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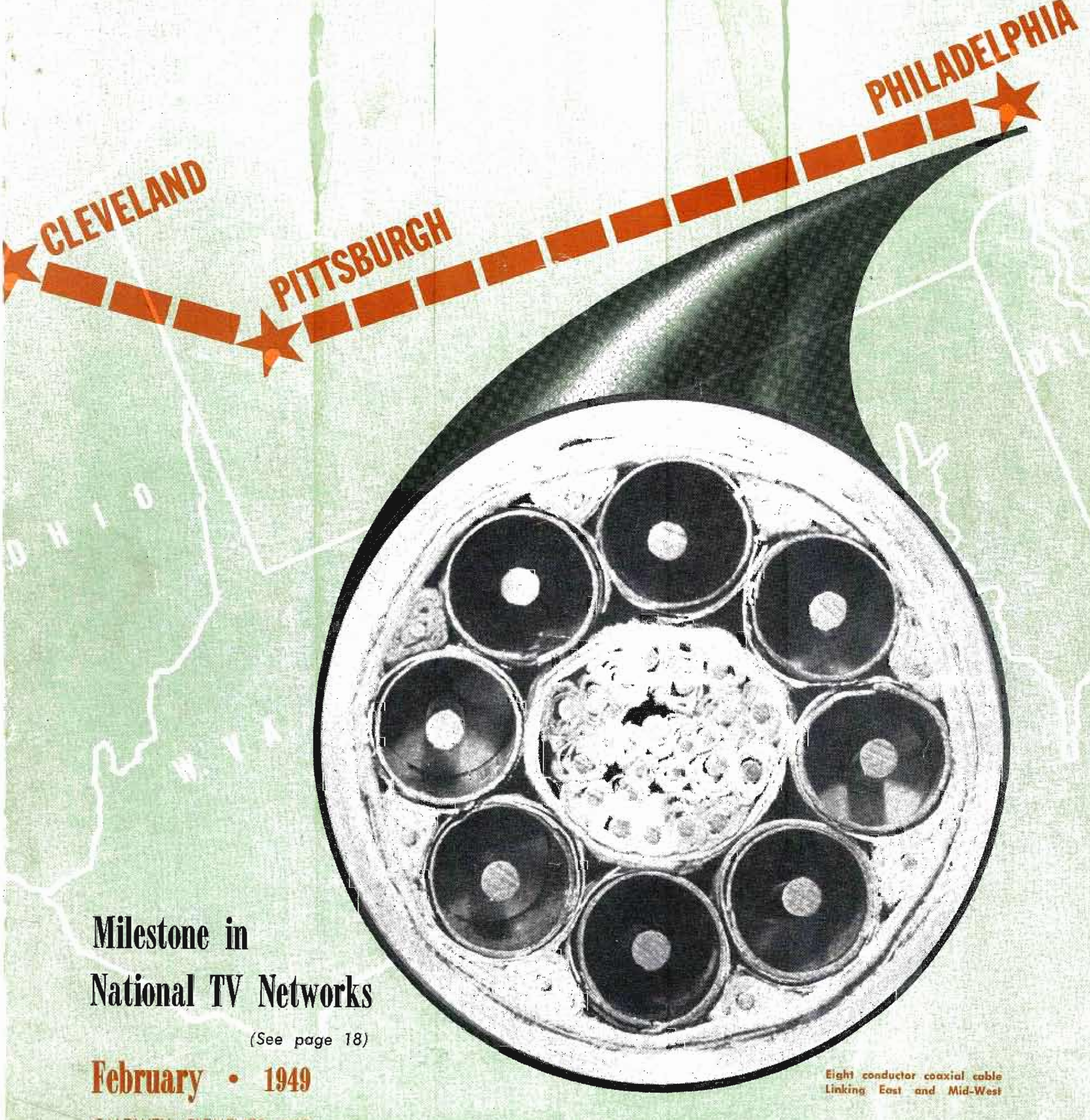

Milestone in National TV Networks

(See page 18)

Eight conductor coaxial cable Linking East and Mid-West

February • 1949

CALDWELL-CLEMENTS, INC.

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TELE-TECH

TELEVISION • TELECOMMUNICATIONS • RADIO

FEBRUARY, 1949

COVER: Cut-away view of coaxial cable used in Cleveland to-Philadelphia TV link, officially opened January 12. Cable contains eight coaxial lines, each capable of transmitting 600 simultaneous phone conversations or one TV program. See page 18.

Editorial Contents

CALDWELL-CLEMENTS, INC., Publication Office, Orange, Conn., Editorial and Executive Offices 480 Lexington Avenue, New York 17, N. Y., Tel Plaza 3-1340

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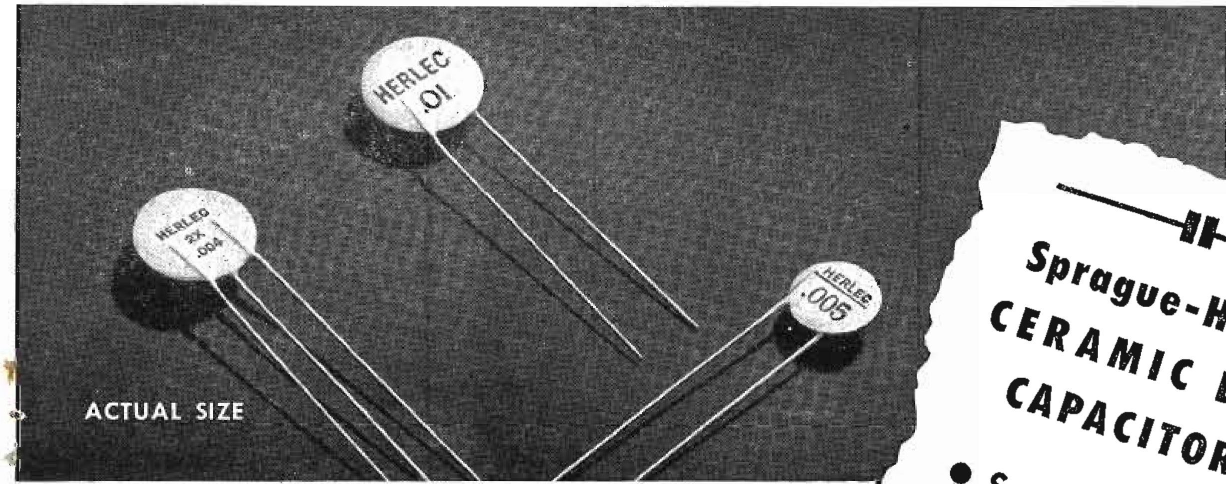
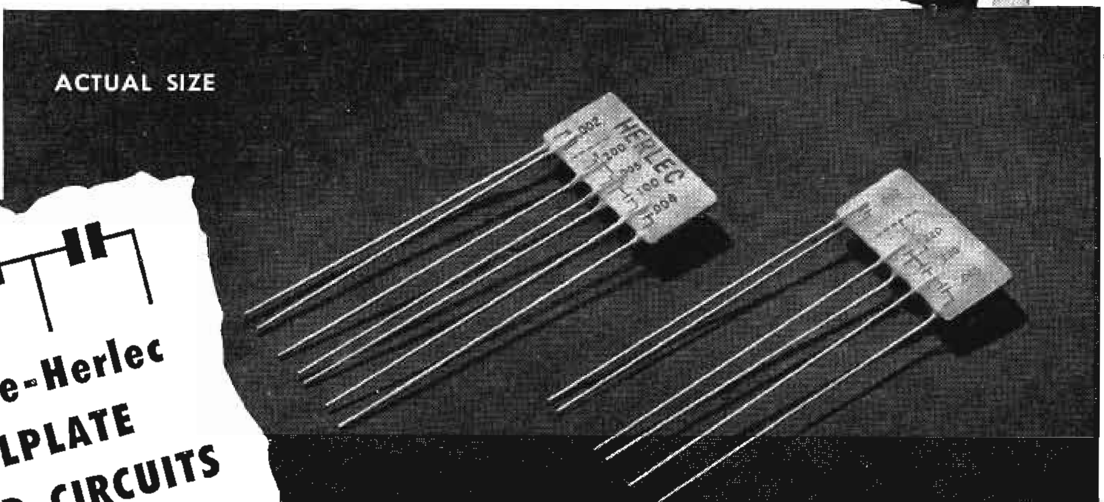


