmitter and a UHF Pylon Antenna, can develop from 24 to 27 kw ERP on any channel, 14 to 83. TTU-1B is self-contained and all air-cooled. It is well suited as a driver for a high-power amplifier.

RCA

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT **CAMDEN, N.J.**

than the longest output pulse in order to keep the dc signal voltage on the signal multivibrator grid during the entire pulse time. This necessitated a change in switch design.

A series type regulator was designed using two subminiature tubes. This regulator was designed to work with the −15 volt battery used for the discharge tube as a reference source. A mercury battery is employed because of its excellent voltage stability. The use of a battery for reference eliminates trouble from gas reference tube inability to follow fast signal variations due to the keyer pulses. The series tube used is a subminiature type 5902 audio beam power tube having a heater-cathode voltage rating of 200 v. and a maximum plate current of 40 ma. A type 5702 is used as the amplifier. The internal impedance of the regulator is approximately 200 to 250 ohms up to about 500 KC over an input voltage range of 200 to 250 v. and improves at higher input voltages.

Fig. 15: Complete airborne unit is 124 cu. in.

The keyer design finally decided upon is illustrated by the block diagram of Fig. 13. The delay multivibrator is used to increase the usable source resistance to a relatively high value as compared with previous keyers.

Two effects are present when the input source resistance is increased. The first results in decreased trigger amplitude, the second results in an output pulse width error due to the increased charging time of the capacitance across the input through the source resistance.

Decreased trigger amplitude is produced by the voltage dividing action of the conducting discharge tube and the increased source resistance in combination with the increased curvature of the input waveshape for the larger source resistance.

Output pulsewidth error is caused by the curvature mentioned previously. Elimination of a physical storage capacitor does not result in zero input capacitance. Due to Miller effect, the first section of two monostable multivibrators may produce as much as 40 μμf. This capacitance, plus strays, produces enough to cause serious charging time error

(Continued on page 96)

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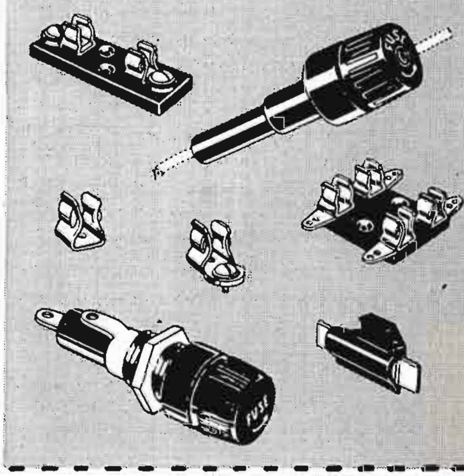

The cost of a fuse is small, compared to the value of the product it protects, — but the *customer influence* of a BUSS Fuse can be many times greater. The name BUSS is recognized as meaning fuses of unquestioned high quality. What better "silent salesmanship" could you ask for to complement your product?

To maintain this high standard each and every BUSS fuse is tested in a highly sensitive electronic device that rejects any fuse that is not correctly calibrated — properly constructed and right in physical dimensions.

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City & Zone ______________ State ______ TT1252 when unusually high source resistances are used.

V_{1a} is used as a discharge tube as in the other circuits described. V_2 is a monostable multivibrator which produces a 50 usec pulse when triggered through the cathode follower, V_{1b}. The 50 μsec pulse trailing edge is used to trigger the signal multivibrator, V_3. V_4 is a gate multivibrator, negative output of which keeps the discharge tube, V_{1a} cut off for a time longer than the maximum signal pulse duration.

The inclusion of the delay multivibrator enables the signal multivibrator to trigger only after the signal voltage at its first grid has risen close to maximum when used with the highest source resistance which will allow triggering.

This keyer is capable of operation with source resistances up to 250,000 ohms with no compensating capacitance across the source. For source resistances above this value, the necessary capacitance is not large and little error is introduced. Fig. 14 is an illustration of the keyer showing its plug-in type construction.

Fig. 15 is an illustration showing the complete airborne unit as supplied to the user. Dimensions (excluding pressurized plugs and receptacles) are: 16.27 in. long x 3.26 in. diam. (at endplates). Total volume is approximately 124 cu. in.

Conclusion

It is felt that the work described here has resulted in worthwhile contributions to the field of medium capacity time division radio telemetering. The author wishes to acknowledge with thanks the work done by Mr. A. W. Weissenburger of ASCOP in solving circuit design problems encountered, and Mr. A. G. Wentzel, also of ASCOP, for contributions to the mechanical design of the equipment.

Thanks are also due to Messrs. R. J. Egger and H. Zancanata of the Ballistic Research Laboratory, Aberdeen Proving Ground Md., for their cooperation and technical assistance.

This work was accomplished under the sponsorship of the Ballistics Research Labs., Army Ordnance Corps, under Contract No. DA-36-034-Ord-38.

REFERENCES

1. L. J. Neelands and W. Hausz. "Telemetry for Guided Missiles." *Engineering Sect on, Radio News.* Jan. 1948.
2. V. D. Landon. "Theoretical Analysis of Various Systems of Multiplex Transmission." *RCA Review,* June and Sept. 1948.
3. H. Salinger. "Transients in Frequency Modulation." *Proc. IRE,* vol. 30, no. 8, p. 378. Aug., 1942.
4. V. D. Landon. "Impulse Noise in FM Reception." *Electronics,* vol. 14, no. 2, pp. 26-31, Feb., 1941.

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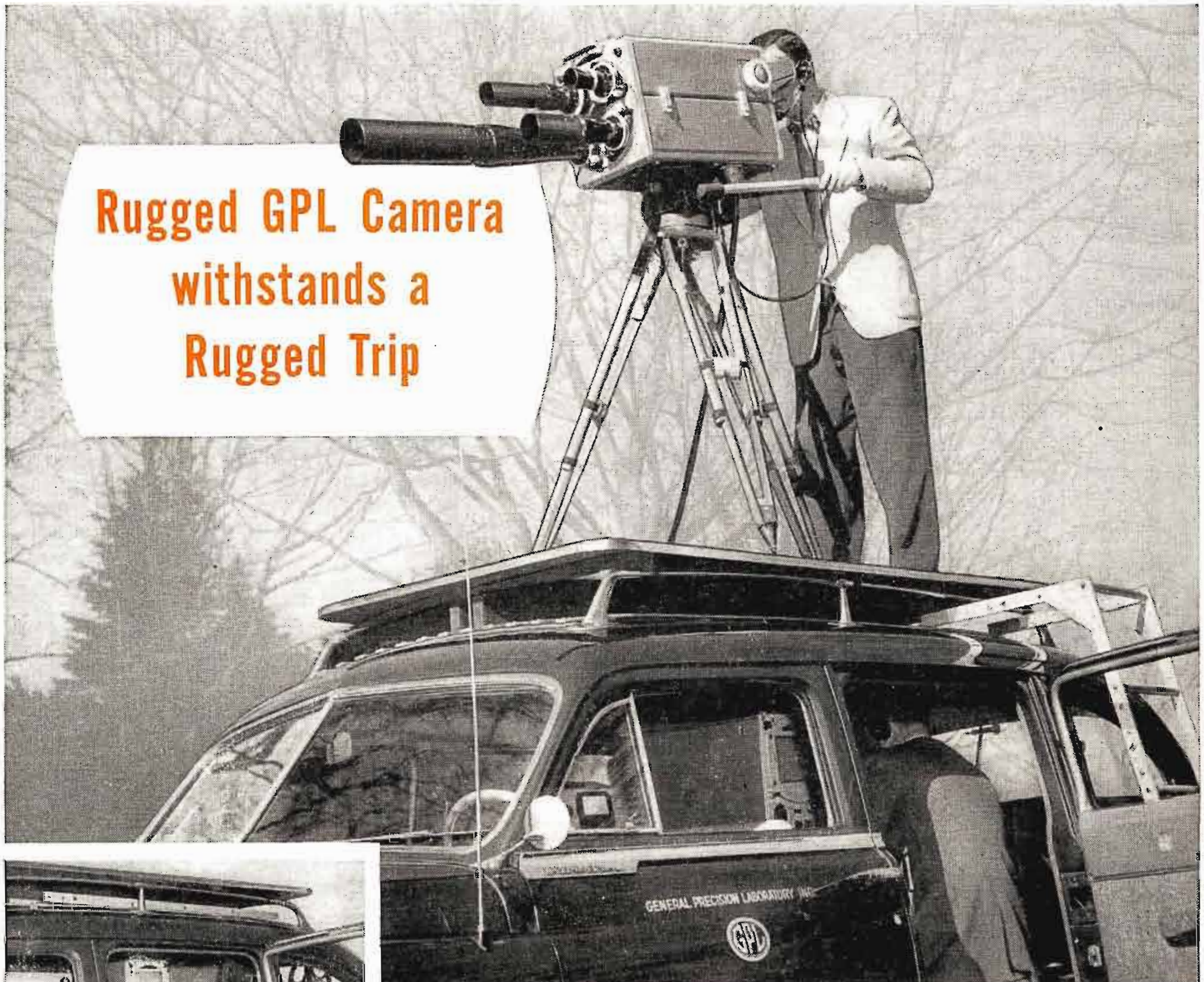

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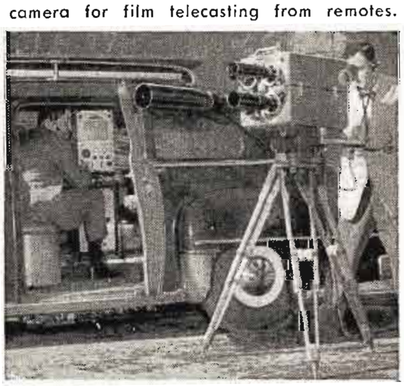

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Microwave Phase Shifters

(*Continued from page* 47)

movable sections of the phase shifter.

An experimental linearity curve for this phase shifter is given in Fig. 4. As has been mentioned previously, substantial improvement in the overall error may be obtained in applications that require two or more units in cascade.

The staggered pin design just discussed has several attendant disadvantages. One is the fact that the voltage breakdown is generally determined by the pin having the deepest insertion. The depth of insertion of this pin is also considerably more critical than that of the lower susceptance elements.

This leads one to expect that a more efficient design could be obtained by a variable number of equal value susceptances. Each element would then, in effect, contribute a small increment of differential phase shift; resulting in a larger number of less critical susceptances, capable of transmitting substantially higher power levels.

The method used is again based on a matrix anaylsis. In this case, the problem is solved by raising a matrix to the n power. The approach is similar to that used by W. L. Pritchard for coupled filters.

In accordance with our original requirement, and in order to obtain a reasonably definite solution, the following assumption are made:

a. All susceptances are equal.

b. Susceptances are spaced $\lambda_g/4$ apart.

c. Susceptances are ideal, or lossless.

A typical symmetrical section may be used in which the susceptance, Y is preceded and followed by a section of transmission line, $\lambda_g/8$ long, as shown in Fig. 8.

General Circuit Matrix

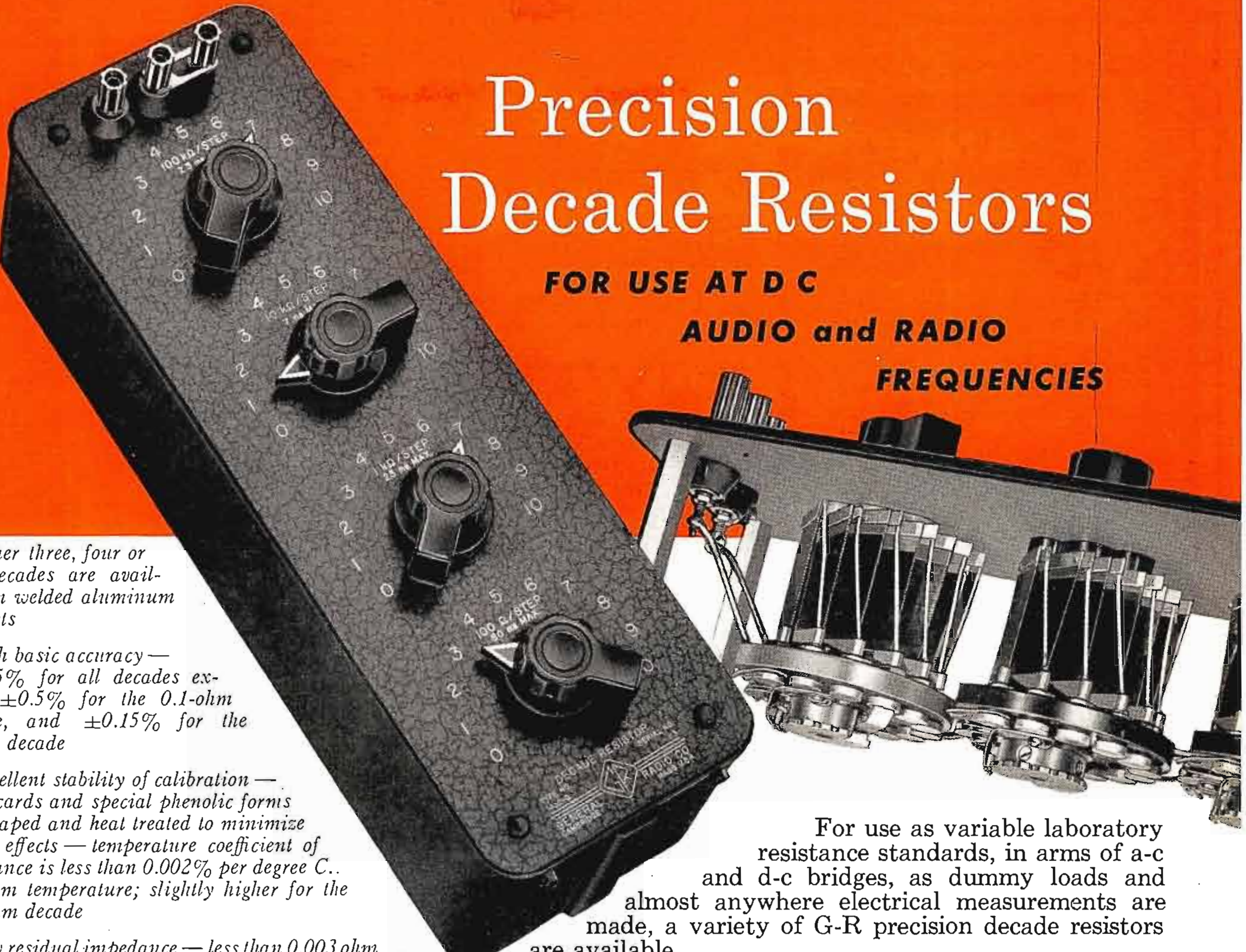
The solution is obtained by converting the general circuit matrix to diagonal form and pre- and post-multiplying by a pair of inverse matrices as shown in Table IV. This results in an expression for phase shift of n elements, ϕ_n, as an arc tangent of a quotient of Tchebyscheff polynomials.

Since the typical line section contains a $\lambda_g/8$ length of line on either end of the susceptance, there will exist an additional 90° of phase shift in addition to the phase shift existing between the end points of the n susceptances, for the complete assembly. This additional phase shift may

(*Continued on page* 102)

Precision Decade Resistors

FOR USE AT D C AUDIO and RADIO FREQUENCIES



★ *Either three, four or five decades are available in welded aluminum cabinets*

★ *High basic accuracy — ±0.05% for all decades except ±0.5% for the 0.1-ohm decade, and ±0.15% for the 1-ohm decade*

★ *Excellent stability of calibration — mica cards and special phenolic forms are shaped and heat treated to minimize aging effects — temperature coefficient of resistance is less than 0.002% per degree C. at room temperature; slightly higher for the 0.1-ohm decade*

★ *Low residual impedance — less than 0.003 ohm per decade at dc; 0.04 ohm at 1 Mc. Zero inductance per decade is 0.10 microhenry. Effective shunt capacitance varies from 10 to 45 micromicrofarads depending on combinations of decades in use*

★ *Excellent frequency characteristic permits use up to several hundred kilocycles*

★ *Excellent mechanical and electrical shielding provided by welded aluminum cases*

★ *TYPE 1432 DECADE RESISTORS in ten sizes with resistance ranges from 0 to 111 ohms in 0.1-ohm steps, to 1,111,100 ohms in steps of 10 ohms. PRICES: $56 to $133*

For use as variable laboratory resistance standards, in arms of a-c and d-c bridges, as dummy loads and almost anywhere electrical measurements are made, a variety of G-R precision decade resistors are available.

These boxes have very high accuracy, low residual impedance, excellent stability and good frequency characteristics from zero to several hundred kilocycles.

The individual decades of the Type 1432 boxes are ideal for assembly into production test instruments, laboratory apparatus and custom-built equipment. These Type 510-D Resistance Units are available in ranges from 1 ohm to 1,000,000 ohms, maximum, at prices from $7.50 to $40.00, each.

Type 670-F Compensated Decade Resistor . . . $74.00

This unit is used when even the very low inductance of the Type 1432 Decade Resistors is too large. This decade resistor is valuable wherever non-reactive increments in resistance are required, as tuned-circuit substitution measurements and variable resistance elements in antenna measuring circuits.