Sprague-Herlec CERAMIC DISC CAPACITORS

- Small in size
- Light in weight

These little by-pass and coupling type ceramic disc capacitors—shown here in actual size—offer distinct size advantages that warrant careful investigation. Now available in a broad range of values in single- and dual-capacity units that assure small size and a minimum of weight.

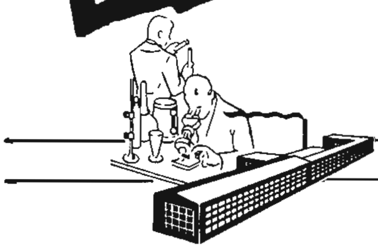


Sprague-Herlec *BULPLATE PRINTED CIRCUITS

- Space savers
- Simplify assembly
- Speed production

*Trademark Applied for

Here, in a unit only 1″ long x ½″ wide and 3/32″ thick, it is possible to obtain a 4-section capacitor incorporating such typical values as 2000, 5000, 220 and 220 mmfd.—and with only six leads to be soldered. Write for details of standard capacity combinations.



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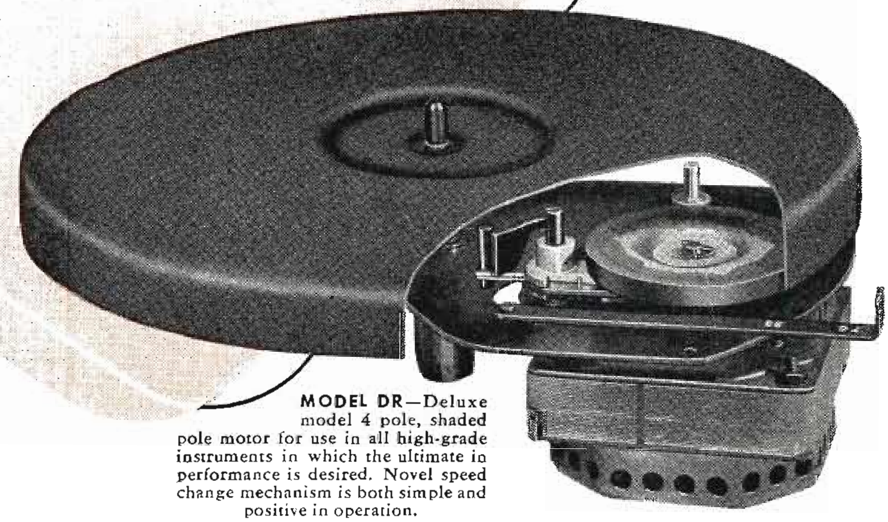
MODEL DM—Compact low cost 2 pole, shaded pole motor designed for portables, table models and other instruments in which space is an important factor. Simple speed change mechanism incorporates a special long-lasting molded neoprene belt.

Only GI offers you *TWO* rim drive

DUAL SPEED PHONOMOTORS



MODEL DR—Deluxe model 4 pole, shaded pole motor for use in all high-grade instruments in which the ultimate in performance is desired. Novel speed change mechanism is both simple and positive in operation.

Here they are . . . not one, but TWO dual speed phonomotors by General Industries . . . for both 33⅓ and 78 R.P.M. operation...for every type of instrument, from inexpensive table model to deluxe console combination.

Representing years of research and development, these two motors excellently meet today's needs for dependable rim drive phonomotors that will accommodate both the new long-playing and conventional type records. Both motors have been proved in extensive laboratory tests—and already are being widely used in many leading phonograph instruments.

Like all GI Smooth Power products, both new dual speed phonomotors are built to the highest quality and performance standards attainable. Their cost, however, is surprisingly low.

For additional information, specifications and quotations, write *today* to:

The GENERAL INDUSTRIES Co.

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RAYTHEON AM–FM & TV TRANSMITTERS

are equipped with

Adlake Relays

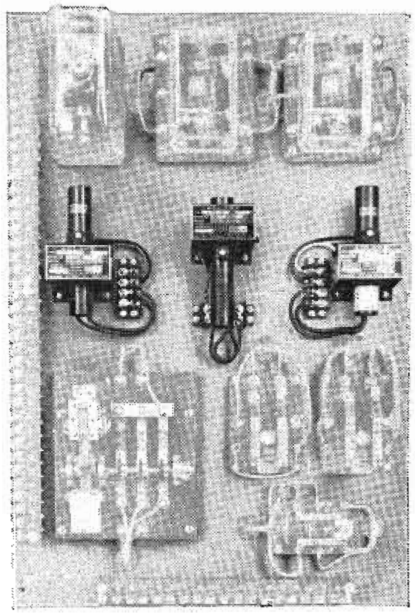
RAYTHEON Manufacturing Company's AM, FM and TV transmitters, including the famous "RF-3" 3-KW FM, "RA-5" 5-KW AM and the new "RTV-500" 500 watt TV and "RTV-5" 5000 watt TV equipment, employ Adlake Relays for CONTROL.

Silent and chatterless, Adlake Mercury Plunger Type Relays are an integral part of these streamlined transmitters which produce high fidelity modulation with a low noise level.

Besides silent operation, Adlake Relays bring these advantages to *any* job where relays are used:

- **Hermetically sealed contact mechanism is impervious to dust, dirt and moisture.**
- **Liquid mercury-to-mercury contact prevents burning, pitting and sticking.**
- **Adlake design armors relays against outside vibration or impact; they are usable on either stationary or fixed equipment.**

Whatever your relay needs are, there's an Adlake Relay to do the job. You'll like our free, illustrated folder giving full details. Write for it today to: The Adams & Westlake Company, 1117 N. Michigan, ELKHART, Indiana.



(Above) Relay panel in Raytheon's RF-3A 3-KW FM AMPLIFIER (shown below)

THE

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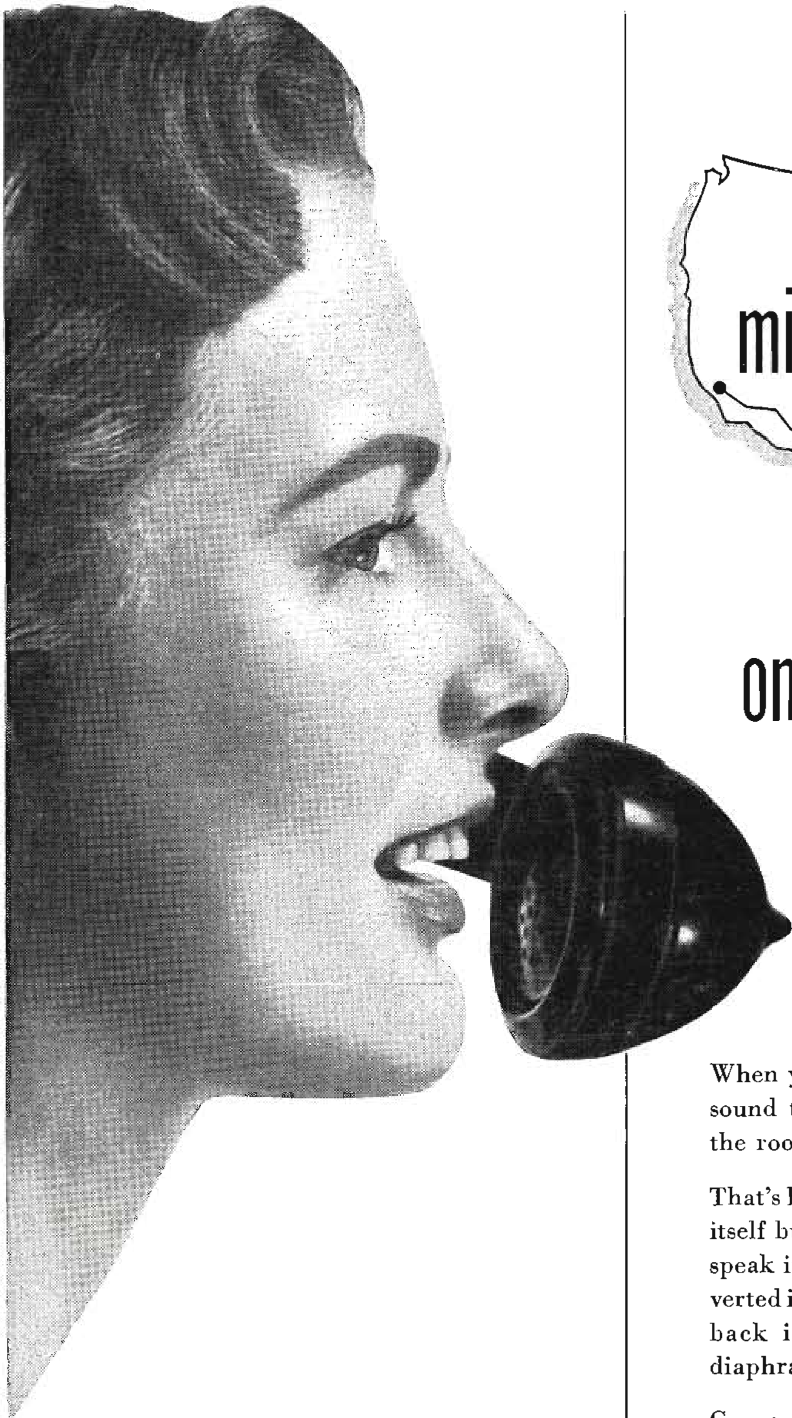

miles of speech—

only inches of sound!

When you talk by telephone, far or near, the actual sound travels much less than when you talk across the room!

That's because the telephone system carries not sound itself but an electrical facsimile of sound. When you speak into a telephone transmitter your voice is converted into electrical vibrations which are not changed back into sound until they reach the receiver diaphragm.

Conversion of sound into its electrical equivalent, through the invention of the telephone, opened the way to the measurement of sound by accurate electrical methods. In developing means to make the telephone talk farther and sound clearer, the scientists of Bell Telephone Laboratories had to develop the tools for sound-wave analysis and measurement.

The condenser microphone, the wave filter, the amplifier — each the product of telephone research — have helped to reveal the structure of sound as never before. Each has helped to build the world's finest telephone system.

BELL TELEPHONE LABORATORIES

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

TELE-TIPS

REPORTER'S RECORDER to be hidden under lapel is next step in up-to-date newspaper practice. Walter Howey, veteran of "The Front Page" and long-time radio-electronic inventor, is reported to have worked out an invisible recorder which will take down a half-hour interview, just as the interviewee spoke it, to be played back for putting into type later.

TV TELESCOPE—Our own long-time dream of an electronic astronomical telescope with pickup lens widely separated from the CR viewing screen, and amplification obtainable by electronic deflection, seems in part realized by an Arizona inventor. He is William Rhodes, 4333 N. 14th Street, Phoenix, and he is reported to use an electron multiplier to bring the image from his backyard telescope to his living-room easy chair.

MICROWAVE VIDEO CIRCUITS—At the present time, Western Union has in operation two one-way micro-wave circuits between New York and Philadelphia. available to any customer. These circuits handle video only; no sound channels. Western Union is making no commitments of any kind in regard to further micro-wave services until the FCC reaches a decision as to allowable rates. As far as engineering is concerned, the project is in a state of suspended animation. It is no secret, however, that WU has purchased sites for micro-wave installations in Minneapolis, Kansas City and Atlanta.

WHO'S WHO?

An engineer is a man who knows a great deal about very little, and who goes along learning more and more about less and less, until finally he knows practically everything about nothing.

A salesman, on the other hand, is a man who knows a very little about many things, and keeps learning less and less about more and more, until he knows practically nothing about everything.

A purchasing agent starts out knowing practically everything about everything, but ends up knowing nothing about anything, due to his association with engineers and salesmen.

What do you want to be when you grow up?

FP FOR TV

TELEVISION DEMANDS *PERFECTION*

There can be no compromise with quality — in television. New standards are essential for long life, dependability and trouble-free operation.

Mallory FP Capacitors are accustomed to severe service — have been operating at 85° C. for years. Even though this extreme temperature may not be apparent in your particular model, it's good to know that Mallory gives you an extra margin of safety.

The fact that no human hand* touches any vital part during processing and assembly shows the extreme care taken to insure the long life so characteristic of this remarkable Mallory product.

**The chlorides present in perspiration cause destructive corrosion and shorten the capacitor's life in the field.*

FP is the type designation of the Mallory developed electrolytic capacitor having the characteristic design pictured. Adopted as standard by RMA, it is famous for dependable performance.

P. R. MALLORY & CO., Inc.

MALLORY

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

SERVING INDUSTRY WITH

Capacitors, Rectifiers, Contacts, Switches, Controls, Vibrators, Power Supplies, Resistance Welding Materials

MICROGROOVE long-playing recordings are here to stay. This means that every broadcast station and recording studio must have quality equipment, especially for microgroove reproduction.

The new PRESTO type 153 reproducers include two separate Pickering diamond stylus heads for microgroove or regular recording, an exceptionally fine arm, and a 4-position compensating network.

Durability of equipment, fine performance, and economical first cost make these PRESTO reproducers ideal for microgroove and also for lateral standard recordings.

Write today for full specifications on the PRESTO 153M for microgroove recordings and 153R for regular recordings. Your nearest PRESTO distributor can show you the equipment.