★ *Inductance remains constant within 0.1 microhenry at any resistance setting*

★ *Resistance increments are correct within ±0.1% for 10-ohm steps; ±0.25% for 1-ohm steps, and ±1% for 0.1-ohm steps*

★ *Temperature coefficient is less than .002% per degree C. at room temperatures*

★ *Resistance range is 0 to 111 ohms in steps of 0.1 ohm*

GENERAL RADIO Company

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be disregarded by inverting the argument as follows:

$$\phi_n^1 = \tan^{-1}\left[\frac{T_n(x)}{U_n(x)}\right]$$

Since we are interested primarily in the differential phase shift between the two orthogonal modes in the phase shifter, we do not have to consider the fixed phase shift due to line lengths between the susceptance elements, since this will exist in common for both modes. Thus, the differential phase may be assumed as zero for X = 0, for all values of n.

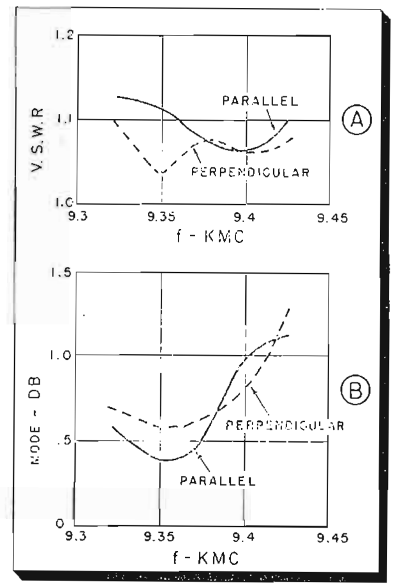

Fig. 12: (a) VSWR and (b) mode frequency characteristics for a 10-element λ/2 section

This means that for even values of n, 90° must be added to all values of phase. A plot of phase as a function of susceptance for values of n from 3 to 10, is given in Fig. 9. The corresponding plots for insertion loss, L_n, for values of n from 3 to 6, and from 6 to 10 are given in Figs. 10 and 11.

Design Procedure

The following design procedure may be used for obtaining a specific differential phase shift. Choose an initial value, n, for the number of elements. From the insertion loss figures, obtain values of Y which provide perfect match. Refer to the phase plot for the differential phase shift corresponding to the value of Y chosen. After a few trials the correct value of Y is obtained to provide the desired amount of differential phase shift and good match.

On the basis of this theory, a half-wave section was designed using ten susceptance pins. The required value

(*Continued on page* 104)

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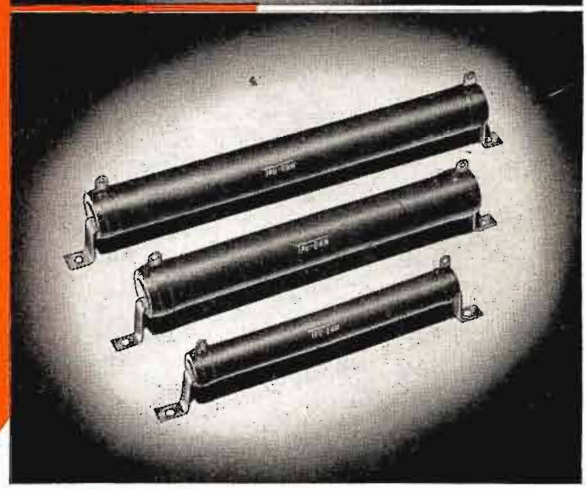
The resistor line which is specified by engineers employed by the nation's foremost manufacturers of original equipment.



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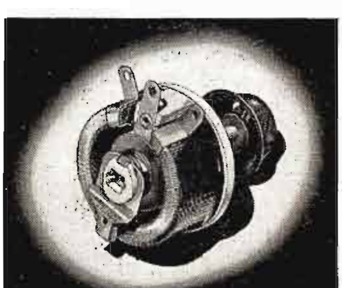

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MANUFACTURERS: Power Rheostat, Fixed Resistors, Adjustable Resistors, "Econohm" Resistors of susceptance B/Y_0 was 0.62. This is contrasted to 1.7 obtained for the deepest pair of pins in the staggered five-pin design. Thus the power handling capacity of the phase shifter is increased. Moreover, since the new value of susceptance is on the lower slope section of the curve, the tolerance in insertion is somewhat greater.

Phase Shifter Element

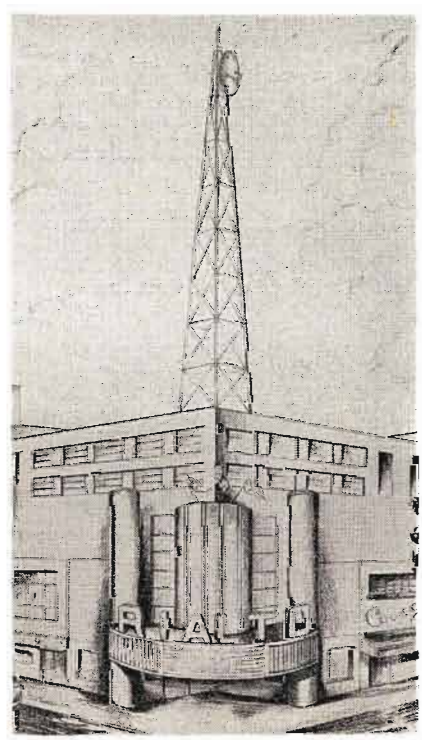
Performance of the half-wave section as a phase shifter element was checked by coupling this section to a quarter wave plate of the type previously discussed. The VSWR and ellipticity of this assembly was measured in a frequency band centered at 9375 MC. Results of these measurements are plotted in Fig. 12. It can be seen that very little deterioration is produced in the circular polarization. In fact, somewhat better results were obtained with the equal susceptance, ten element $\lambda/2$ section, than with the staggered five-element section, indicating good verification of the theory.

Theatre Television

(*Continued from page* 43)

remote program source link and an intra-city distribution system were offered in evidence. These are too lengthy to present here. To give a general idea of the type of equipment proposed the approximate cost of some of the items follow. These

Fig. 5: Theatre tower for receiving TV signals



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Type G (CM 75-80-85-90-95)

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Type H (CM 45-50)

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SC51-8

are for 3-circuit operation and include the cost of installation.

At the New York City terminal: Antennas $14,400; Transmitters & Receivers $71,000; Other costs $39,-000. At a typical relay repeater station: Land, Buildings & Tower $22,-000; Antennas $20,000; Transmitters & Receivers $20,000; Other costs $6,000. At the Washington terminal: Land, Buildings & Tower $69,000; Antennas $71,000; Transmitters & Receivers (duplicate standby equipment provided) $258,000; Other costs $76,000. At a typical downtown theatre: Tower $1,500; Antenna $1,030; Receiver $14,000; Other costs $6,500, (does not include projecting equipment). Costs for typical theatre equipment, *less installation,* would be: Tower $500; Antenna $830; Receiver $10,000; Audio $5,000.

Sequential System

The petitioners consider color TV for the theatre highly desirable and because of simplicity stated that the sequential system would be used. It is realized the resolution of pictures in color would be less than pictures in monochrome but it was hoped that the appeal of color would partly compensate for this.

Decision Next Year

Each of the two consulting engineers, Mr. Bailey and Mr. Inglis, who carried the major load of engineering testimony did commendable jobs in the thorough preparation of their exhibits and in presentation. A majority of members of the Commission were present through the hearing which was ably presided over by Chairman Walker. The decision of the FCC on this petition, which may drastically affect the long-range planning of a large portion of the 25,000 motion picture theatres in the U. S. A., will not be expected until several months after the close of the second half of the hearing scheduled for Jan. 12, 1953.

Community TV Antenna in Palm Springs, Calif.

The first reception of TV in Palm Springs, Calif., has been accomplished by the installation of a community antenna system by the Palm Springs Community Television Corp., subsidiary of International Telemeter Corp.

A Styroflex coaxial cable, installed by Phelps-Dodge Copper Products Corp., carries the signals into Palm Springs from an antenna mounted atop a 4000-ft. mountain nine miles west of the city. For a detailed description of the Styroflex cable, see Nov. 1951 TELE-TECH, p. 42.

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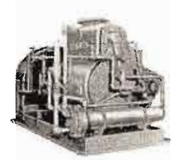

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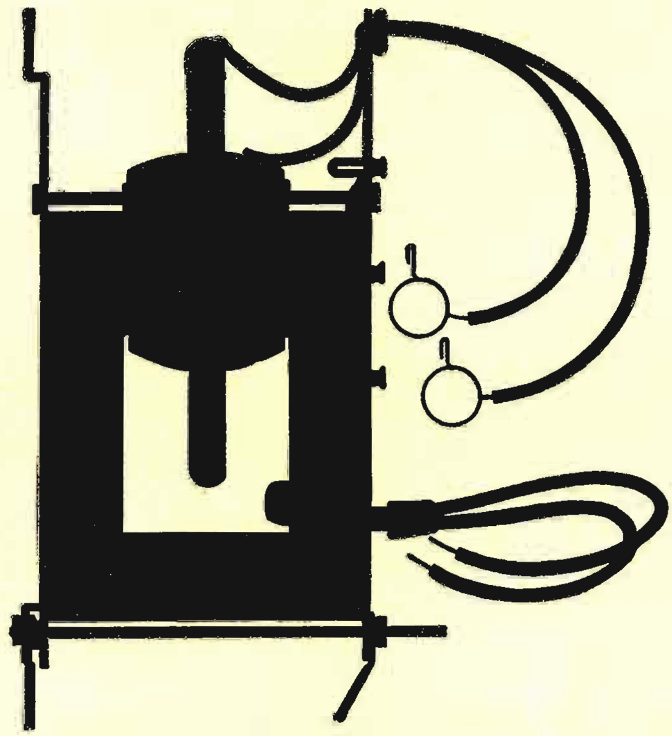

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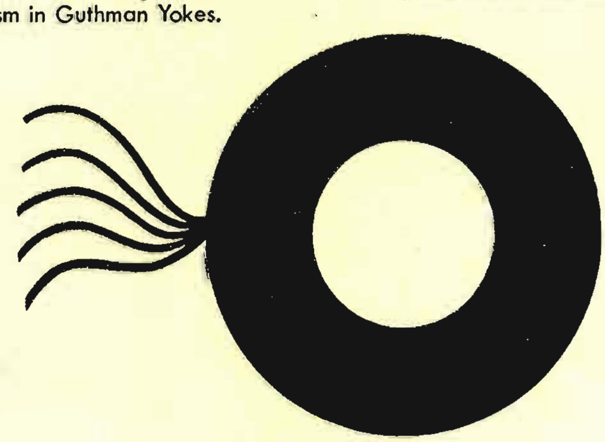
Coils used in Guthman Yokes are form wound. Complete isolation between vertical and horizontal coils achieved by a molded nylon piece permits a yoke rating of 5,000 volts pulse maximum. Anti-magnetic core retainer band and brass mounting nut assures no magnetism in Guthman Yokes.



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Inertial Navigation

(*Continued from page* 53)

the aircraft's motion. A transducer for north-south and one for east-west respond to changes in the aircraft's motion, sending electrical signals proportional to these inertial forces to amplifiers. The acceleration components are shown on north-south and east-west indicators. After passing through an integrating circuit, speed components are shown; a second integrator yields the distance components. In addition to indicating functions, these signals may be fed to flight-control servomechanisms.

The plane's absolute speed and direction of motion may be displayed directly on a Course Indicator connected to terminals 1 and 2 of Fig. 1. Such an indicator, shown in Fig. 2, utilizes a cathode-ray tube to compound the velocity components vectorially. The distance from the center of the screen to the trace indicates speed, and the trace's angular position shows absolute direction of motion, not merely aircraft heading. The Traversed Distance Indicator of the new device is the aircraft counterpart of an automobile speedometer mileage register, and is another feature never before available in an aircraft instrument.

A Position Indicator, similar to the Course Indicator, may be connected to terminals 3 and 4 of Fig. 1. By placing a map overlay on the CRT, the plane's position relative to any reference point is displayed.

It is the inventor's belief that the inertial navigation system has a place in long-distance air navigation, but for the present, pin-point accuracy is not obtainable because of the drift in reference gyros presently available. Ultimately, this system will be tied in with radio systems to provide memory and extrapolation during r-f fadeouts, and will serve as a medium-accuracy navigator in zones where no radio aids are available.

Security restrictions still prevent disclosure of the military applications of this device or of its degree of practical development. The civilian flying applications of the reasonably near future will include automatic dead-reckoning navigation during radio blackouts. The true ground speed indicating feature will also find widespread application, particularly in pressure-pattern flying. In the more distant future, this device and its descendants will provide a practical solution to the problems of navigation and flight control in outer space.

Liquid Dielectric

(*Continued from page* 41)

central position under all conditions of bending and flexing.

3. The characteristic impedance must be 50 ohms up to a frequency of 10,000 MC.
4. The attenuation of the liquid dielectric cable must not be greater than the attenuation of the equivalent size standard solid dielectric cable.

Three types of center conductor supports were considered for suspending the center conductor along the axis of the cylindrical outer conductor, namely, bead supports, channeled core construction, and helically wound filament. Typical examples of these constructions are shown in Fig. 4.

The "beaded" type construction was considered to exhibit poor bending and flexing characteristics. In flexing such a cable that part of the center conductor which is not constrained by the solid dielectric will not remain in its central position and the impedance of the cable changes at these points. Since this naturally introduces reflections, all "beaded" type constructions were eliminated as being electrically inferior.

"Channeled" Cores

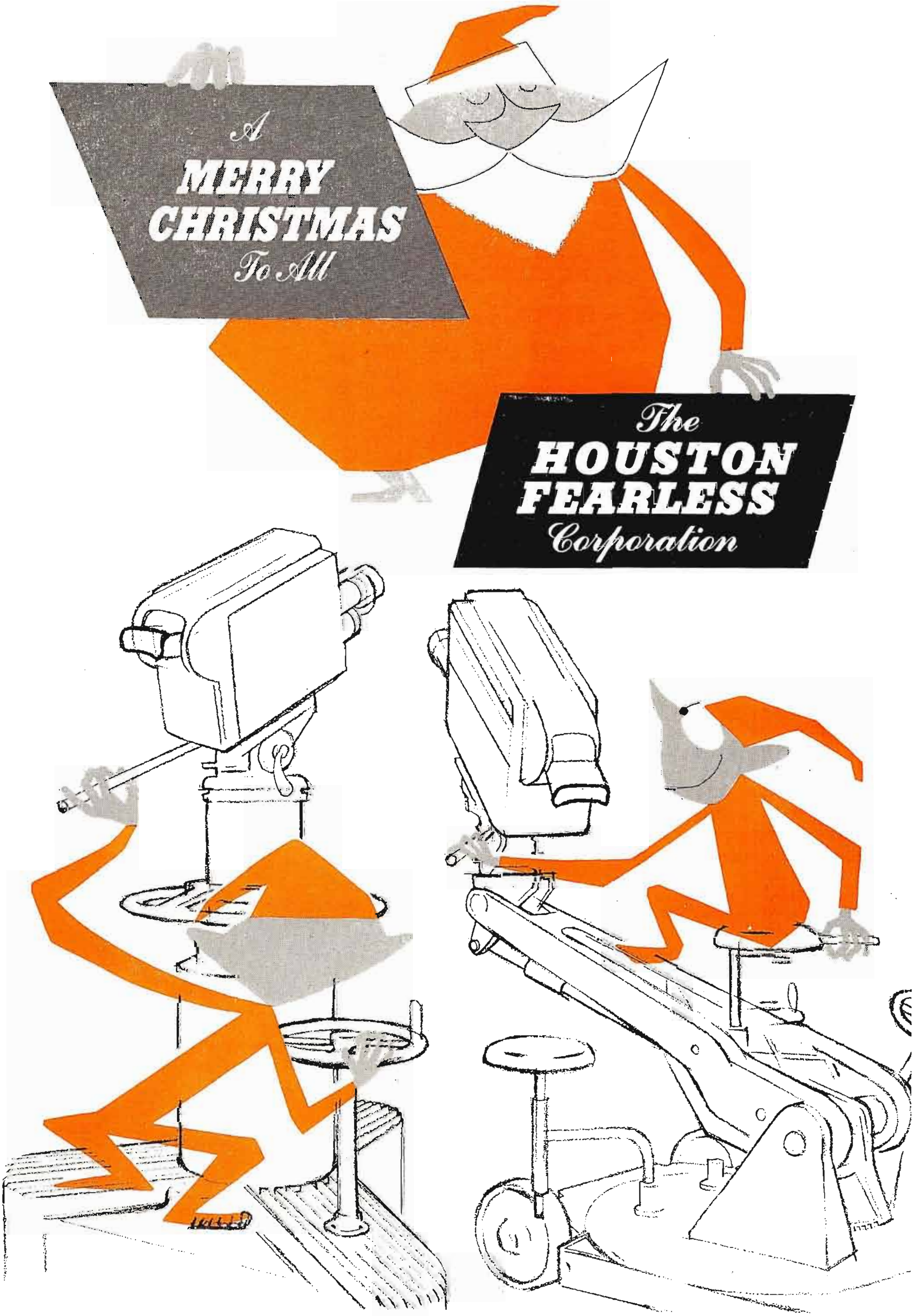
The "channeled" cores hold the inner conductor in its central position, provide a low reflection support, and possess low electrical losses, all of which are desirable coaxial cable design features. The two legged "channeled" construction, E of Fig. 4, exhibits inferior characteristics similar to the "beaded" constructions.