FOR HIGHEST FIDELITY . . . IT'S PRESTO DISCS

Microgroove, even more than regular recording, demands a perfect disc. The answer is Presto. For, sixteen years ago, Presto made the *first* lacquer-coated discs . . . and today Presto discs are *first* in quality.

PRESTO

RECORDING CORPORATION

Paramus, New Jersey

Be ready for Microgroove!

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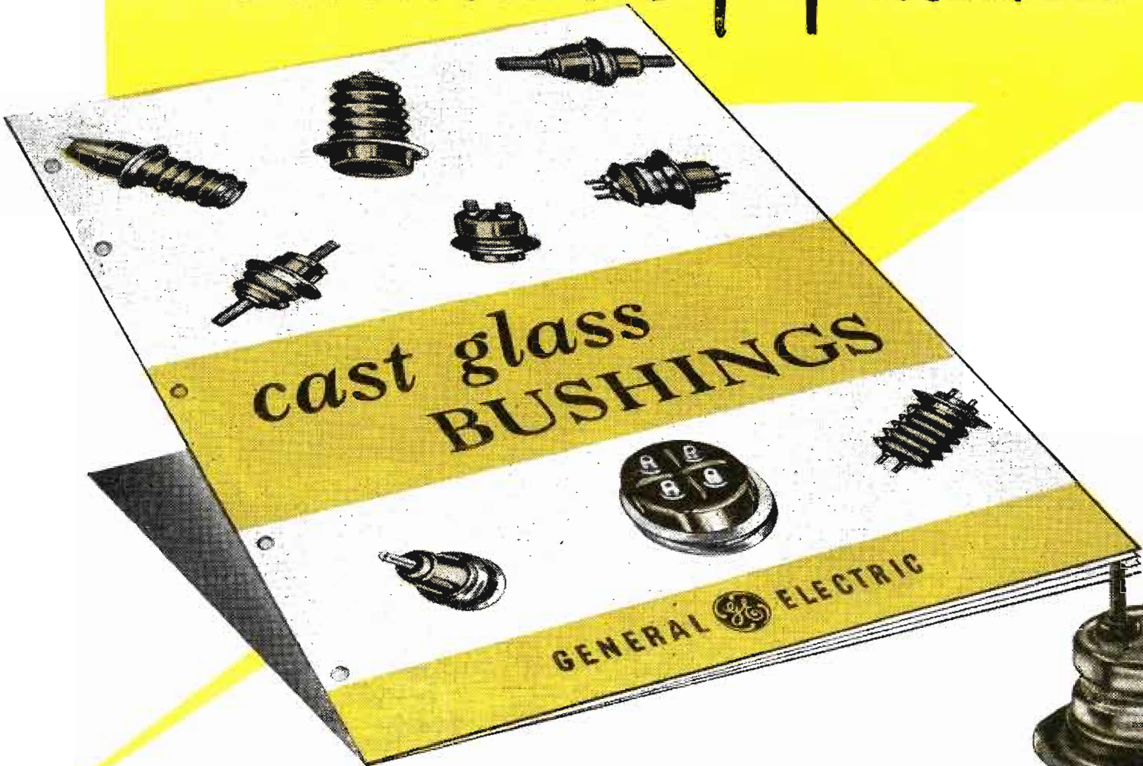
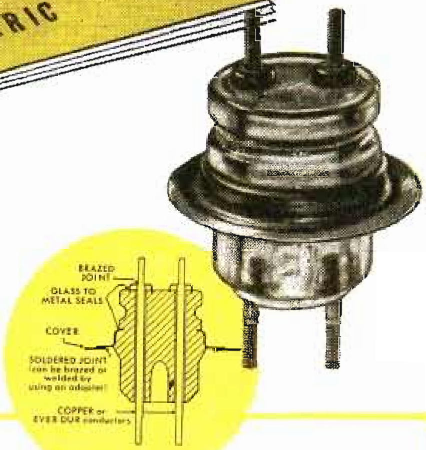
In Canada: WALTER P. DOWNS, LTD., Dominion Sq. Bldg., Montreal

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

If you manufacture Electronic Equipment...





you'll want this NEW bulletin on glass bushings

General Electric is now offering to other manufacturers the cast glass bushings it has used so successfully on many types of electrical equipment.

These bushings are cast of a stable, low-expansion glass. Metal hardware is a special nickel-alloy steel, fused to the glass in casting. Bushings can be attached directly to the apparatus without gaskets—by soldering, welding or brazing.

The resulting joint between bushing and equipment is permanent, vacuum-tight, and of high mechanical strength. It is especially desirable for equipment subject to vibration, shock, attack by fungus growth or severe changes in temperature. It eliminates moisture problems and often permits more compact, light-weight design of equipment.

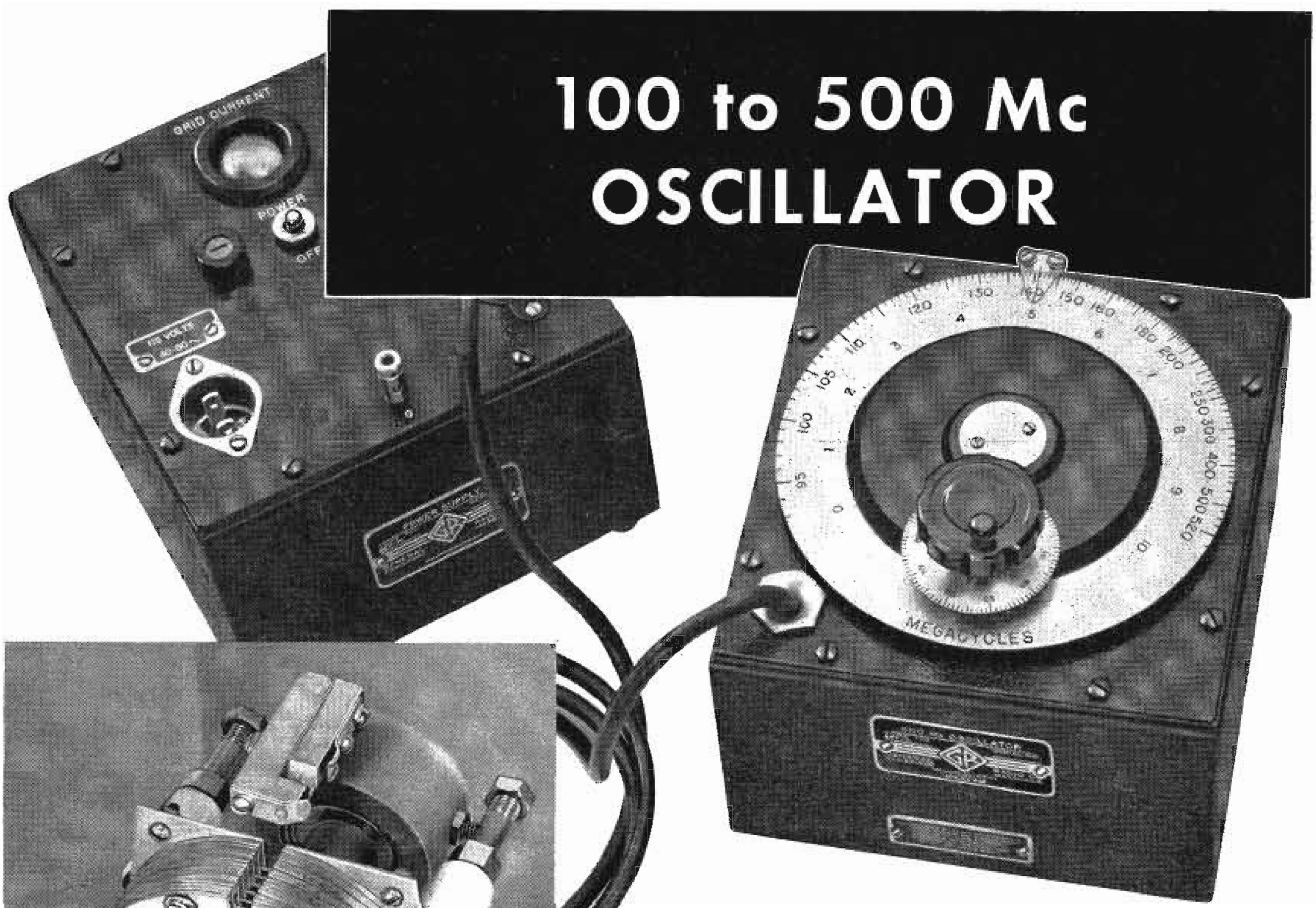
Our new bulletin, GEA-5093, contains a complete listing of standard designs now available—giving withstand voltages, current ratings and physical dimensions. A copy of this bulletin is yours for the asking. Just write *Apparatus Department, General Electric Company, Schenectady 5, New York.*

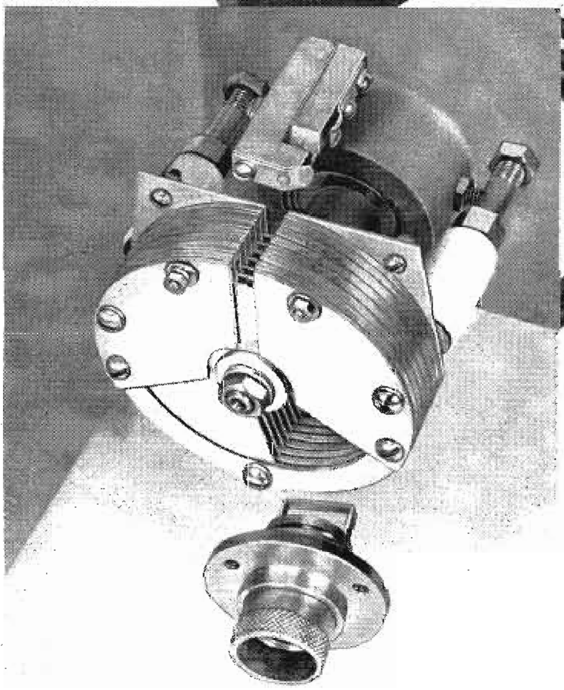
Glass bushings are currently available to meet dry, 60-cycle, flashover values of from 10 to 50 kv, and in current ratings of 25 and 50 amperes (large sizes up to 800 amperes). They may be single or multi-conductor and can be provided with a top flange to permit mounting tube sockets directly on the bushings. Diameters range from 1⅝ to 3⅜ inches and weight from 2½ oz. to 4 lb.

GENERAL ELECTRIC

401-57

100 to 500 Mc OSCILLATOR





THIS oscillator, designed for use as a power source for general laboratory measurements and testing, covers the frequency range of 100 Mc to 500 Mc. With its associated power supply it is small, lightweight and compact. The entire range is covered with a single-dial frequency control with a slow-motion drive equipped with an auxiliary scale.

The tuned circuit of the Type 857-A Oscillator is our well-known Butterfly type. The difficulty of sliding contacts in any part of the oscillator circuit is avoided in this unique construction. The photograph above shows the output coupling loop and output jack. Coupling can be changed from maximum to almost zero by rotating the output jack.

FEATURES

- Dial calibrated directly in megacycles to an accuracy of ± 1%
- Vernier dial with 100 divisions, covering the oscillator range in ten turns
- Output through a coaxial jack with provision for varying coupling
- Output of ½-watt at 500 Mc
- Electron-ray tube in power supply to indicate grid current and furnish indication of oscillation
- Filament and plate power furnished by the Type 857-P1 Power Supply which is furnished with the oscillator

TYPE 857-A U-H-F OSCILLATOR (with power supply) . . **$285**

WRITE FOR COMPLETE DATA

GENERAL RADIO COMPANY **Cambridge 39, Massachusetts**

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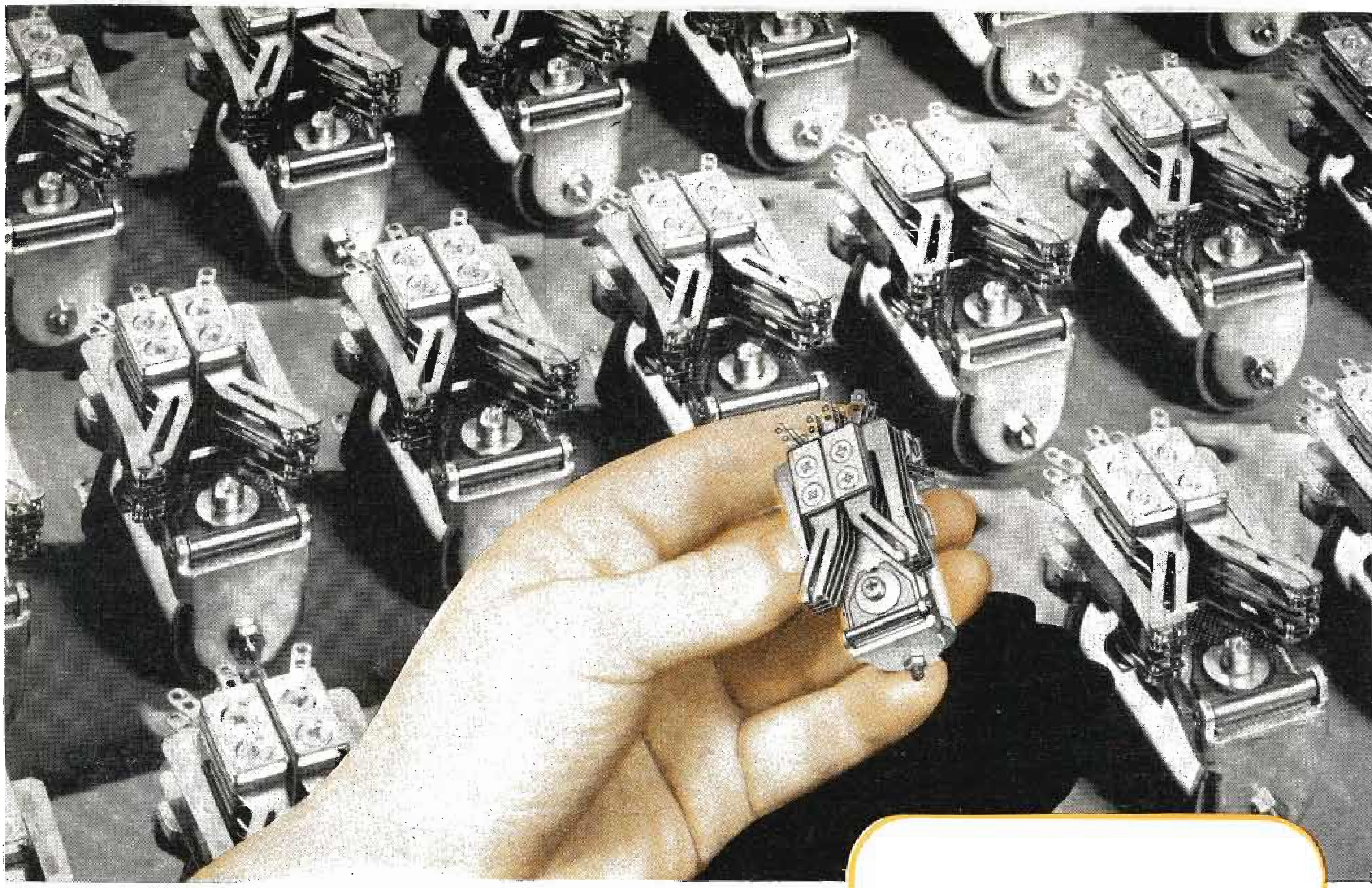


One Relay or 100,000 . . .