The "filament" type construction is also capable of maintaining the inner conductor centered if the length of the helix is held to a small value compared to the radius of the sharpest bend encountered in the cable. Being a continuous helix of small cross-sectional area compared to the total dielectric cross-sectional area, the electrical losses in this type support are small when a good dielectric is used for the filament.

Thus both the filament and channeled core construction can be utilized in supporting the center conductor of the liquid dielectric cable.

An analysis of the various types of available flexible outer conductors was conducted in which they were qualitatively rated on four points in the following order of importance: (1) liquid seal properties,

(*Continued on page* 112)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(2) attenuation, (3) radio-frequency leakage, and (4) flexibility. Three types of flexible tubing were rated, and the results appear in Table II.

In general, the bellows type construction was best suited for this application because it is formed from one piece of metal whereas the overlapping strip resembles interlocking cylinders of variable electrical contact area. Of the two types of bellows construction, the shallow type had the best rating.

Having evaluated the physical cable design characteristics, it was necessary to consider next a suitable liquid dielectric which possessed the various properties listed in Table III. A search of the available liquids was conducted which indicated that mineral oil, silicone oils, and the fluorinated hydrocarbon oils are suitable for use as dielectrics. The cost and scarcity of the fluorinated hydrocarbon oils precluded their use in the preliminary measurements. Therefore, it was decided to use ordinary highly refined mineral oil supplied by the A. H. Carnes Company and designated as No. 340 Mineral Oil and No. 9996-100 Silicone Oil furnished by the General Electric Company. The published data for the properties of mineral and silicone oils as well as the desired values are listed in Table III.

Based on the theoretical findings,

(*Continued on page* 114)

Air Reconnaissance Service for Microwave Paths

An aerial survey service to speed layout, assure accuracy, and effect savings in establishing microwave transmission paths has been developed by the Engineering Products Department of RCA Victor, Camden, N. J. Qualified engineers and aerial navigators will provide subscribers to the new service with data and photographs compiled to form a complete analysis of any projected microwave system. Included in the survey will be general topographical details, a study of possible station sites, aerial photographs, and charts delineating the microwave paths.

The surveys are designed to expedite the laying out of both long-range and short-range microwave communication, channeling, and telemetering systems for right-of-way users such as gas and oil pipe lines; water, gas, and electric utilities; telegraph, radio, and telephone companies; railroads, and government agencies.

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it was decided to assemble two experimental types of liquid dielectric cables using the filament and channeled core constructions, respectively. The physical features of both cables are listed in Table IV and illustrated in Fig. 1.

These two cable constructions were evaluated using first, silicone oil, and then, mineral oil as a liquid dielectric.

Modified Connectors

In order to perform tests upon these cables, radio-frequency connectors which would mate with standard equipment, allow the entrance and exit of the liquid dielectric, and provide a liquid seal at the mating ends were needed to terminate the cable. The simplest expedient was to modify standard radio-frequency connectors to provide a liquid tap such that the modification in no way interfered with the radio-frequency performance of the connectors. Special connectors exhibiting a low reflection coefficient were also designed for use in the measurements of attenuation and characteristic impedance of the liquid dielectric cables. These connectors are illustrated in Fig. 1.

With the cable assembly as shown in Fig. 1, it was then possible to perform the desired measurements of characteristic impedance, attenuation, and power rating.

For the measurement of characteristic impedance and attenuation of the liquid dielectric cable, the slotted line variable short circuit technique was utilized. The results of one set of data from such measurements can be used to determine both the attenuation and characteristic impedance. The typical arrangement of equipment for this measurement is shown in Fig. 7.

Characteristic Impedance

By use of the above method, data was obtained over the frequency range of 700 MC to 3000 MC for the two liquid dielectric coaxial cables. During these measurements the flow rate of the liquid dielectric was adjusted to an arbitrary value and held constant. The characteristic impedance values for the filament type cable and the channeled type cable using mineral oil dielectric are given in Table V. The characteristic impedance of a sample length of RG-8/U cable, measured with the same equipment, is also presented in Table V for comparison.

The comparison of the liquid dielectric cable construction can be

(*Continued on page* 116)

more readily visualized if normalized impedance values are used with 50 ohms as the reference. The values appearing in Table V were so converted and the results are presented in Fig. 8. It is seen that the normallized impedance of the filament type liquid dielectric cable varied over a much greater range than that of the RG-8/U cable, while the values for the channeled core type cable compared favorably with those of RG-8/U cable. These experimental results show that a 50 ohm liquid dielectric coaxial cable has been attained.

No impedance data is included for the silicone oil because of the high attenuation resulting from the use of this dielectric at the frequencies involved.

Attenuation

The attenuation values of the dielectric coaxial cables versus frequency were obtained from the same measurement data of the slotted line—variable short circuit technique. The results for the two cable constructions using mineral oil as a dielectric and also for the filament type cable using silicone oil are shown in Fig. 9. In addition, the measured attenuation values obtained on a sample length of RG-8/U cable are shown in Fig. 9. The attenuation of the filament type construction using mineral oil dielectric is approximately twice as great as the attenuation of RG-8/U cable while the channeled core construction is about 1.2 times greater.

These experimental results are not in agreement with the theoretical evaluation of cable attenuation using the published values for loss tangent of the mineral oil. With the published values, both the solid dielectric and liquid type cable constructions should have the same attenuation. To further clarify this discrepancy measurements of the loss tangent of mineral oil were performed at 3000 MC and indicate an increase of approximately 2½ times over the published values. Thus, it is apparent that the attenuation of the mineral oil liquid dielectric cable is related to the ratio of liquid to solid dielectric.

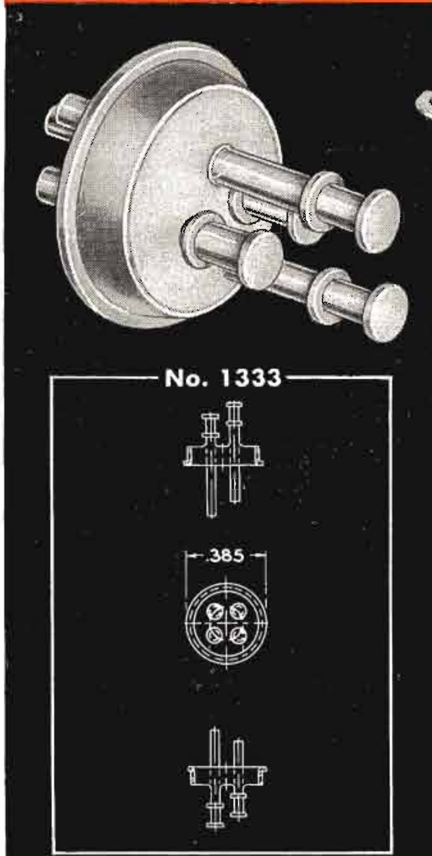
Low Loss Tangent

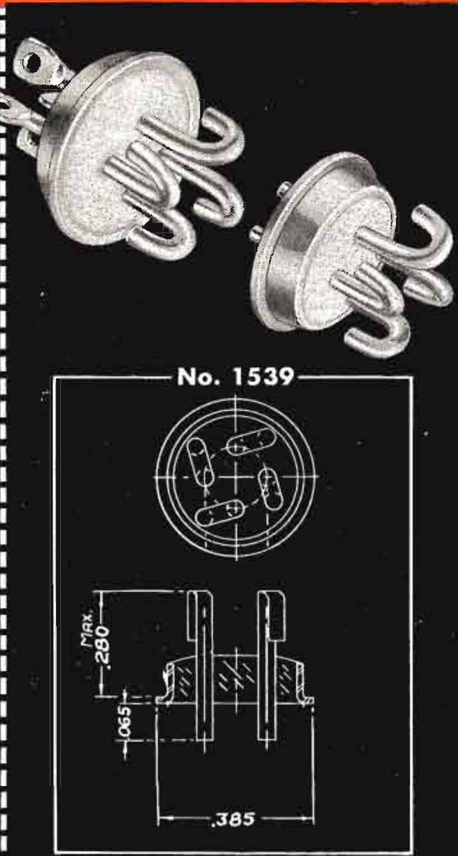
Therefore, if a liquid dielectric becomes available which possesses the same low loss tangent as exhibited by currently used solid dielectrics, the attenuation of the liquid dielectric cable can be expected to equal that of standard RG-8/U cable.

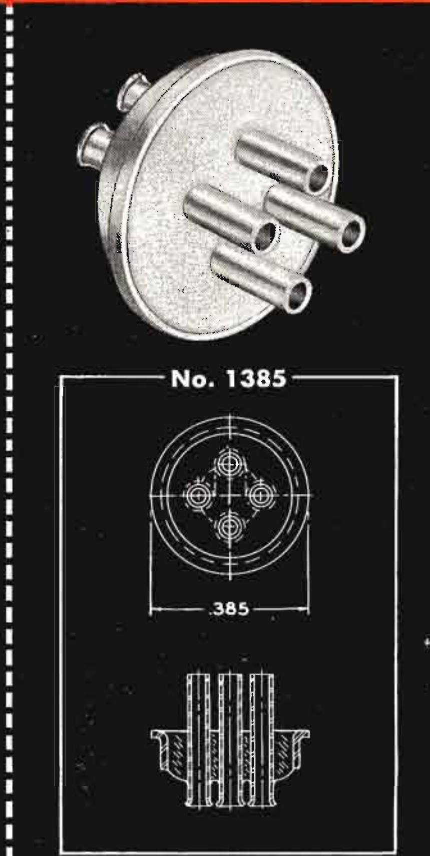
Since the increase in power han-

(*Continued on page* 118)

MILESTONE in MINIATURIZATION







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dling capacity over that of standard solid dielectric cables is the prime purpose of this development, experimental data was obtained to substantiate the conclusions reached in the theoretical heat transfer investigation. Actual measurements under high power radio-frequency conditions were performed.

Experimental Equipment

The experimental equipment was assembled as shown in Fig. 10. The radio-frequency generator power source is variable from approximately 100 watts to 5000 watts at a fixed frequency of 915 MC. The coaxial cable was connected to the high power radio-frequency generator at "A" and terminated by a water cooled matched load at "B." The liquid dielectric connectors were at "C" and "D." Using this experimental equipment set up, radio frequency power was applied in increasing steps to the coaxial cable. During these tests, the flow rate of the liquid dielectric was varied to maintain a low temperature rise. Some of the resulting data is shown in Table VI.

It can be seen from this table that small rates of flow of the liquid dielectric were sufficient to maintain safe operating temperatures at high power input. The flow rate at 3760 watts input was not determined because the uncooled portion of the input liquid tap connector failed electrically.

Performance Tests

A series of tests were conducted to determine the performance characteristics of the liquid dielectric coaxial cable. The first factor controlling the power rating of the liquid dielectric coaxial cable is the liquid dielectric flow rate. The power input to the cable and the temperature rise of the dielectric coolant were measured at various flow rates. The resulting data apears in Table VII.

The liquid dielectric temperature rise could thus be controlled and regulated by small flow rate adjustments.

The second factor controlling the power rating of the liquid dielectric transmission line is the temperature of the center conductor at its "hottest" point. This point as determined by surface temperature measurements was found to be near the terminating end of the liquid cable where the temperature rise due to the heating of the liquid dielectric is larger than the temperature de-

(*Continued on page 120*)

crease due to the attenuation. In order to measure the center conductor temperature directly without disturbing the electrical continuity of the cable under test, use was made of a quarter wave stub support. Through a small hole in the center conductor of the stub support, a thermocouple junction was inserted and soldered to the center conductor of the cable. Because of the high input impedance of the shorted stub, the thermocouple junction has very little effect on the electrical operation of the coaxial cable.

Using this direct method of measurement, the center conductor temperature was measured to be 160° F. with 3500 watts input to the cable at a frequency of 915 MC. The liquid dielectric flow rate, maintained at ¼ gallon per minute, gave a resulting liquid dielectric temperature rise of 35° F. The center conductor temperature was low in comparison to the high power input and the small flow rate of the liquid dielectric. Since mineral oil was used in these tests, direct comparison of the experimental results with the theoretical analysis using silicone oil as described in Section II may not be made. However, the general conclusions of moderate temperature increases and low flow rates of the liquid dielectric are confirmed by the experiments as most of the physical properties of silicone and mineral oils are comparable.

The present investigation which is still in progress has illustrated that a liquid dielectric coaxial cable can be constructed which will withstand a power input of eight times as great as the standard equivalent RG cable and is also not affected by changes of atmospheric temperature and pressure. The results of electrical tests indicate that when a suitable liquid dielectric is available the cable will meet all the necessary electrical requirements.

This paper was first presented at the 1952 National Electronics Conference held in Chicago, Sept. 29-Oct. 1.

ACKNOWLEDGMENT—The development of the liquid dielectric coaxial cable is being sponsored by the Wright Air Development Center, Dayton, Ohio.

REFERENCES

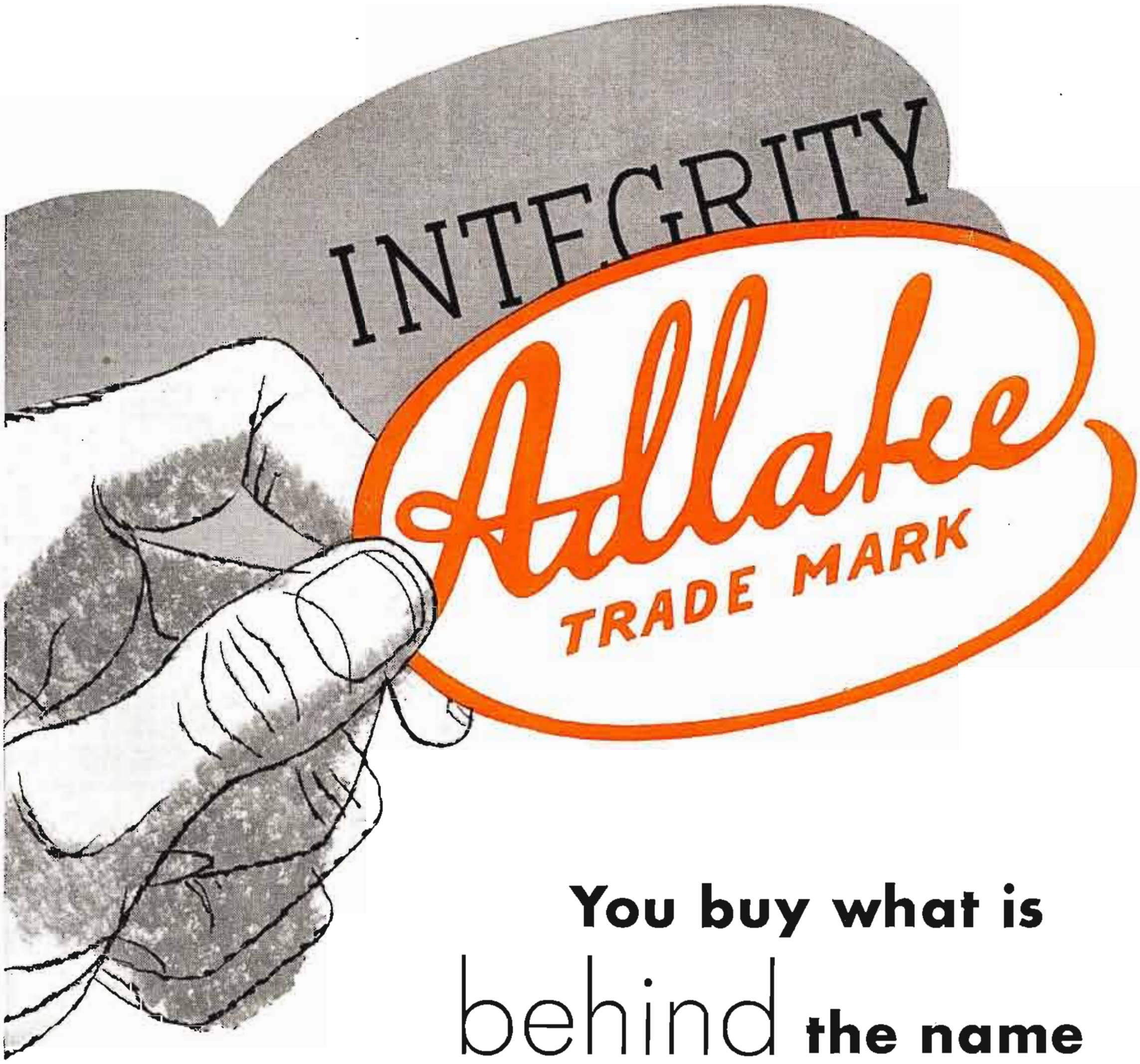
Max Jakob, "Heat Transfer, Volume I," John Wiley and Sons, Inc., New York, New York; 1949.