CLARE RELAYS

Are *Each* Carefully Tested Against Your Specifications

Clare's Chief Inspector reports only to the president. He is responsible for the most important thing in our business . . . that the Clare Relay you order is *exactly* the Clare Relay you receive.

Whether your order is for one Clare Relay or 100,000 . . . every single relay is 100% inspected and tested against your specifications.

Mechanical adjustment, electrical characteristics, physical appearance and construction . . . every detail is gone over by experts specially trained in Clare's precise requirements. Not a single relay is sealed for packing until it conforms in every way with the highest standards of relay performance.

Such infinite capacity for taking pains is a basic reason for Clare's leadership in the industrial relay field. It accentuates the value of Clare's superior design, precise manufacture and unusual understanding of difficult relay design problems.

Clare sales engineers, fully experienced in every type of relay requirement, are located in principal cities for your convenience. If you have a relay problem that seems really tough . . . look to Clare. Enjoy the services of this organization whose entire business is devoted to making sure that you have the relay which best meets *your* needs.

Look in your classified telephone directory . . . or write: C. P. Clare & Co., 4719 West Sunnyside Ave., Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

Every Single CLARE Relay Must Pass These Tests

For Mechanical Adjustment

1. Contact Pressures (Make or Break)
2. Contact Follow, or Wipe
3. Sequence of Make and Break Contacts
4. Correct Airline
5. Residual Setting
6. Spring Straightness

Physical Inspection

1. Plating (For Marks or Scratches)
2. Proper Insulation
3. Condition of Insulation (No cracks, etc.)
4. Tapping of Screw Holes
5. Spring Thickness
6. Coil Data on Label and Condition of Label

Electrical Inspection

1. Coil Resistance
2. Coil Breakdown
3. Pileup Breakdown
4. Operation (as specified)
5. Direction of Winding
6. Test for Shorted Turns

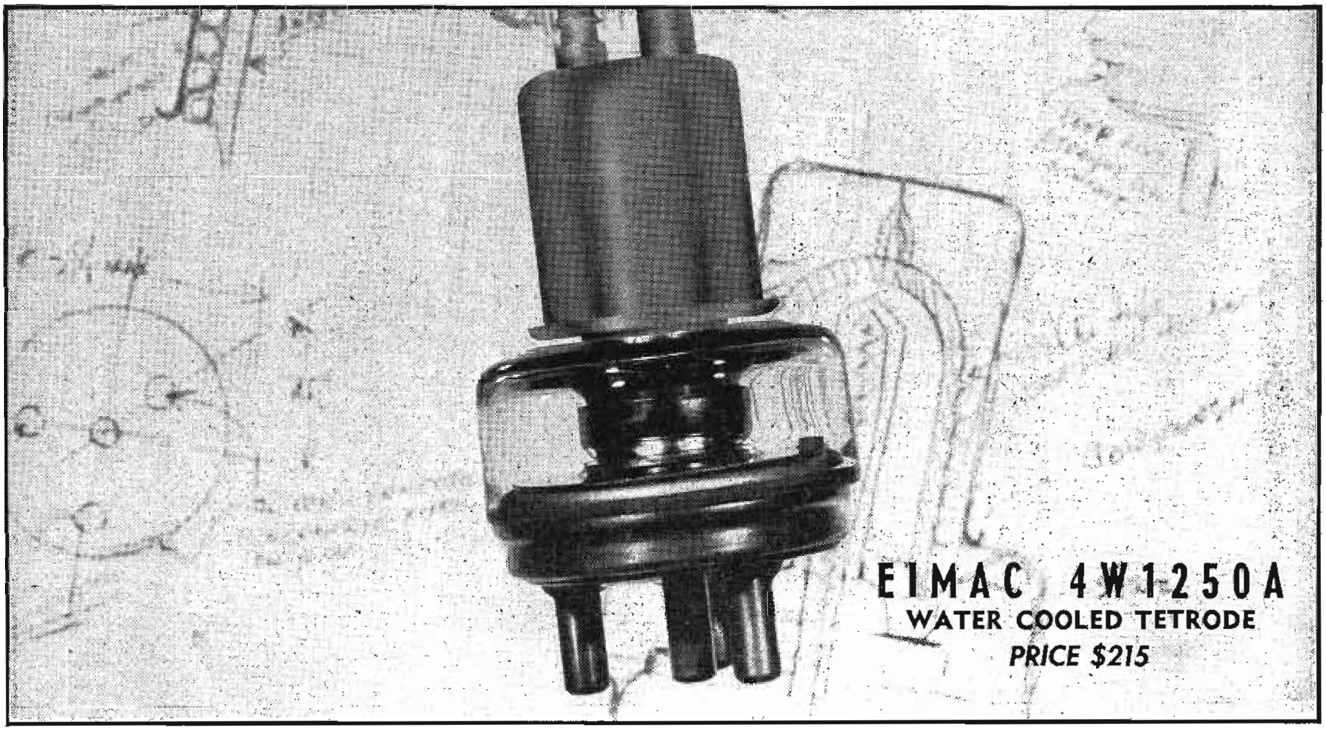
All Clare Relays Are Packed Immediately Following Inspection

CLARE RELAYS

First in the Industrial Field

Follow the Leaders to Eimac Tubes — The Power for R-F

A NEW TUBE FOR TV



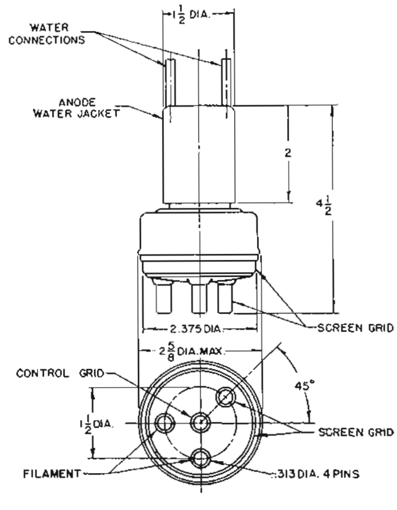
A new tetrode . . . the forerunner of more Eimac developments providing higher power in the upper frequency brackets.

GENERAL CHARACTERISTICS
EIMAC 4W1250A TETRODE

Filament: Thoriated Tungsten	
Voltage	5.0 volts
Current	13.5 amperes
Screen Grid Amplification Factor (Average)	6.2
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.05 uufd
Input	12.8 uufd
Output	5.6 uufd
Transconductance (i_b=200ma., e_b=2500v., E_{c2}=500v.)	5200 umhos

RADIO FREQUENCY POWER AMPLIFIER
Television Class-B Linear or Grid-Modulated Amplifier.
MAXIMUM RATINGS (Frequencies up to 216 Mc.)

D-C PLATE VOLTAGE	3500 VOLTS
D-C SCREEN VOLTAGE	750 VOLTS
D-C GRID VOLTAGE	– 500 VOLTS
D-C PLATE CURRENT	750 MA.
PLATE DISSIPATION	1250 WATTS
SCREEN DISSIPATION	30 WATTS
GRID DISSIPATION	10 WATTS



For further information on the 4W1250A, write direct

EITEL-McCULLOUGH, INC.

207 SAN MATEO AVENUE, SAN BRUNO, CALIFORNIA

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TELE-TECH

TELEVISION • TELECOMMUNICATIONS • RADIO

O. H. CALDWELL, Editorial Director ★ M. CLEMENTS, Publisher ★ 480 Lexington Ave., New York (17) N. Y.

SHORTAGE OF INTERNATIONAL AIRCRAFT CHANNELS—The continuing growth of international air travel, which has brought with it an increasing necessity for communication between aircraft in flight and ground stations, has produced a serious scarcity of the radio frequencies used in such communications, and has made necessary the redrafting of the world pattern of frequency allotment. A draft allotment plan for the international air routes of the 51 nations which are members of the International Civil Aviation Organization is being carefully examined by technical experts at the Third Session of the ICAO Communications Division now meeting in Montreal.

Only 149 radio channels in the high frequency bands are available for exclusive use of civil aviation on a world-wide basis. During daylight hours a number of transmitting stations can operate on the same frequency without interference. But at night, when radio signals travel much further, stations working on the same frequency channel are likely to interfere seriously with one another even when they are far apart. Limited radio spectrum space and rapidly developed civil aviation make planning extremely difficult. Careful coordination is necessary to ensure that the international air services of ICAO's 51 member nations make the best use of what is available.

US RECOGNIZES ADV. COSTS—A new section of the Armed Services Procurement Regulations, dealing with the types of costs which may be allowed in research and development, supply and material, and construction cost type contracts for the Army, Navy, and Air Forces, has been adopted by the three Departments after coordination by the Munitions Board, and becomes mandatory this month.

In general, the new Section XV is based upon the principle that reasonable and necessary costs of preformance should be allowed. In accordance with this precept, four major items not previously allowable in computing contract costs are now permissible. These are: State income taxes; use and occupancy insurance; ordinary local charity and community benefit donations. Advertising in trade and technical journals also is allowable on research and development, and supply and material cost type contracts.

Final approval of section XV was developed by the Armed Services Audit Coordination Committee, headed by Rear Admiral Frank Baldwin, USN, representing procurement cost accounting organizations of the Army, Navy, and Air Force; the Armed Services Procurement Regulation Ad Hoc Committee headed by Rear Admiral James D. Boyle, and the Procurement Policy Council, composed of Major General Daniel Noce, of the Army; Rear Admiral M. L. Ring, of the Navy, and Major General F. M. Powers, of the Air Force, representing the chief departmental procurement offices.

ARE SCREENS TOO BRIGHT? Television retailers, as with those handling new automobiles, just now expect part of their profits from the extra gadgets that they try to sell with each purchase. Many of these have great merit, others seem trivial.

After the expenditure of hundreds of man-years in research on fluorescent materials and their application to cathode-ray tubes, we expect that the tube manufacturers have done a pretty good job in interpreting needs in the matter of color, brilliance, contrast range etc. That is, until we see the voluminous advertising, (a great deal of it from television stations controlled by set manufacturers'), relating to screens, filters and other attachments to "improve the pictures", "prevent eye strain," etc. While not entering with the arguments about the merits of these devices we only suggest that if such corrective measures are necessary they should be sprayed onto the screen by the tube manufacturer in the first place.

Along with doing whatever it is supposed to do now, a film in contact with the face of the tube might help in reducing halation effects, and mitigate those of an implosion, as well.

UHF TUNING HEADS ALOFT! To handle TV signals of the assigned 500-900 MC range in the case of installations with very long down-leads, Dr. DuMont makes the interesting suggestion that it may be necessary to mount the RF head of the receiver aloft at the antenna itself. It has already been pointed out that signal directivity must be utilized to the highest degree, using either large arrays or else reflectors, in order to get usable pickup strength.

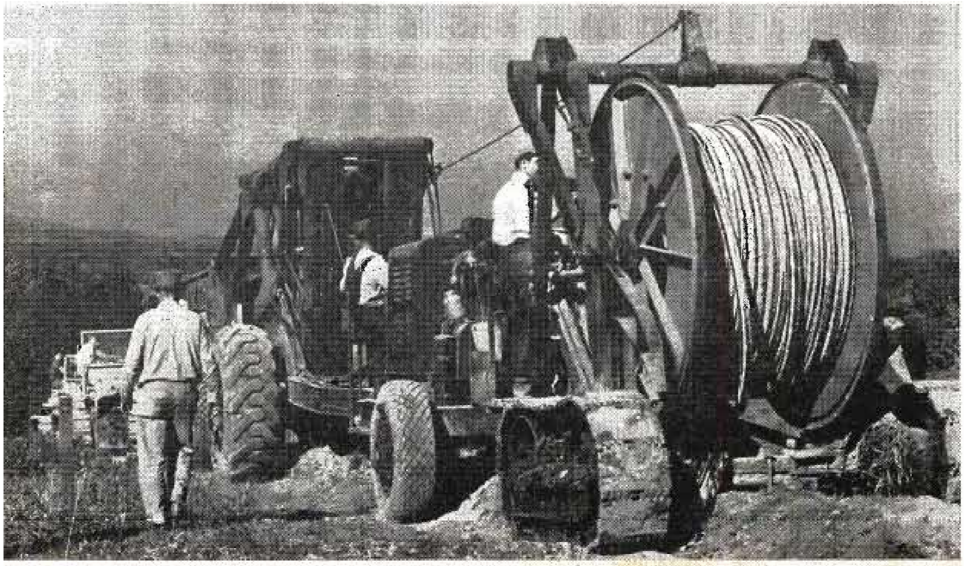
When the 500-MC band becomes active this means that home antenna masts may have to be wind-braced to carry not only the complicated array or reflector structures but also little "bird houses" to enclose the receiver front-ends. And that selsyn control wires and power lines may have to be carried up to the antenna tips to effect both rotation and tuning, and to energize the lofty tubes.

TV has been built on the practical solution of radical proposals like this one, so let's all be open-minded.