W. H. McAdams, "Heat Transmission, 2nd Edition," McGraw-Hill Book Company, Inc., New York, New York; 1942.

J. W. E. Griemsmann, "Handbook of Design Data for Microwave Connectors," Report No. R-158-47, Polytechnic Institute of Brooklyn 107; July 1947.

C. G. Montgomery, "Technique of Microwave Measurements," McGraw-Hill Book Co., Inc., New York, New York, Chapter 8; 1947.

L. Essen, "The Measurement of Balanced and Unbalanced Impedances at Frequencies Near 500 mc/sec, and Its Application to the Determination of the Propagation Constants of Cables," *J.I.E.E.*, Vol. 91, Part III, No. 14, pp. 84-95.



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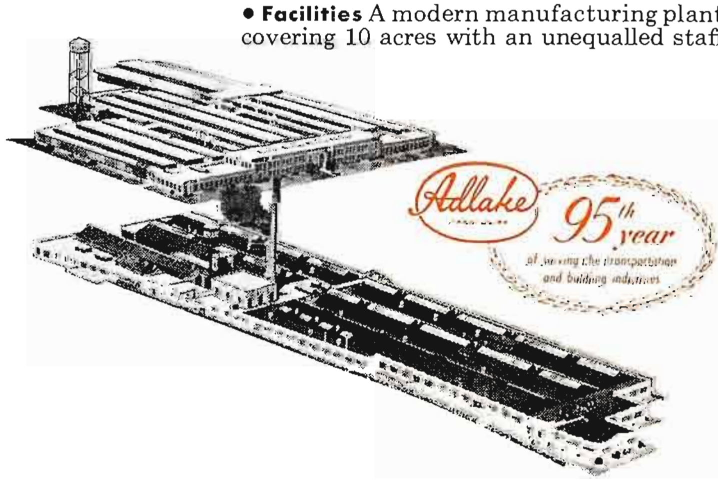

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CUES for BROADCASTERS

(Continued from page 59)

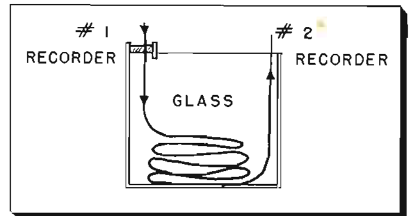
while playing was seemingly suspended in mid-air.

To overcome this on the Gates CB-14 turntables in use at WCHS, the small aluminum hubs furnished by the manufacturer were fastened to an aluminum plate. This aluminum plate was made from an old 12 in. recording disc and cut to a diameter of 8 in. The hub was fastened over the center hole of the aluminum disc so that the holes would line up with two 6/32 flat head screws. The heads of the screws were recessed to avoid damage to the felt of the regular turntable. To the aluminum disc was glued a piece of felt with an O.D. of 8 in. and I.D. of 5½ in. 45 rpm records can now be placed so that all the friction of driving is applied to the outer portion of the disc, and the center raised portion fitted into the space between the felt and the center hub. This not only enables the disc jockey to play these discs without slipping but gives greater ease in placing them on the table, since he can hold them while the turntable is revolving.

Delaying Network Programs from One to Five Minutes

G. SHAFFER, WRTA, Altoona, Pa.

OCCASIONALLY we have been confronted by the problem of delaying a network program anywhere from one to five minutes. In one case, it was five minutes on a fifteen minute program. A glass box was made. Glass worked best because of static discharge from the tape. The box is 19 in. high and 21 in. wide. The sides are separated by wood strips along the sides and bottom allowing an inside clearance of ⅜ in. This inside clearance is just a fraction wider than the tape itself. The top of the box remains open, with the exception of a small cardboard slot placed in the left corner. This permits the tape to run in the box in one place continuously. The box was held together by running strips of masking tape all around at several spots.



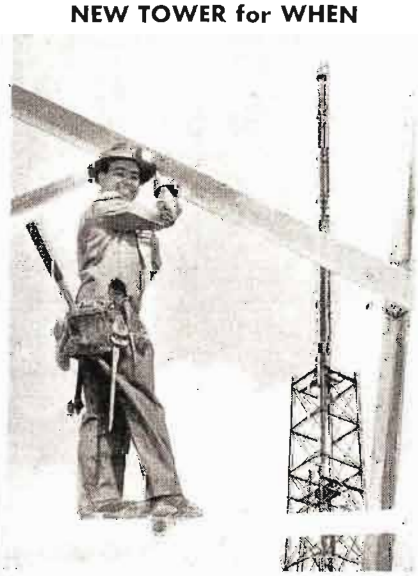
Glass box holds tape for delayed use

Two Tape Machines

Two tape machines are used. The program into our studio is recorded on number one recorder and the left end, instead of running onto the take-up reel, is allowed to fall into the box placed on the floor directly between the two machines. The end of the tape is fished out of the box with a simple wire hook, and pulled up onto the second machine. This end is then run onto the take-up reel of number two machine.

With number one machine recording the weight of the tape causes it to fall into the glass box. It will then loop back and forth across the bottom of the box one layer upon the next and does not tangle. When the time arrives for play-back, number two machine is put in playback position and the beginning of the program cued to the start. The second machine is then started by pulling the tape out of the box. As number one machine is putting tape into the box the second machine is pulling it out from the bottom layer, playing it on the air, and winding the tape on the takeup reel. By this time there is approximately five minutes of tape in the box and amount of time will remain five minutes as long as the number one machine continues to record. At the conclusion of the program allow enough tape to fall into the box to permit complete passage into number two take-up reel.

NEW TOWER for WHEN



Chief Engineer H. Eugene Crow of television station WHEN, Syracuse, N. Y., rides aloft on first section of steel to be fitted to base of station's new tower at Sentinel Heights

NEW 7″ REELS OF
audiotape* give you **EXTRA VALUE**

at no extra cost!

GUARANTEED SPLICE-FREE

SPLIT-SECOND TIMING
with New 2¾″ Hub

Improved reel design reduces timing errors by decreasing tension and speed changes throughout the winding cycle. Ratio of OD to hub diameter is the same as on the standard NAB 2500-ft. reel.

PERFECTED ANTI-FRICTION PROCESS. Reduces head wear—eliminates annoying tape "squeal" – prevents "tackiness" even under extreme temperature and humidity conditions.

MAXIMUM UNIFORMITY OF OUTPUT. All 7″ and 10″ reels of plastic-base Audiotape are guaranteed to have an output uniformity *within* ± ¼db – and reel-to-reel-variation of less than ± ½db. What's more, there's an actual *output curve* in every 5-reel package to prove it.

With Audiotape, all of these extra-value features are *standard*. There's no extra cost – no problem of separate inventories or variations in tape quality.

For there's *only one* Audiotape – the finest obtainable anywhere. Test it – compare it – let Audiotape speak for itself.

The new 7-inch plastic reel with large diameter hub for greater timing accuracy is now being supplied on all orders unless otherwise specified. Because of increased hub diameter, maximum reel capacity is slightly over 1200 feet. Older style Audiotape reels with 1¾″ hub and 1250 feet of tape will continue to be furnished on request at the same price.

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United Nations

(*Continued from page* 53)

are all connected to the input of a preamplifier via the microphone keys show. The impedance conditions in the input of this amplifier being such that five or six keys can be thrown simultaneously without any marked change in volume. Following the preamplifiers, there is a second preamplifier common to all of the floor channels, and this is followed by the main volume control and a limiter amplifier adjusted to provide AVC.

Fig. 7: Control booth for one small studio

A line amplifier on the output of the latter feeds the main volume meter and all of the various output circuits. About 12 output circuits are used for supplying loudspeakers in the meeting hall, headphones on chairs, and the simultaneous interpretation booths. A second group of output circuits feed through a security key to the operating center, the recording room, radio booths, etc. All these latter can be cut off by operating the security key when it is desired that the meeting shall be "closed" and not heard by anyone outside.

Simultaneous Interpretation

Simultaneous interpretation is done by groups of three interpreters per booth, each group responsible for an output in one of the five official languages. The three interpreters in a booth each has a microphone in front of him and headphones to which he can switch either the floor channel or the output of any other simultaneous interpretation booth so that he can, if necessary, translate from a translation in cases in which there is no one in the booth who can go direct from the language being used on the floor to the language for which the booth is responsible. There is little doubt that, with so much equipment under the control of one operator, AVC is desirable in the five language outputs as well as in the floor channel.

(*Continued on page* 126)

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SPACE-SAVER DUAL-SHAFT CONTROLS

Tiny Stackpole Type LR Controls in dual-shaft* designs, with or without line switches, handle ample power in minimum space for TV receivers, auto radio and other equipment. A variety of standard curve, tap, switch and shaft specifications is available.

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Extremely quiet, stable under wide humidity variations and built for long life, these little Stackpole LR Controls dissipate a full .5 watt under normal TV or similar use. S.P.S.T. or D.P.S.T. line switches available.

A CONTROL FOR HEAVIER DUTY

Only slightly larger than the smallest Stackpole controls, these popular Type LP units are conservatively rated at .6 watt for the average application. Standard construction includes gold-plated ring spring contactors.

WRITE FOR CATALOG RC-8

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Electronic Components Division

STACKPOLE CARBON COMPANY

St. Marys, Pa.

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A special type of system is required for the Plenary Hall. Here delegates do not use microphones immediately in front of them, but walk to a rostrum at the end of the hall. The bigger conference rooms and council chambers have each some hundreds of seats equipped with simultaneous interpretation; in the Plenary Hall there are about 2,000 such seats, and in addition, equipment in the Plenary Hall includes several bays of amplifiers to feed the very large loudspeaker system required for sound reinforcement. Fig. 3 shows the loudspeakers being mounted in their chambers above the podium in the Plenary Hall.

Radio and Television

UN radio consists of a large number of transmissions in various languages following one another so that for many hours of the day there are two programs going out simultaneously. These feed, by line or radio-link, transmitters operated by State Dept., Canadian Broadcasting, and a number of other transmitting authorities. Most of these programs originate in five small talks studios associated with each of which is a control booth and a recording, playback and observation room. A view in a booth associated with one of the small talk studios is shown in Fig. 7. The main console in the center has two output channels which can be used separately or one in association with the other for echo. The turret to the right now contains a variable "effect filter" in place of the blank panel shown; the jack field carries all of the line termination to the operating center and central recording room, etc. The controls below the jack field are start-stop controls for magnetic tape machines located just behind the operator. To the left may be seen two disc reproducers. In addition to these five small studios, there are two medium size studios provided with similar audio equipment but having in addition camera cables and lighting so that they can be used for television interviews, or film interviews as well. Still two other studios were wired originally as interview booths, but are now equipped as ordinary talk studios in the same way as the five small speech studios.

Central Recording Suite

Just across a corridor from these five studios is the central recording suite consisting of a main recording room, a dubbing room and the record library. Part of the main record-

(*Continued on page* 128)

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ing room is shown in Fig. 4. The central console can be used for switching any incoming line to any of the recording machines around the room. Machine spacing in this room is such that a single operator can give adequate attention to four machines. Loudspeakers are mounted over each machine and the floor, ceiling and opposite wall have been acoustically treated to permit loudspeaker monitoring.

Lines from the control rooms in all the meeting halls, and from the studios all converge on the audio operations center, shown in Fig. 5. Next door is the TV section of the operating center, and this consists of two rooms, in one of which are the TV camera cables termination racks, the camera channel control equipments, and the vision mixer and the sound equipment associated with the TV sound operation, and in the other is a 16 mm kinescope recording equipment with rapid developing and processing. Fig. 6 is a view of the TV portable equipment.

Part two will appear in the Jan. issue

Microwave Spectroscopy

(Continued from page 41)

rectangular waveguide required increases with increasing wavelength. Thus measurements within the range of 900 and 3400 MC would require a waveguide cross section of 3¼ x 6½ in. down to 900 MC and waveguide sizes of 1½ x 3 in. and smaller for frequencies above 200 MC. To avoid the need of changing large, cumbersome waveguide sections and to make the experiments more practicable at the lower frequencies, L. J. Rueger and R. G. Nuckolls of the NBS microwave spectroscopy laboratory developed the broad-band coaxial Stark cell.

The coaxial structure of the NBS absorption cell provides two electrodes—the center and outer-conductors—across which the so-called "Stark" (electric) field is applied. The outer diameter of the cell is chosen so that at frequencies as low as zero and as high as 3400 MC only single-mode transmission of the radio energy is possible.

The separately applied Stark voltage sets up a transverse field that alters the absorption frequencies of the enclosed gas molecules. When the microwave energy alone is impressed on the cell, the slight absorption which occurs as the frequency is varied through the resonant frequency of the gas is difficult to observe. However, the presence of a Stark field, being applied and removed at some predetermined rate, causes a corresponding alternation in the gas absorption. This alternating signal is more readily detected.

The NBS coaxial Stark cell is made up of a ten-foot section of 1½ in. brass tube, which forms the outer wall of a

(Continued on page 130)

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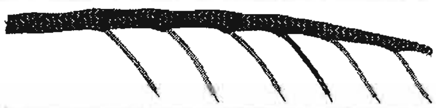

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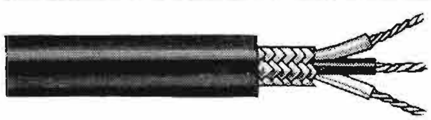

SHIELDED JACKETED MICROPHONE CABLE
Conductors: Multiple—2 to 7 or more conductors of stranded tinned copper. Insulation: extruded color-coded plastic. Closely braided tinned copper shield. Tough, durable jacket overall.

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Conductors: Extra-flexible tinned copper. Polythene insulation. Shield: #36 tinned copper, closely braided, with tough durable jacket overall. Capacity per foot: 29MMF.

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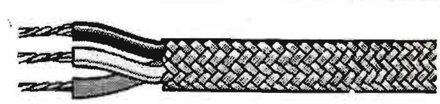
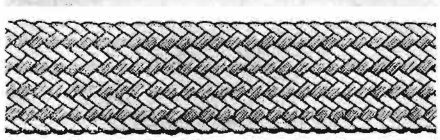
Conductors: Multiple—2 to 7 or more of flexible tinned copper. Insulation: extruded color-coded plastic. Closely braided tinned copper shield. For: Auto radio, indoor PA systems and sound recording equipment.





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Construction: #34 tinned copper braid, flattened to various widths. Bonding Braids conforming to Federal Spec. QQ-B-575 or Air Force Spec. 94-40229.

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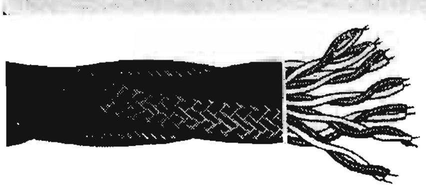
Conductors: Multiple--2 to 7 or more of flexible tinned copper. Insulation: extruded color-coded plastic. Cable concentrically formed. Closely braided tinned copper shield plus brown overall cotton braid.



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Conductors: #22 stranded tinned copper. Insulation: textile or plastic insulated conductors. Cable formed of Twisted Pairs, color-coded. Cotton braid or plastic jacket overall. Furnished in 2, 5, 7, 13 and 25 paired, or to specific requirements.

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vacuum-tight chamber. The center conductor is composed of a series of ⅝ in. brass rods, each 15 in. long, connected end to end by threaded joints. One rod has a sliding joint that telescopes to accommodate longitudinal expansion during heating or cooling. The ends of the cell are vacuum-sealed by clamping "Teflon" disks at the centers and rims of the tube. An exhaust manifold for adjusting the gas pressure is attached to the cell through 4 quarter-inch holes in the side of the brass tube.

In a preliminary model, the center rod was supported in the coaxial cell by a series of disk spacers. However, the disks gave rise to small standing waves at specific frequencies. These effects are materially reduced by using sets of three longitudinal fins spaced and rotated at random with respect to each other.

Signal voltages are coupled to the cell through coaxial-to-waveguide-to-coaxial transformers placed at both ends. The transformers are made from L-band waveguide sections and are scaled down from broadband, S-band commercial waveguides. One transformer is modified to permit the insertion of the Stark voltages. Although in this system the frequency range for operation is limited to 900 MC by the size of the transformer sections enployed, additional transformers are readily constructed and interchanged without disturbing the absorption cell itself. The transformers act as a waveguide-below-cutoff attenuators to prevent the direct application of the Stark modulation voltages to the detector. Resonant reflections within these waveguide sections are reduced by the insertion of IRC resistor boards cut to act as tapered attenuators.

The source of r-f energy for the spectrograph in which the cell is used is a conventional klystron oscillator. At the absorption frequency of a particular gas, the frequency of the oscillator is varied by a motor driven control either of the sweep voltage (over a small frequency range) or of a cavity plunger for wide range tuning. This permits observations of the gas absorption to be recorded on a strip chart as a function of frequency.

Railroads Triple Use of Radio

Radio facilities placed in operation by the nation's railroads over a three-year span have virtually trebled, according to reports given at the 1952 annual meeting of the Communications Section of the Association of American Railroads at Edgewater Park, Miss.

F. H. Menagh, of Cleveland, Ohio, superintendent of communications for the Erie Railroad, disclosed that as of last May there were 10,625 authorized base and mobile radio stations and inductive carrier installations, compared with 3,613 of the communication outlets in the same month of 1949. The increasing number of railroads which have installed either radio stations or inductive carriers or both number 114, an increase of 42 lines since 1949.

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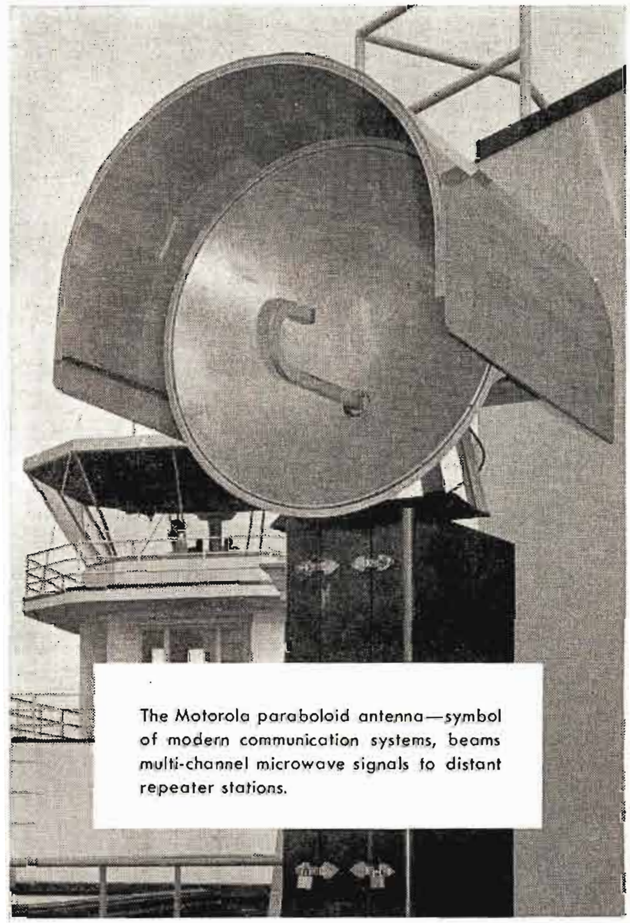
Motorola engineers, with over 24 years experience and research in mobile radio communication, have installed *more than 70%* of all operating pipeline microwave systems. Flashing through space with the speed of light, voice messages, telemeter, teleprinter and supervisory control signals span thousand-mile pipelines with instant 2-way contact—cut communication costs, save vital man-hours, speed industrial operations.

Motorola custom-tailored systems provide full communications facilities for industry, transportation, utilities and public services. Microwave and VHF radio tie-ins blanket plant areas, railroads, pipelines and entire cities. Your business, too, can profit from Motorola 2-way radio—write today for friendly Motorola engineering service.



The Motorola paraboloid antenna—symbol of modern communication systems, beams multi-channel microwave signals to distant repeater stations.

The Ever-Growing List of Companies Using MOTOROLA Communication Systems Reads Like a "Who's Who" of American Business

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Pennsylvania RR
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Public Service Company of Northern Ill.
Rock Island RR
Sinclair Oil Company
Southern California Gas Co.
Shell Oil Company
Southern Pacific RR
Staley Mfg. Co.
Ford Motor Co.
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Communications and Electronics Division
4545 Augusta Blvd., Chicago 51, Illinois
Rogers Majestic Electronics Ltd., Toronto, Canada

Plug-in Amplifiers

(*Continued from page* 61)

tubes and components, the amplifier circuits were revised to accommodate the 12AY7. A photograph of the present preamplifier using 12AY7 tubes and a block diagram of its electrical circuit are shown in Figs. 1 and 3. The input transformer is mounted over the 15 pin connector shown at the front of the amplifier, and next to the transformer, the input and phase-inverter stages. At the other end of the amplifier are the output transformer and push-pull output stage, with filter condensers between input and output sections. Four miniature push-button switches are shown attached to the chassis under the output transformer. These allow tube condition checking with a single meter which registers voltage across small resistors in the cathode circuit of each tube. Resistors are mounted on terminals attached to two boards placed lengthwise along the center of the amplifier chassis. The novel mounting arrangement permits the resistors to be soldered with long leads preventing any change in resistance value because of heating at the time of soldering. The mating connectors are Cannon DA-15 type, with 15 gold plated contacts mounted in a nylon insulator. The shell of the male connector serves as positive mating guide, and in addition, a heavy guide pin is attached to the amplifier cover.

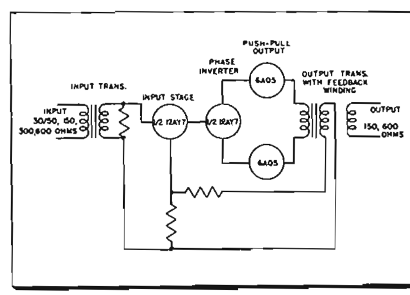
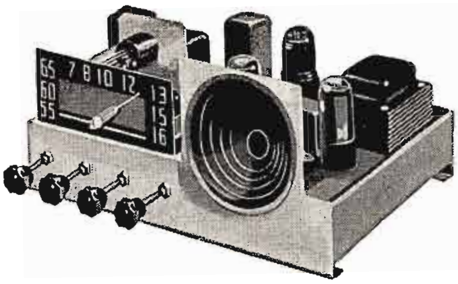


Fig. 6: A-429B line-monitor amplifier circuit

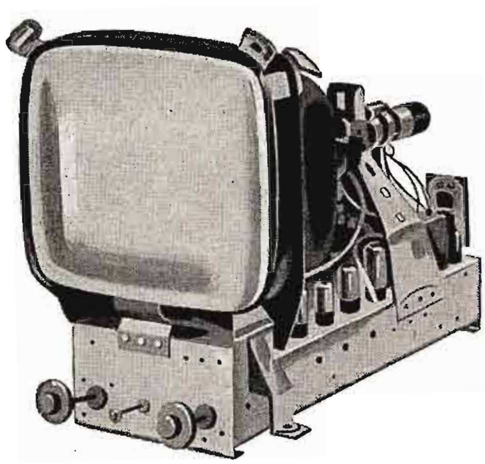
In the second amplifier type, also, a large amount of feedback is used. A few details of the preamplifier circuit are worthy of note. The amplifier gain, while normally 40 db, may be reduced to 34 db by series connection of the two feedback windings on the output transformer. This is often desirable where the amplifier is used for booster service or where input levels as high as −14 dbm are encountered. The input transformer is terminated in its nominal impedance. While it is true that higher signal to noise ratio

(*Continued on page* 134)

FOR RADIO



AND TV



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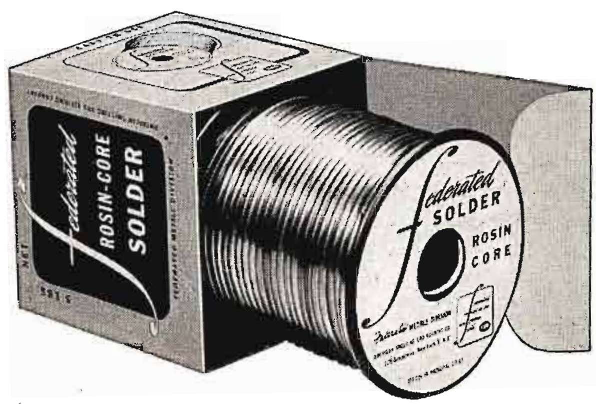

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(thermal agitation and tube noise) will result with unterminated input transformer, many types of dynamic and ribbon microphones will have their optimum frequency characteristics and transient response when loaded, through the input transformer, by their nominal impedance. In some cases, operation of unterminated input transformers from a source impedance much lower than that of the nominal transformer rating will result in a peak in the high-frequency response of the transformer depending on the leakage inductance and distributed and load capacities of the transformer. The input termination may be removed, however, when it is desirable to do so. This causes a 6 db increase in amplifier gain which may be compensated by increased feedback from series connection of the output transformer tertiary coils in those cases where the amplifier must handle −20 dbm maximum input level.

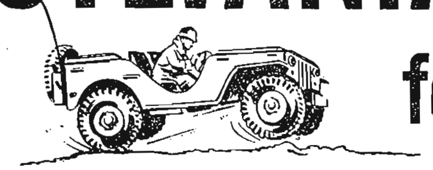
Performance Curves

Curves of intermodulation distortion versus power output for a typical preamplifier are shown in Fig. 4. Other specifications which are met by production amplifiers are frequency response within 1 db from 20 to 20,000 cps, ½% total harmonic distortion from 50 to 15,000 cps at +20 dbm output, and equivalent input noise level of −124 dbm or better. Both input and output transformers may be connected for a range of source and load impedances between 30 and 600 ohms. Plate supply required is 10 ma at 260 v. and filament supply is 0.6 amp at 6.3 v. ac. Sizes of the unit is 1½ x 4¾ x 10 in., including handle, and it is provided with a cover tray 1⅝ in. wide, also shown in Fig. 1 which mounts a mating receptacle.

Design of a higher power amplifier for program output and monitor speaker drive was undertaken with the same considerations regarding size and performance that guided design of the preamplifier. A single amplifier type should be used for either program or monitor service. Here it was decided that in the monitor function, the amplifier should produce 8 watts output over a wide frequency range, this being the greatest power that could be obtained from available miniature tubes in a balanced circuit while operating at a reasonably high percentage of their maximum dissipation rating. Design of an output transformer for this unit presented particularly difficult problems. The

(*Continued on page 136*)

SYLVANIA TUBE SOCKETS



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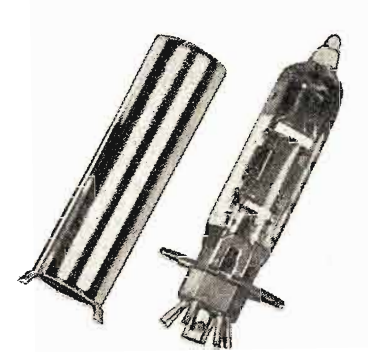
JAN OCTAL TUBE SOCKETS

Saddles of these sockets are nickel plated brass, either top or bottom mounted, with or without ground lugs. Body and contacts are of the same materials as the JAN miniature tube sockets. Contact tabs and saddle ground lugs are hot tin dipped.



JAN 7- AND 9-PIN MINIATURE TUBE SOCKETS

These sockets are available in grade L-4B or better ceramic, or type MFE low loss plastic. The contacts are either phosphor bronze or beryllium copper, silver plated. Contacts and center shield tab are hot tin dipped. Nickel plated brass shields equipped with sturdy springs are available for all 7- and 9-pin sockets.

BUTTON TYPE SUBMINIATURE (T3) TUBE SOCKETS

These sockets are available for round 8-pin subminiature tube types. Insulation is type MFE low loss plastic and contacts are beryllium copper silver plated with gold flash covering. Contacts especially designed for positive connection and high pin retention even after many insertions. Sockets are of rugged construction for long life.

When you order Sylvania Tube Sockets you get the extra value of Sylvania's experience and know-how at no extra cost. Designed for maximum strength and optimum electrical properties, Sylvania Sockets assure high tube retention and tube pin contact even under severe vibration. Highest quality is guaranteed by Sylvania's own exacting quality control.

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PLUG-IN AMPLIFIERS

(*Continued from page* 134)

transformer developed is contained in a case 2¼ x 3 x 2½ in. and is rated at 10 watts output from 50 to 15,000 cycles. At lower power, the response is within 1 db from 20 to 45,000 cps. The size indicated above is believed to occupy a volume ⅓ to ½ that of any other commercially available transformer with the same performance rating.

A gain of 50 db is about the optimum value which is compatible with both line amplifier and monitor amplifier functions in the speech input equipment for which the unit was designed. With this gain and a maximum amplifier output of +39 dbm, it is apparent that the input transformer which was designed for the preamplifier will also serve for the input circuit of the larger amplifier, since its maximum power rating is +8 dbm. A photograph of the monitor amplifier appears in Fig. 5 and a block diagram of its circuit in Fig. 6. Similarity to the preamplifier in both physical layout and circuit design is shown. It should be noted that only two tube types are used for both amplifiers. The most limiting requirement in one case is that of obtaining low noise level while in the other, high output power in a small space. The requirements are admirably filled by the 12AY7 and 6AQ5 tubes.

Some comments have been made regarding low life expectancy of the 6AQ5 tube. It is our information that these tubes are production tested to provide ⅔ of their maximum rated signal output after 500 hours of operation at a maximum rated plate dissipation of 12 watts. In the monitor amplifier circuit, the tubes function at about ⅔ of the rated plate and screen-grid dissipation, and should have somewhat longer than 500 hours life before falling too

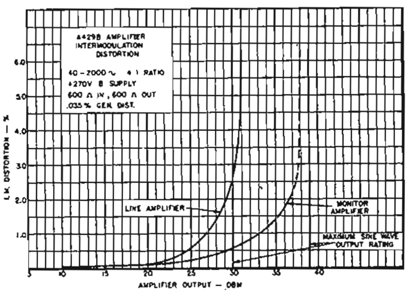


Fig. 7: Intermodulation distortion curves of A-429B amplifier show output levels which are average of wave consisting of 40 and 2000 CPS

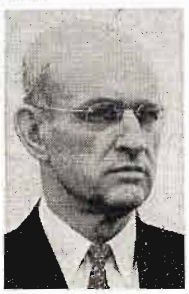
low in output capability. In the line-amplifier service, where a maximum of +30 dbm output power is required, provisions are made to reduce the plate and screen voltages to much lower values by means of an external resistor. This increases tube life and greatly reduces power supply demands in broadcast equipment, where in general, line amplifiers will be much more numerous than monitor amplifiers.

Restrictions on noise level are less stringent for the line and monitor amplifiers than for the preamplifier; therefore, we are able to use a circuit which applies feedback to an unbypassed portion of the first stage cathode resistor, rather than requiring that the cathode current pass through the low-resistance tertiary of the output transformer as in the preamplifier circuit. Maximum noise level for the line-monitor amplifier is −110 dbm. Other specifications are maximum output of +39 dbm from 50 to 15,000 cps at 1% total harmonic distortion as monitor, and +30 dbm from 30 to 15,000 cps at ½% total harmonic distortion as line amplifier. Frequency response is within 1 db from 20 to 20,000 cps. Plate supply is 70 ma at 270 volts for the monitor amplifier and 30 ma at 270

PERSONAL

Victor Welge has been appointed associate director of engineering of P. R. Mallory & Co., Inc., Indianapolis, Ind. He came to Mallory from Consolidated Vultee Aircraft Corp., San Diego, where he headed the staff of the firm's Electronics and Missile Section.

Vice Admiral Edward L. Cochrane, USN (Ret.), Dean of the School of Engineering at the Massachusetts Institute of Technology and until recently, Chairman of the Federal Maritime Board, has been elected a director of Raytheon Manufacturing Co., Waltham, Mass.



COCHRANE

KIRKPATRICK

Donald N. Kirkpatrick has been appointed chief engineer of the National Co., Malden and Melrose, Mass. He was formerly chief engineer of the Boonton Radio Corp., Boonton, N. J.

(*Continued on page* 140)

volts (with external dropping resistor) for the line amplifier. Dimensions are 2¼ x 4⅜ x 10 inches, including handle, with a cover tray 2⅜ inches wide, as shown in Fig. 5. Intermodulation distortion curves for the line-monitor amplifier are shown in Fig. 7.

The design of the cover trays permits the amplifiers to be mounted adjacent to each other, with two screws fastening the bottom of each cover to the mounting surface which may be a flat plate or channel. A rack mounting assembly was devised which permits the installation of nine preamplifiers or six line-monitor amplifiers in 7 in. of vertical rack space, a hinged mat giving access to the amplifiers from the front of the rack. The Altec Lansing identification numbers assigned to the preamplifier and line-monitor amplifier described above are A-428B and A-429B, respectively.

In addition to these amplifiers, two types of miniature plug-in power supplies were designed specifically to be used with the amplifiers. The P-522A power supply provides 135 ma at 270 v. plate supply and 5.2 amps at 6.3 v., biased to +65 v., for tube filaments. The P-523A power supply furnishes 12 v. dc at 1.2 amps for operation of relays and signal lights in speech input systems. This power supply incorporates three relays which are wired to the plug-in connector and may be used for loudspeaker control. Both power supplies are the same physical size as the A-429B monitor amplifier and use an identical 15-pin Cannon connector. They may be mounted in the same cover trays as the monitor amplifier, but in practice different cover assemblies, with guide pins relocated, are used to prevent accidental interchange of amplifiers and power supplies.

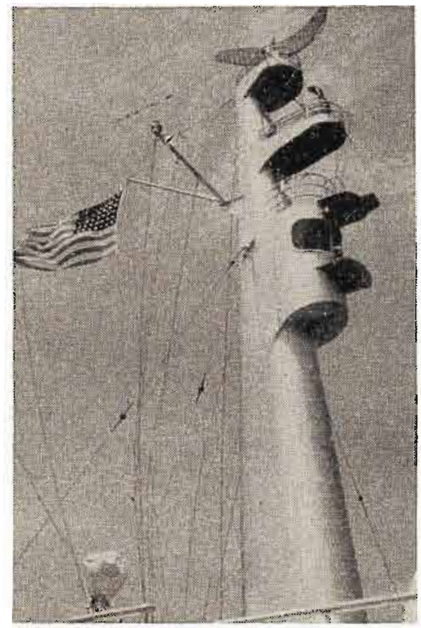
In the Altec Lansing 250A console, the miniature amplifiers are mounted vertically in the rear of the console, where the tube-metering buttons may be operated when the hinged top panel of the console is raised. The seven preamplifiers, two boosters, two line and one monitor amplifier in this console are contained in a space 10 x 22½ in.

The most important single contribution toward attaining small size in the amplifiers and power supplies described was the careful and ingenious design of the transformers accomplished by Mr. E. B. Harrison of the Peerless Div. of Altec Lansing Corp.

Latest Radar Guides S.S. UNITED STATES

First luxury liner to be built in conformance with Navy standards, the 990-ft. S.S. *UNITED STATES* carries two radar systems for long and short range navigation. Mounted atop the all-aluminum mast is Raytheon's 12-ft. S-

The S.S. UNITED STATES' all-aluminum radar mast carries scanners for S-band and X-band



band (10 cm) scanner. Situated just below this antenna is Sperry Gyroscope's 8-ft. X-band (3 cm) radar scanner.

Of notable interest is the $70,000,000 vessel's gyro-pilot steering system manufactured by Sperry. In it, the electronic turning rate control obtains a dc voltage from the generator geared to the gyro-compass. This voltage, proportional to the turning speed, is mixed in a magnetic amplifier with a heading displacement signal, and applied to a valve control. The valve in turn controls a hydraulic arrangement which actuates the steering mechanism, keeping the ship on course.

Other features included in the country's largest and fastest passenger ship are Hose-McCann sound-powered telephones for engine room use where high ambient noise levels exist, communication transmitters made by Radiomarine Corp. of America, and sonic-echo fathometer manufactured by Raytheon. Almost all of the communication and navigation equipment is installed in duplicate to insure safe operation in case of failure.

New Raytheon Laboratory

A $2,000,000 laboratory is being constructed in Bedford, Mass. by the Raytheon Manufacturing Co., of Waltham, Mass. The building will be used by the company as a research and development center. Approximately 700 persons will be employed in the project.

Radio Engineers Name Officers for 1953

Dr. James W. McRae, vice president of Bell Telephone Laboratories, New York, N. Y., has been accorded one of the nation's highest professional honors with the announcement of his election as president of the Institute of Radio Engineers for 1953. He succeeds Dr. Donald B. Sinclair, chief engineer of the General Radio Co.

Regional Directors elected for 1952-1953 are as follows: Region 2 (North Central Atlantic), John R. Ragazzini, professor of electrical engineering, Columbia University, New York, N. Y.; Region 4 (East Central), Conan A. Priest, assistant to the general manager of the commercial and government equipment department, General Electric Co., Syracuse, N. Y.; Region 6 (Southern), Archie W. Straiton, professor of electrical engineering and director of the electrical engineering research laboratories, University of Texas, Austin, Texas; Region 8 (Canadian), John T. Henderson, senior research physicist, National Research Council, Ottawa, Ont., Canada.

J. W. McRae was born on October 25, 1910, in Vancouver, British Columbia. He received the B.S. degree in electrical enginering from the University of British Columbia in 1933, the M.S. degree in 1934 from the California Institute of Technology, and the Ph.D. degree from the same institution in 1937. Early in 1937 he joined the staff of Bell Telephone Laboratories, Inc.

Personal

(*Continued from page* 137)

Howard Briggs, formerly assistant vice-president in charge of the Hoffman government contract office in Washington, D. C., has been appointed assistant to the president of Hoffman Laboratories, Inc., Los Angeles, Calif.

Raymond F. Crisp was recently appointed manager of technical services for Hycon Manufacturing Co., Pasadena, Calif. Prior to his recent assignment, Mr. Crisp held the position of chief electronics engineer for the company.

Color TV "Package"

An impressive equipment "package" containing all units required for the generation and test of the color and monochrome TV signals in existing systems has been developed by Telechrome, Inc., 88 Merrick Rd., Amityville, N. Y. for Gilfillan Bros., Inc., of Los Angeles. It is thought that organizations interested in instituting a comprehensive color TV development program would be interested in similarly designed units. The equipment transmits and receives via automatic push-button controls, all extant systems: NTSC, RCA, FCC Field Sequential and Line Sequential Color as well as RTMA and CBS Monochrome; there is also a complete TV picture and sound transmitter. The seven racks comprising the system are functionally arranged into a vast integrated assembly 15 ft. long.

High-Q Measurements

(*Continued from* page 64)

stant over the frequency range used. The accuracy of the frequency reading is then the accuracy with which the high-frequency generator can be read. For unloaded Q's of 20,000 the accuracy is very good.

There is a lower limit of Q which can be measured by this method. The restriction of taking data at least three bandwidths away from the center frequency, plus the restriction due to limited linearity of the modulator output usually prevents the measurement of bandwidths over 1 MC. Large bandwidths require much wider band modulators than are readily available.

The measurement of insertion loss is made with the UHF generator alone, modulated either internally or externally with audio. Care should be taken to measure insertion loss under the same setup conditions as when measuring bandwidth. Otherwise the results may be in error by excessive amounts in either direction.

Coupling Alignment

The input and output couplings are also aligned with the UHF alone. It will be found that extremely small loops or probes are needed for high Q cavities. It is hard to make a coupling which will not load the resonant circuit down considerably, and extra care should be taken to match whatever is used.

There are two other techniques worth mentioning. The block diagram of the first is shown in Fig. 7. Again the outputs of two generators are mixed. Instead of all the mixed frequencies being transmitted to the cavity, however, only the UHF is used. The other generator acts only as reference, and as such must be perfectly stable. This is a handicap where such stability is not available. The features of the method are those of the two-terminal method plus the added range due to the ability to read the frequency better. The increase in range is not very great, however, because the frequency is changed in the UHF signal generator with a coarse adjustment that becomes increasingly hard to control.

The second technique is a mechanical one and involves the calibration of the motion of a cavity plunger in terms of frequency. The bandwidth is measured by holding the signal-generator frequency fixed and tuning the cavity through resonance with the calibrated plunger. This method can be used together with any of

(*Continued on page* 142)

those previously described to increase the range of measurable Q.

There are derived below some relationships on the input SWR and the insertion loss of cavities. The application to the adjustment of a bandpass filter composed of coupled cavities is illustrated by an example.

Referring to Figs. 8 to 13, let

R_c = the shunt impedance of an unloaded cavity at resonance, being a pure resistance.

$R_L = AR_c$ = resistance shunting the cavity due to the loading of the generator and load.

$A = R_L/R_c$ a numeric of proportionality.

Q_o = unloaded Q of the cavity (proportional to R_c)

Q_1 = singly-loaded Q

Q_2 = doubly-loaded Q shape parameter.

$p = k^2 Q_1{}^2$ = circuit parameter

k = coefficient of coupling

f_o = resonance frequency

$\triangle f$ = deviation from resonance = half the bandwidth

1. The SWR into a cavity at resonance, with equal input and output loading is, with reference to Fig. 8:

$$SWR = \frac{R_{gen}}{R_{in}} = 2AR_c \left(\frac{1}{R_c} + \frac{1}{2AR_c}\right)$$

$$= 2A + 1 = \frac{(Q_o/Q_2) + 1}{(Q_o/Q_2) - 1} \quad (1)$$

The Q formula is derived by using the relationships

$$Q_o = B/G = BR_c$$

$$\frac{1}{Q_2} = \frac{G}{B} = \frac{1}{B}\left(\frac{1}{R_c} + \frac{2}{2AR_c}\right)$$

$$= \frac{1}{Q_o}\left(1 + \frac{1}{A}\right)$$

where $B = \omega C$ is the susceptance of the cavity. Thus, for example, a doubly loaded cavity with $Q_2 = Q_o/2$ has $A = 1$ and $SWR = 3$ to 1. The quantity Q_o/Q_2 is the reciprocal of the magnitude of the voltage reflection coefficient of the cavity and load impedances with respect to the generator impedance.

Actual measurements are made at a 50 ohm level which is usually the impedance of both the generator and the load. These impedances are transformed up to those shown on Fig. 9 by the transformation ratio of the coupling as indicated.

It is the transformation ratio which is adjusted to transform 50 ohms to a high enough resistance to give the desired SWR. The same SWR appears at the 50 ohm level where it is measured. Calculations are made, therefore, with Fig. 8 and the results will apply to measurements made at a 50 ohm level.

2. The insertion loss is obtained from the ratio of the power supplied to the load when it is ideally connected to the generator, to the power with the cavity inserted. With equal input and output loading, the power when the cavity is omitted is, for Fig. 8

$$P_0 = \frac{(E/2)^2}{2AR_0}$$

With the cavity inserted, the power into the load is

$$P = \frac{V_{in}^2}{2AR_0} = \frac{(E/2)^2}{2AR_0\,(A+1)^2}$$

The insertion loss is

$$L = 10 \log_{10} \frac{P_0}{P}$$
$$= 10 \log_{10} (A+1)^2$$
$$= 20 \log_{10} (A+1)$$
$$= 20 \log_{10} \frac{1}{1 - Q_2/Q_0}\ \text{db} \qquad (2)$$

Use of the corollary to Thévenin's Theorem is used to find V_{in}. The expression (2) in terms of Q follows in the same manner as shown for (1). As an example, when the loaded $Q_2 = Q_0/2$ then $A = 1$ and $P_0/P = 4$ for which the loss is 6 db.

It might be said that the insertion loss includes the actual losses in the cavity plus those due to a mismatched line. However, it is perhaps better to refer to match or mismatch as the relationship between generator and load impedances only.

3. For two overcoupled cavities of identical Q_0 that have equal loading, the insertion loss at the transmission peaks is

$$L = 20 \log_{10} \frac{1}{1 - Q_1/Q_0}\ \text{db} \qquad (3)$$

This is the same as (2) except that the singly-loaded Q is used instead of the doubly-loaded value. Since critical coupling is the limiting case, it follows that the insertion loss at the peaks for overcoupled cavities is the same as that of critically coupled cavities at the resonance frequency.

4. Take two cavities with identical Q_0 and equal loading, one with the generator and the other with the load. When these cavities are overcoupled, the input SWR at the peaks is practically independent of the coefficient of coupling. It is the same as that at the resonance frequency for critically coupled circuits.

$$SWR = \frac{(Q_0/Q_1) + 1}{(Q_0/Q_1) - 1} \qquad (4)$$

(*Continued on page* 144)

The quantity Q_o/Q_1 is the reciprocal of the magnitude of the reflection coefficient at the input.

The critically coupled case is shown in Fig. 10, where the cavity resistances at resonance are represented by Q_0 and Q_0' for the two cavities. As far as insertion loss and input standing-wave ratio are concerned, Fig. 11 for a single cavity is identical with Fig. 10 for two cavities, since the stipulated conditions require that $Q_0 = Q_0'$ and $R = R'$.

5. With two cavities having identical unloaded Q's and identical singly-loaded Q's, the input SWR at the resonance frequency is

$$\text{SWR} = \frac{R}{R_{in}} = \frac{R}{R_c}(1+p) + p = \frac{1+p}{(Q_o/Q_1) - 1} + p \qquad (5)$$

Fig. 12 shows the schematic of two identical cavities at resonance.

6. The SWR of a single resonant cavity, singly-loaded, shown in Fig. 13 is

$$\text{SWR} = (Q_o/Q_1) - 1 \qquad (6)$$

7. With two overcoupled cavities, the loss at the center frequency with respect to that at the peaks is given by

$$\text{Depth of dip} = 20 \log_{10} \frac{p+1}{2\sqrt{p}} \text{ db} \qquad (7)$$

where the parameter p is defined in the list of symbols above.

8. The band width at the edges of which the gain is equal to that at the center frequency is

$$\frac{2\Delta f}{f_o} = \frac{1}{Q_1}\sqrt{2(p-1)} \qquad (8)$$

Suppose it is required to design and adjust two cavities or a double-tuned circuit to have a center frequency $f_o = 1000$ MC, a bandpass curve 3 MC wide at the 1-db point, and a 1-db dip between peaks due to overcoupling. An insertion loss of 3 db is permitted at the peaks.

By (7) the 1-db depth of dip requires that $p = 2.66$. The shape of the selectivity curve can be judged from the curves on page 121 of the 1949 Federal Tel. and Radio Corp. *Reference Data for Radio Engineers.*

The singly-loaded Q is determined by (8) to be $Q_1 = 607$.

Since the insertion loss at the peaks is 3 db, the unloaded Q of each cavity can be found by (3), being $Q_o = 2100$.

The cavities can now be set up and adjusted by making standing-wave measurements. Each cavity must have an unloaded Q_o of 2100 and a singly-loaded Q_1 of 607 as found above. The unloaded Q_o is determined by the procedure described in the early part of this paper. Then the input coupling of one cavity, and the identical output coupling of the other, are adjusted with the cavities separated. By (6) the SWR of either one alone is 2.46. Now the two are secured together and the coupling between them is adjusted to show a maximum SWR between two minimums. This results from the dip at resonance between the two transmission peaks. The value of the maximum SWR is given by (5).

$$SWR = \frac{1 + 2.66}{(2100/607) - 1} + 2.66 = 4.15$$

It is found that the performance of selective circuits and cavities, when measured and adjusted by the above outlined methods gives the desired selectivity within practical limits. This system is fast and direct, requiring a minimum of computation.

The author wishes to acknowledge the assistance of R. T. Adams, M. Dishal, A. Biagi and W. W. Macalpine in coordinating the experimental work with the theory of cavities. Much of the section giving the equations of impedance and losses has been rewritten by Macalpine on the basis of this material.

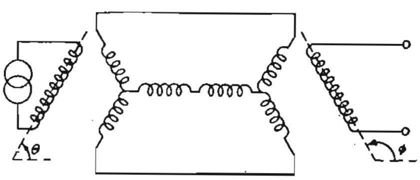
Microwave Relay

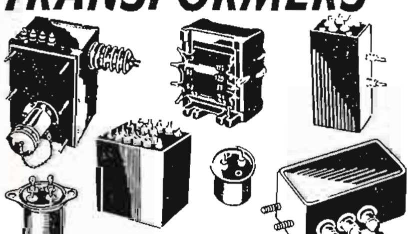
(*Continued from page* 57)

the necessity for a pressurized line or any desiccant. Since the interior of the shelter could accumulate much warm moist air under certain weather conditions, and this could rise through the waveguide plumbing and up into the horn where it would condense, a teflon barrier 0.002 in. thick is mounted across the waveguide just below the input flange of this horn, and is completely effective in preventing condensation. A de-icer made of calrod embedded in aluminum has been designed and tested for this horn, but experience indicates that de-icers are not necessary for this kind of antenna feed. When the antenna assembly is mounted with its axis horizontal as is always done when line-of-sight exists without a tower, then a type of umbrella is mounted over the antenna assembly and is of such dimensions that water from rain or even from a firehose cannot be made to enter the feed horn, regardless of the direction from which the water is sprayed.

To match the feed horn and the antenna perfectly without the use of tuning screws or other waveguide inserts, we take advantage of the ability of the parabolic reflector to form an excellent beam even when the feed horn is positioned slightly away from the exact geometric fo-

(*Continued on page* 146)





cus. The reflection coefficient of the paraboloid relative to the waveguide feed is on the order of 0.07; the phase of this reflection varies with frequency in accordance with the number of wavelengths in the round trip from feed horn to paraboloid and back into the feed horn. This means that a given set of dimensions will match perfectly at only one frequency. However, because the change in reflection coefficient with frequency is essentially one of phase rather than of magnitude, the horn itself is so designed that a few millimeters of de-focusing can maintain the impedance match of the assembly over a wide frequency band, say several hundred megacycles.

Feed Design

The feed designs have a different iris for each main frequency band, such as common carrier, operational, or government band, and in each of these bands the focal distance is set with a simple mechanical gauge to obtain a match of 1.05 or better, this being sufficient so that there is no need for buffer tubes between the microwave oscillator and the antenna. From this very small reflection coefficient, and from the short length of waveguide between the antenna and the transmitter klystron, the microwave distortion of the system is kept very low, not even an antenna phase shifter being necessary.

Waveguide Switch: If we consider about 50 tubes in a microwave repeater station and 40 stations in cascade to make a complete system, then the system can be interrupted by the failure of any one of 2,000 tubes. If each tube were to last 40,000 hours, then there would be a failure on the average of every 20 hours. That is, the system would fail every day on the average and sometimes would fail several times per day. To correct the situation there are only two alternatives, both of which have been used in this design. One is to derate greatly every tube so that it will survive as many hours as possible. The other is to provide an automatic switchover circuit and a full duplicate standby equipment with appropriate sensing devices so that any serious failure in the main unit will cause an immediate switchover to the standby unit. The standby unit is then kept fresh and free from failures because the main unit is repaired and restored to normal operation while the standby unit rests. The standby circuitry includes in full duplicate the r-f head, power supplies and controls, and a waveguide switch to connect either main or standby r-f unit to the single antenna.

In the waveguide switch assembly, a power monitor crystal and its associated directional coupler and polyiron load is the power sensor for the main transmitter; whenever its output falls below a pre-set level, the reduced output voltage causes a switchover. Another directional coupler assembly with test flange permits a measurement with external instruments of the transmitted microwave carrier or permits injecting a test signal into the microwave receiver. In both main and standby r-f units, the microwave transmitter and receiver are multiplexed from the same waveguide switch leg. A pushbutton on the switchover control panel restores the waveguide switch to its main position and other pushbuttons permit testing by temporarily moving the switch to either position. The assembly is matched to about VSWR = 1.02, and never worse than 1.06.

Transmitter and receiver plumbing: Fig 9 is a cutaway view of all plumbing for the transmitter and receiver. In operation, the signal leaving the transmitter moves upward through the "WYE" duplexer because any portion moving toward the receiver would see a stub phased to present a high impedance across the parallel junction of the duplexer. Since the receivers contain cascaded iris cavities, they are readily phased for the transmitter frequency by means of a thin spacer which may be inserted when necessary between the duplexer and receiver flanges. Similarly, signals from a remote station are sent down the antenna waveguide, through the waveguide switch, and through the duplexer into the receiver leg because the entire transmitter leg acts as a stub for receiver frequencies. The phasing of this stub is accomplished by tuning the phase shifter to obtain maximum signal current as indicated by maximum i-f limiter current.

The transmitter klystron, type 5976, has a nominal output power of 0.1 watt. It is probe-coupled into the waveguide through an impedance transformer to obtain a good match and is trimmed for different frequencies by operation of a waveguide plunger. The frequency monitor directional coupler is coupled at −22 db, which is adequate to prevent pulling of the transmitter by the resonant cavity. A loaded Q of 2,000 is sufficient to give a sharp indication for putting the transmitter klystron on the specified frequency.

With the klystron on frequency, the monitor signal passes through a cavity into a crystal detector where it is rectified and passed to the control panel for meter indication. The duplexer, built integrally with the transmitter, obtains a bilateral impedance match when stubbed either by transmitter or receiver. This is accomplished by forming the two curved legs so that their center lines intersect, not as a tangent, but as a crossover, and by trimming with a tuning screw (located at approximately that intersection) for any frequencies at which a perfect match is not otherwise obtainable.

Quadruple Cavity

Signals entering the receiver pass through a quadruple cavity of half-wave elements spaced a quarter-wave apart and tuned with a quarter inch screw in the broad dimension. With an insertion loss of less than two db for the assembly, the bandwidth is 20 MC for the highest frequency of each frequency band and is reduced by the cube of the frequency for lower frequencies which are obtained by inserting the tuning screws further. The wiggles which are characteristic of the top of the bandpass response of a true Tchebeysheff circuit are smoothed out and minimized by opening the first and last iris a little more than the in-between irises. This avoids the sharp shoulders which are otherwise found at the top of the bandpass response curve of this kind of multiple cavity.

From the quadruple cavity, the signal enters the mixer crystal which is tuned in susceptance by a plunger. For this operation, it is adequate to observe either the i-f strip limiter current or the local oscillator injection current because the assembly is adequately broad-banded to satisfy both signals. The crystal is matched in conductance by its lateral position which is a few millimeters off the center line of the waveguide. This distance varies from one frequency band to another, but is sufficiently broad-banded within any one frequency band so that a match may be obtained with nearly any IN23A crystal in the receptacle. Although a number of tuning screws, or other waveguide loading devices could be utilized, the simple expedients of a fixed conductance match and an adjustable susceptance match have proved to be very satisfactory and easy to use in the field.

The klystron local oscillator output is controlled in amplitude by an attenuator (13) to obtain 0.4 ma dc from the mixer. The small amount of r-f signal necessary for this current is obtained through a directional coupler which is decoupled by 17 db.

To stabilize the local oscillator further and obtain the desired r-f level for local oscillator monitoring, a pad precedes the monitor cavity and detector, which are identical in design to those of the transmitter monitor except that the loaded Q is only 500 to obtain some indication on the local oscillator monitor meter even when the local oscillator is shifted slightly in frequency by AFC action. The various distances between the mixer, the nearest cavity iris, and the local oscillator injection coupler, are so proportioned that resonance does not occur; such resonances would couple excessively to the local oscillator and prevent local oscillator injection at some of the frequencies in the intended frequency band.

Same Anode Supply

Transmitter and local oscillator klystrons are powered from the same anode supply but are connected differently in their common repeller supply in order to obtain a maximum of AFC control on the local oscillator repeller.

Various different models of this plumbing assembly have been built for owners with special applications. The "microplex," or economy model, contains, instead of the receiver assembly previously described, only a single cavity and tunable mixer. There is no local oscillator nor highly selective cavities, the intent being to let a little transmitter signal through the low Q cavity into the mixer where it acts as local oscillator injection. In this case the mixer output is modulated by both the local transmitter modulation and the incoming signal modulation, but since all of the modulation is frequency shared subcarriers, the undesired modulation is merely not accepted by the filters in the subcarrier receivers. However, since the combined peak modulation of transmitter and incoming signal must pass together through the i-f amplifier, the combined bandwidth of the two is limited to the bandwidth of the i-f strip and therefore each signal, the outgoing and incoming, may contain only 50% of the deviation which is ordinarily obtained in the more standard circuit.

In either model, the standard or the microplex, microwave deviation is a compromise between signal/cross-

(*Continued on page 150*)

talk ratio and signal/noise ratio. For maximum signal/noise, the deviation should be large in order to maximize the FM improvement factor, but excessive deviation could operate the klystron in a slightly nonlinear region of the repeller modulation curve and thereby could introduce cross talk between the subcarrier channels. In practice, these equipments are usually deviated ±3 MC and sometimes ±6 MC. The r-f multiplex principle has also been used for combining two transmitters or two receivers in one r-f unit instead of one of each, for operators who transmit a large intelligence bandwidth in one direction only. Other units have been delivered with as many as three receivers and three transmitters in the same r-f unit, driving the same antenna, for the operator who requires two-way communication with three times the normal amount of bandwidth. The ±3 MC bandwidth in the standard equipment is adequate for 24-channel voice communications.

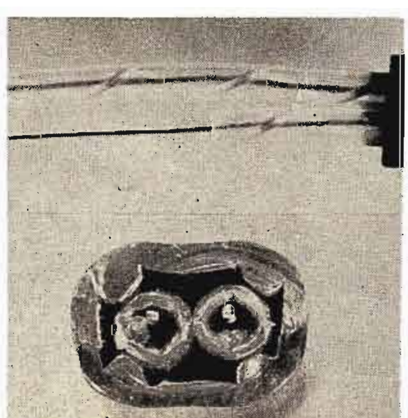
Fig. 10 shows the technique of r-f allocation, which allows for receiver selectivity, antenna configurations, transmitter power, and other system parameters.

Part II of this article, to be published in the Jan. 1953 issue of TELE-TECH, will describe the construction and circuitry of video, sweep, AFC, switchover, squelch, power and lighting equipment.

New UHF Television Transmission Line

A new 300-ohm UHF TV transmission line, featuring extremely low loss characteristics in the presence of dirt and moisture, has been developed by RCA Service Co., RCA Victor Div., and the Anaconda Wire and Cable Co. Anaconda is now manufacturing and selling
(*Continued on page* 153)

Cross-sectional and cutaway views of new UHF transmission line for home TV shows parallel conductors centered by spiral polyethylene threads and covered by polyethylene sheaths. Dielectric construction provides low losses



Microwave Alarm

(*Continued from page 48*)

inside the gatehouse with the beam passing through the top half of one of the windows and projecting out along the path of an approaching car. Thus, with all the units of the device indoors, it is relatively simple to install and maintain regardless of the weather. See Fig. 4.

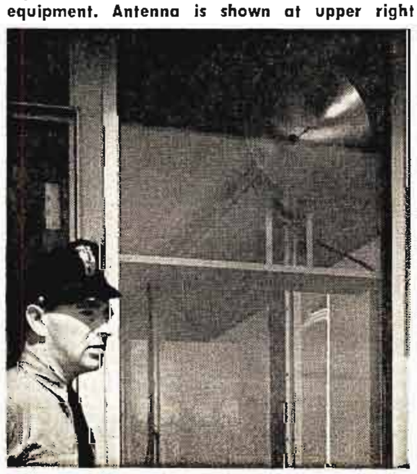
The distance at which a moving object is detected is proportional to its reflectivity and size. The flat end of a metal-body trailer truck is far more reflecting than the curved, irregular surface of a wooden-body station wagon. However, the latter can be picked up at about 250 ft. Theoretically, it should be possible to drive so slowly that a car cannot be detected. Actually this was found to be almost impossible.

Tests indicate that approaching cars could probably be picked up at distances up to 600 ft. if space were available for a three- to four-foot diameter parabolic reflector. Bicycles and pedestrians moving in the beam are also detected, but at a lesser distance than cars.

Experience has indicated that a two-chime bell is the most suitable form of alarm. This gives a single musical note when the car enters the zone of protection and another note of different tone when the car clears the beam. This is less irritating than a bell ringing continuously as long as the moving car is in the beam.

Doppler effect is only one of the several special applications of microwave characteristics that should be useful for the solution of a number of problems in connection with industrial control devices. Among the other properties of microwaves that should also find application are standing waves, polarization, refraction and diffraction. These properties of course are also common to light, but are usually much more practical to utilize with microwaves.

Fig. 4: Gatehouse contains microwave alarm equipment. Antenna is shown at upper right



Santa Fe Operating Philco Microwave

The installation of a Philco multichannel microwave communications relay system between Galveston and Beaumont, Texas, has recently been completed by the Gulf, Colorado and and Santa Fe Railway Co. It connects the southern terminus of the Santa Fe's 1353-mi. Chicago-Galveston trunk line with the important lumber and cattle freight terminal at Beaumont, 68.5 mi. away, and replaces 315 mi. of open wire lines with a direct microwave system. Operating in the 6575-6875 MC band, the system consists of terminal stations at Galveston and Beaumont with repeater stations at Patton, White's Ranch and Morey. The first hop (Galveston-Patton) is over water, the second is over swampland, and third and fourth hops are over farm areas.

Eight Voice Channels

The system provides eight duplex voice channels with pulse amplitude modulated multiplex equipment, the first such railroad installation, and is capable of being expanded for use of a greater number of channels. Both terminals and all three repeater stations are equipped with r-f standby equipment. One channel is used as a party line connecting all stations and also includes a fault alarm system which indicates whether regular or standby power or equipment is in use.

BULLETINS

RTMA on Tubes

"Must Tubes Be Selected?" is the title of a new brochure published by the Radio-Television Manufacturers Assoc., 777 Fourteenth St. NW, Washington 5, D. C. The problem of efficient tube utilization is discussed as well as the need for closer liaison between tube manfacturers and equipment designers

Microwave Components

Titeflex, Inc., 500 Frelinghuysen Avenue. Newark, N. J. has released a new twelve page catalog describing its line of microwave components. Detailed specifications for both rigid and flexible waveguides plus schematic diagrams and application charts are included. Titeflex rigid waveguides conform to the MIL-T-85B specification and are specifically recommended for installations where there is no movement of the transmission line.

Components

Over 450 new items are covered in Centralab's industrial and distributor stock catalog number 28. The fully illustrated and indexed catalog is available free of charge from any Centralab distributor, or by writing Centralab at 900 East Keefe Avenue, Milwaukee 1, Wisconsin.

Direct-Writing Recorders

"Seven Advantages of Sanborn Direct-Writing Recorders for Industrial Users," may be obtained without obligation by writing to Sanborn Co., 38 Osborne St., Cambridge, Mass.

Amplifiers

Amplifiers and Communication Equipment are highlights of a new 16-page catalog being distributed by Cinema Engineering Co., 1510 W. Verdugo Ave. Burbank, Calif.

It illustrates and describes the Cinema audio frequency amplifiers laboratory type, for scientific laboratories, broadcast and TV program equipment, tape and disc recording apparatus, hi-fi sound systems, and magnetic film recording equipment.

Transmission Line

(*Continued from page* 150)

the new rooftop-to-receiver lead-in. The line can be handled easily and manufactured at less than half the cost of coaxial cables of comparable performance.

In the line, two parallel conductors, Copperweld 22-gauge wires, are wrapped in spiral polyethylene threads, each wire and thread enclosed in a polyethylene tube, and all covered by a polyethylene sheath. Spacing between conductors, and between outside of sheath and conductors, is the same. It uses less than 1.5 lbs. of copper per 1,000 ft., while comparable coaxial cable uses more than 40 lbs. of copper in the same length. Electrical characteristics of the new line are improved and more stable when wet or in close proximity to surrounding objects than those of similar twin transmission lines.

Reduces Oscillation

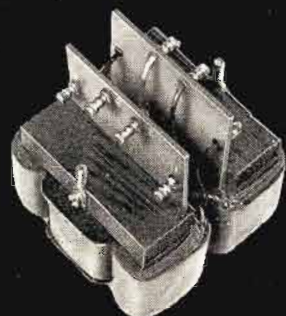
Another feature is that it has greater stiffness than other types of twin lead two-conductors transmission line. This reduces oscillation and bending due to wind stresses, which leads to breakage of the conductors.

In the new line, the two 22-gauge Copperweld conductors are spaced 11/64 in. apart. The width across the entire transmission line in cross-section is ½ in., and the thickness of the transmission line 11/32 in.

ANNUAL INDEX-1952

The Annual Index has been arranged by subjects for easy reference to related topics. The first figure indicates the month in which the article appeared; the second figure indicates the page.

MAGNETIC AMPLIFIERS

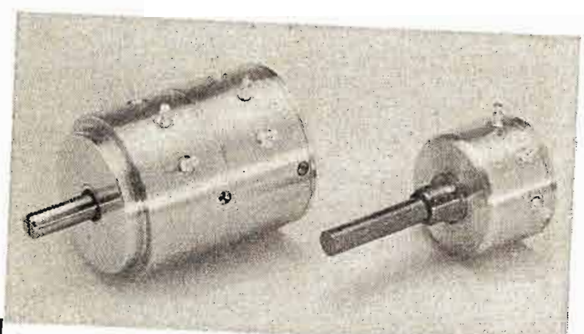


Typical Keystone Magnetic Amplifier, open unit. Also supplied hermetically sealed.

Keystone is noted for its specialization in magnetic amplifiers. No standard "line" . . . rather we build magnetic amplifiers of all sizes, your design or ours. We'll ship them right on schedule, open or hermetically sealed. If magnetic amplifiers for Servo systems are your problem, we'll give your inquiry prompt, intelligent attention. No obligation to consult our engineering department.

KEYSTONE PRODUCTS COMPANY

UNION CITY 6, N. J. **UNION 6-5400**



Type DS-6, Ganged, 1⅝" dia. Type RAS-2, New Design, 1¼" dia.

CORNELL'S

new designs in PRECISION POTENTIOMETERS

CORNELL Precision Potentiometers are designed for application wherever extreme precision is an essential requirement.

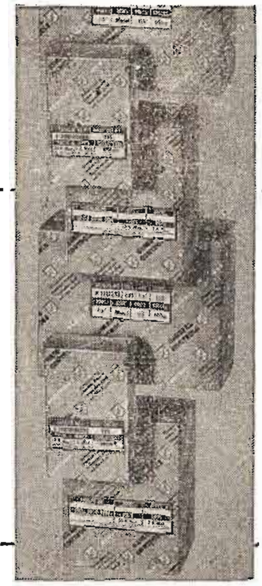
Custom design, both mechanical and electrical, is a featured CORNELL service. Precision linear and NON-linear pots may be designed to meet customer's requirements. Taps and special winding angles anywhere up to 360 continuous winding can be incorporated into both linear and non-linear precision potentiometers.

Expanded facilities will meet customer volume.

Cornell Electronics Corporation

40-33 Main Avenue • Douglaston, N. Y.

Eliminate topheavy package inventories with **Kum-Kleen** **laid-on** *labels!*



a common problem... General Controls Co. of Glendale, California manufactures automatic controls for widely diversified applications. Warehousing formerly required segregation of more than 100 different boxes. Product changes, from time to time, would make certain pre-printed box inventories obsolete.

solved with Kum-Kleen labels... Now box inventories are maintained by size alone—IN HALF THE ORIGINAL SPACE! A self-adhesive Kum-Kleen label identifies the contents of each box *as it is used.* According to General Controls, "The unique characteristics of Kum-Kleen labels made this new packaging program possible, and they are saving us many thousands of dollars yearly." Their many Avery electric label dispensers "are proving themselves daily to be a most worthwhile investment as a time and labor saver."

how Kum-Kleen labels work... They're *pressure sensitive*—LAID ON *fast* with a finger-touch—no moistening, no mess! They stay neat and attractive—won't dry out, pop, curl or peel. Patented Avery dispensers—manual or electric—feed die-cut, Kum-Kleen labels off roller tape for quick, clean labeling.

Where can YOU use these labels in YOUR business?

For case histories, samples and prices, please mail the coupon below.

Kum-Kleen *pressure-sensitive* **laid-on** *labels*

AVERY *producers of pressure-sensitive products since 1935*

AVERY ADHESIVE LABEL CORPORATION

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608 S. Dearborn St., Chicago 5
1616 So. California Ave., Monrovia
Offices in Other Principal Cities

☐ *Please send case histories, free samples.*

☐ *Have Avery label man call.*

Our business is ______

name ______

title ______

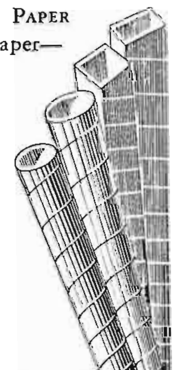
company ______

address ______

BETTER INSULATION... with Laboratory Controlled

PRECISION PAPER TUBES

Exacting manufacturing standards account for the superior insulation, heat dissipation, and low moisture absorption properties of PRECISION Paper Tubes. Spirally wound of the finest dielectric paper—Kraft, Fish, Acetate or combinations—they are die-formed under pressure for maximum strength and minimum weight. Available for every coil requirement in round, square, rectangular and other shapes. Continuous lengths of practically any wall thickness, I.D. or O.D.



Write today for free sample and new Arbor list of over 1,500 sizes.

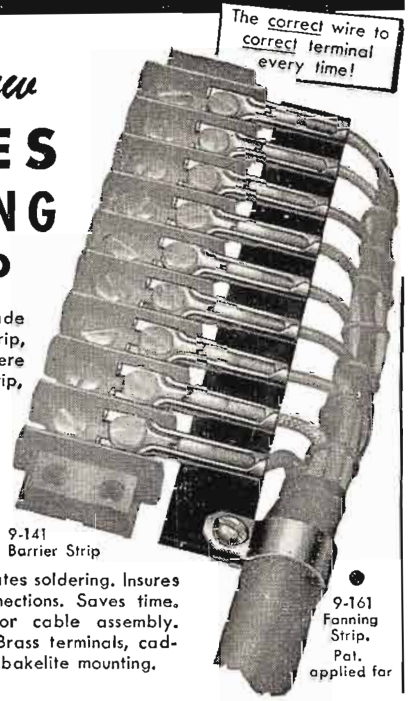
PRECISION PAPER TUBE CO.

2057 W. Charleston St., Chicago 47, Ill.
Plant No. 2, 79 Chapel St., Hartford, Conn.
Also Mfgrs. of Precision Bobbins

Here's BIG HELP IN TERMINAL WIRING!

The correct wire to correct terminal every time!

The New JONES FANNING STRIP



Connections are made through Fanning Strip, on bench or anywhere apart from barrier strip, and quickly slipped into assembly.

Designed for use with Jones Barrier Terminal Strips Nos. 141 and 142, for 1 to 20 terminals.

9-141 Barrier Strip

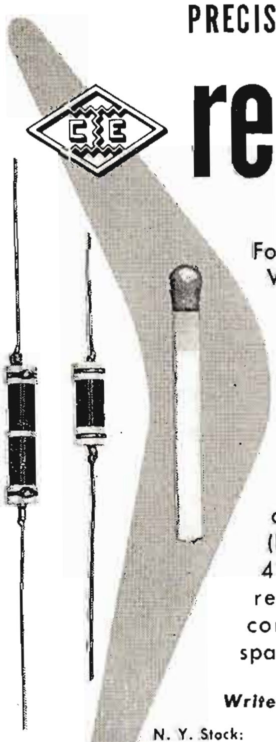
Simplifies and facilitates soldering. Insures positive correct connections. Saves time. Ideal for harness or cable assembly. Strong construction: Brass terminals, cadmium plated. Heavy bakelite mounting.

9-161 Fanning Strip. Pat. applied for

Howard B. Jones Division
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

PRECISION-FIXED WIREWOUND

resistors



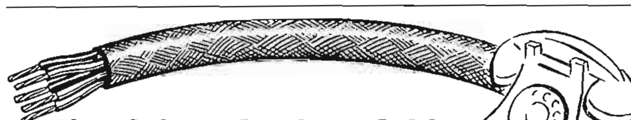
Forty-two types in all, from ¼ Watt to 10 Watts. Three wire alloys. Accuracies to .025%. Resistance range from .1 Ohm to 15 megohms. All receive aging treatment for assured stability. A variety of impregnation treatments and installation mountings to meet your requirements. Shown actual size (left) are the new 412 HE and 413 HE types designed for direct replacement of carbon composition resistors where space is at a premium.

Write for Complete Catalog

N. Y. Stock:
Audio & Video Products Corp. • 730 Fifth Ave. PLaza 7-3091

CINEMA ENGINEERING COMPANY
1510 WEST VERDUGO AVENUE, BURBANK, CALIFORNIA

Export Agents: Frazar & Hansen, Ltd. • 301 Clay St • San Francisco, Calif., U.S.A.



The Select Quality Cable

PHALO COM

TRADEMARK

SHIELDED COMMUNICATION CABLES

If you followed any of these PHALO cables from the first to the last phase of its manufacture, you'd see why we say that this is the "select quality circle" of communication cables.

PHALO *builds* quality into every inch of cable . . . the finest quality control system imaginable plus extra rigid inspection spells the difference.

Get the very best- - PHALO COM !

All inquiries promptly answered!

PHALO PLASTICS CORPORATION
21-25 FOSTER STREET, WORCESTER, MASSACHUSETTS
Manufacturers of Thermoplastic Insulated Wire, Cables, Cord Sets and Tubing

PHALO
TRADEMARK

INSTRUMENTS, MEASUREMENTS, TEST METHODS

FOR MANUFACTURERS—NEW METHODS, MATERIALS, AND MACHINES

MANUFACTURING: RADIO—TV—ELECTRONIC

MATERIALS, PROPERTIES OF

MICROWAVES

RADAR

RECEIVERS

RECORDING & TRANSCRIBING

SERVOMECHANISMS, SERVO SYSTEMS

STATISTICS

TELEMETERING

TELEVISION—GENERAL

COUNTERS!

PULSE CIRCUITRY!

The Walkirt Co. manufactures a line of units for measuring time intervals, or highly repetitive activities up to 3 megacycles per second. Other units, also available from stock, will readily accomplish such functions as time sequential switching, pulse delaying, gating, amplifying, and pulse shaping.

Write for Catalog • Write our Engineering Service Department for specialized applications.

Type: M 1253

LOW SPEED BINARY COUNTER

The Walkirt M 1253 Binary Counter provides a scale of two in a rugged, miniaturized, plug-in package. Economical to buy—Economical to use.

Frequency Range: to 25 KC (higher speed units available) • Power Input: 4 MA. at 250 volts • Output: 80 volts, peak to peak • Ambient Temperature: —40° C to +70° C.

Weight: Only 3.2 ounces. Immediately available in quantity.

Manufacturers of scalers and counters, pulse formers, multivibrators, amplifiers, gates, oscillators and other types of plug-in circuitry.

Representatives territory open

THE WALKIRT CO.

145 WEST HAZEL ST., INGLEWOOD 3, CALIF.

* **HEAT DISSIPATING CONNECTORS**

Vacuum Tube Accessories By Eimac — *Now Available!*

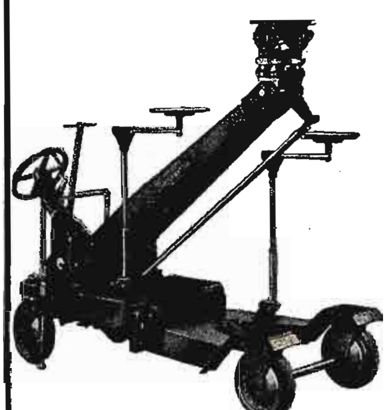
Type HR heat dissipating connectors are designed to provide an efficient method of heat transfer from tube elements and seals to the air. Also facilitate electrical connection to plate or grid leads of most popular transmitting tube types. Machined from solid dural rod, come complete with necessary machine screws for use.

- *Write for new Eimac Catalogue Summary showing Eimac tubes and other accessories.*

* Eimac

Eitel-McCullough, Inc.
San Bruno, California

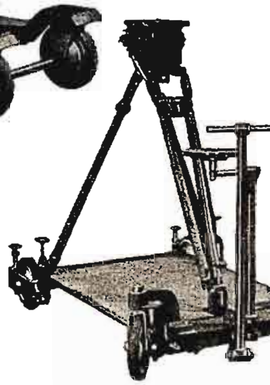
CAMART PRODUCTS



• CAMART CAMERA DOLLY

For motion picture or television cameras. Two seats for operator and assistant. Geared lift for smooth operation of boom arm from 26" to seven feet. 30" width will go through standard door. Weight 350 pounds. Easily transported.

WRITE FOR DETAILS



• CAMART BABY DOLLY

New advanced type glide steering control. Platform for assistant and accessories. Adjustable swivel seat for cameraman. For tripod, baby tripod, or hi-hat. Rigid clamps for tripod legs. Size 35 x 46 inches, it comes apart!

TV EFFECTS PRISMS AVAILABLE.

THE CAMERA • MART INC.

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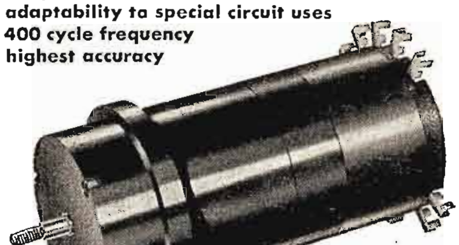
CABLE ADDRESS — CAMERAMART

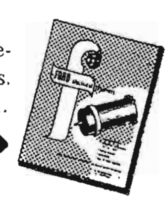
ELECTRICAL RESOLVERS

- interchangeability
- temperature compensation —60°F to +160°F
- adaptability to special circuit uses
- 400 cycle frequency
- highest accuracy



Now you can get the same Ford Electrical Resolvers, precision-built to the highest degree of operating efficiency for our own quality computers and automatic control equipment . . . to meet *your* extra special requirements.

FREE — fully illustrated brochure gives more details, describes Ford Instrument resolver systems. ***SEND FOR YOUR COPY TODAY!*** Write Dept. TT-1.



FORD INSTRUMENT COMPANY

DIVISION OF THE SPERRY CORPORATION

31-10 Thomson Ave., Long Island City 1, N. Y.

TELEVISION—VHF

TELEVISION—UHF

TRANSISTORS

TUBES

AUTHORS' INDEX - 1952

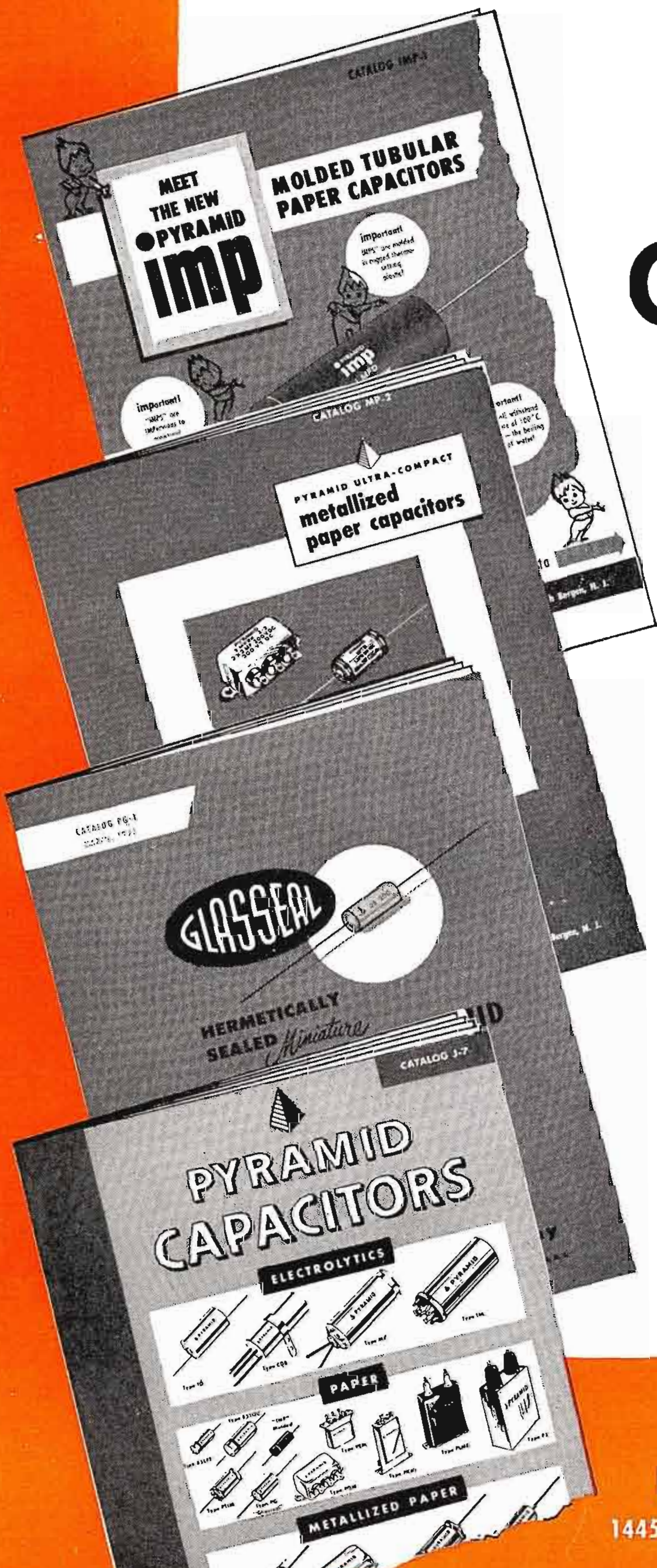
TELE-TECH

Advertisers — December, 1952

While every precaution is taken to insure accuracy, we cannot guarantee against the possibility of an occasional change or omission in the preparation of this index.

Yours for the asking...

this new set of PYRAMID CAPACITOR *catalogs!*



CATALOG IMP-1 describes Pyramid's new line of molded plastic tubular capacitors. "IMPS" are rugged — impervious to moisture and withstand a temperature of 100° C.

CATALOG MP-2 gives detailed information on ultra-compact metallized paper capacitors. Minimum size and weight, and self-healing qualities are characteristics of these units.

CATALOG PG-1 lists miniature Glasseal capacitors. These tubular units perform at temperatures ranging from −55° C. to +125° C.

CATALOG J-7 is a 32-page compilation of paper, electrolytic, oil-paper and metallized paper capacitors. Complete data on eighteen different types, including construction variations, sizes and prices are listed.

Free copies of these colorful, attractive publications are available on letterhead request to Dept. T3

PYRAMID
ELECTRIC COMPANY
1445 Hudson Boulevard, North Bergen, New Jersey

RCA metal-shell kinescopes

give you 8 plus features at no extra cost

RCA-developed metal-shell kinescopes offer design engineers, manufacturers, and users of TV receivers, many important advantages over all-glass types . . .

1 Reflection-free Faceplates: Frosted surface of faceplate prevents reflections of light sources and bright room objects at any angle to the tube.

2 Superior Faceplate Quality: Metal-shell construction permits the use of high-quality sheet glass *made to RCA specifications.* Its use results in greater freedom from imperfections, such as blisters, chill marks, shear marks, mold marks, and ripples. Faceplates of uniform thickness transmit the picture with uniform brightness levels over the entire viewing area.

3 Less Weight: RCA 21" metal-shell kinescopes weigh only about 18 pounds, a value approximately 12 pounds less than comparable-size glass types. Hence, they are cheaper to ship, easier to handle during assembly and testing operations, and can be mounted with lighter supporting structures.

4 Optically Superior: Relatively thin and flat spherical faceplate of uniform thickness permits wide-angle viewing with minimum picture distortion.

5 High Safety Factor: Inherent mechanical strength of metal-shell construction provides greater factor of safety in handling operations.

6 Utilize Time-Tested Components: 21" metal-shell kinescopes permit the use of proven deflection circuits and available components to produce pictures having good corner focus and negligible pin cushion. No need to experiment with special components; volume production can be achieved with minimum delay.

7 Volume Types: Because of RCA's vast production experience, 21" metal-shell kinescopes offer a greater degree of dependability and uniformity.

8 Availability: Manufacturing facilities in two RCA plants insure continuous high-volume supply.

For technical data or design assistance on RCA kinescopes or other types of tubes, write RCA, Commercial Engineering, Section LR 57, or contact your nearest RCA field office:—

FIELD OFFICES: (East) Humboldt 5-3900, 415 S. 5th St., Harrison, N. J. (Midwest) Whitehall 4-2900, 589 E. Illinois St., Chicago, Ill. (West) Madison 9-3671, 420 S. San Pedro St., Los Angeles, Calif.

RADIO CORPORATION of AMERICA

ELECTRON TUBES **HARRISON, N. J.**