Coaxial Cable Joins East & Mid-West

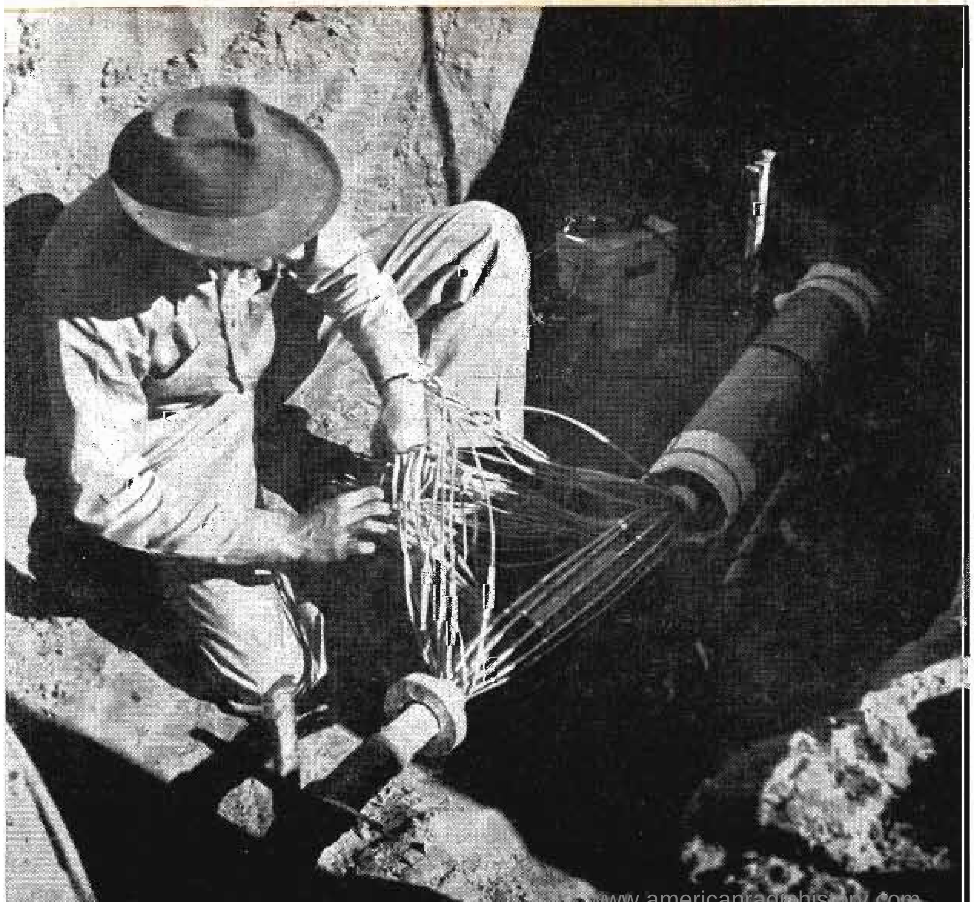
5000 miles of television channel now commercially available to broadcasters

By ROBERT HERTZBERG, Contributing Editor, TELE-TECH



Furrow plowing and cable placement is done simultaneously. Normal plowing depth is 30-in.

Splicing cable lengths involves connecting coaxials and order wires, wrapping joints in polyethylene sheet and muslin insulation, and sealing in cylindrical sleeve shown right



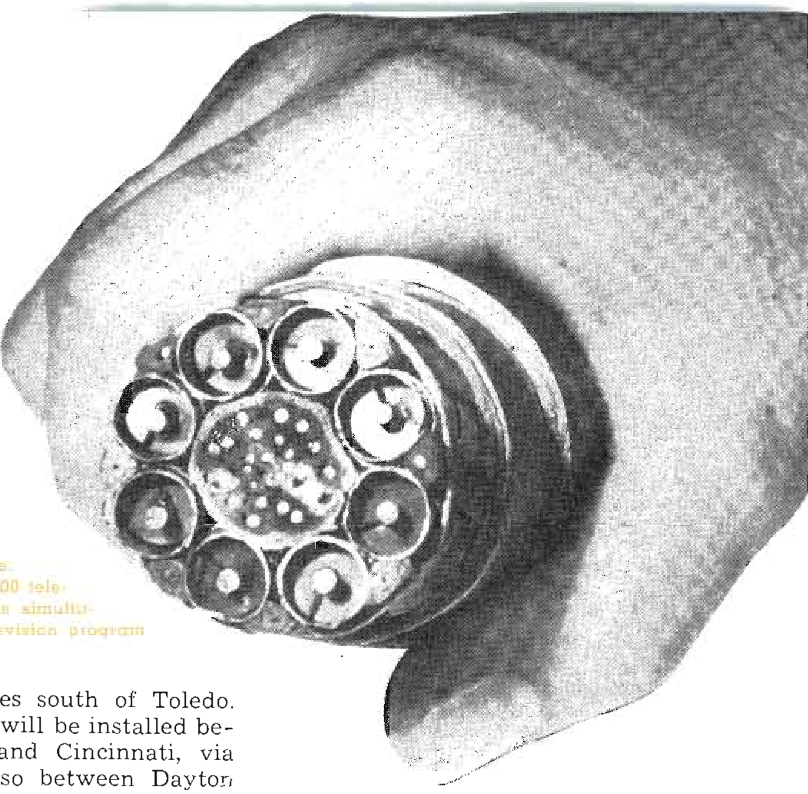
A NEW milestone in television history was achieved on the evening of January 11th, 1949, when the Bell System's East Coast and Midwestern Networks were joined by a coaxial cable running from Philadelphia through Pittsburgh to Cleveland. Chain TV broadcasting then became a reality to fourteen major cities, stretching from Boston and Washington to St. Louis, and representing one-fourth of the nation's population. The occasion was featured by a special inaugural program presented jointly by the American Telephone & Telegraph Company and the American Broadcasting Company, the Columbia Broadcasting System, the Dumont Television Network, and the National Broadcasting Company.

New Network Possibilities

On the following day, January 12th, the network became available on a regular commercial basis. For some weeks prior to this date, there was a behind-the-scenes scramble on the part of the TV broadcasters for the facilities, which are still limited, and a time-sharing schedule was finally worked out. All concerned admit that this is not entirely satisfactory, but it will have to do until new coax and micro-wave radio links, now under construction, are opened for service.

The new combined network extends over about 2,100 miles; 1,740 route miles of coaxial cable and 360 route miles of radio relay. The Bell System figures that this is equivalent to about 5,000 miles of television channels. A "normal" coax cable actually contains eight individual coax lines, but at least half of them are reserved for telephone service. A TV "circuit" in one direction comprises two lines, one a spare that is cut in automatically in event of failure of the other. Two circuits would thus tie up half of a cable. Only a single TV channel is available between New York and Chi-

TV Networks



Cross section of 8-tube coaxial cable. Each tube carries 600 telephone conversations simultaneously or one television program

cago at the present time because of the heavy telephone traffic between these cities.

Most of the new video channels to be placed in service in the next two years will be micro-wave radio relay. The longest system will run between Boston and Milwaukee, via New York and Chicago. By the end of next year, additions along present Bell System video facilities will make five channels available between New York and Boston; New York and Washington; Philadelphia and Cleveland; Cleveland and Chicago; and Detroit and Toledo. The largest new area scheduled for inter-city hook-up lies south of Toledo. Three channels will be installed between Toledo and Cincinnati, via Dayton, and also between Dayton and Columbus. A two-channel link will go between Dayton and Louisville, via Indianapolis. On the West Coast, two channels will connect Los Angeles and San Francisco. No East-West Coast tieup is in sight for 1949 or 1950.

If there is a demand for the service, extensions from the network will include single channels between the following cities: Boston to Providence; New York to New Haven;

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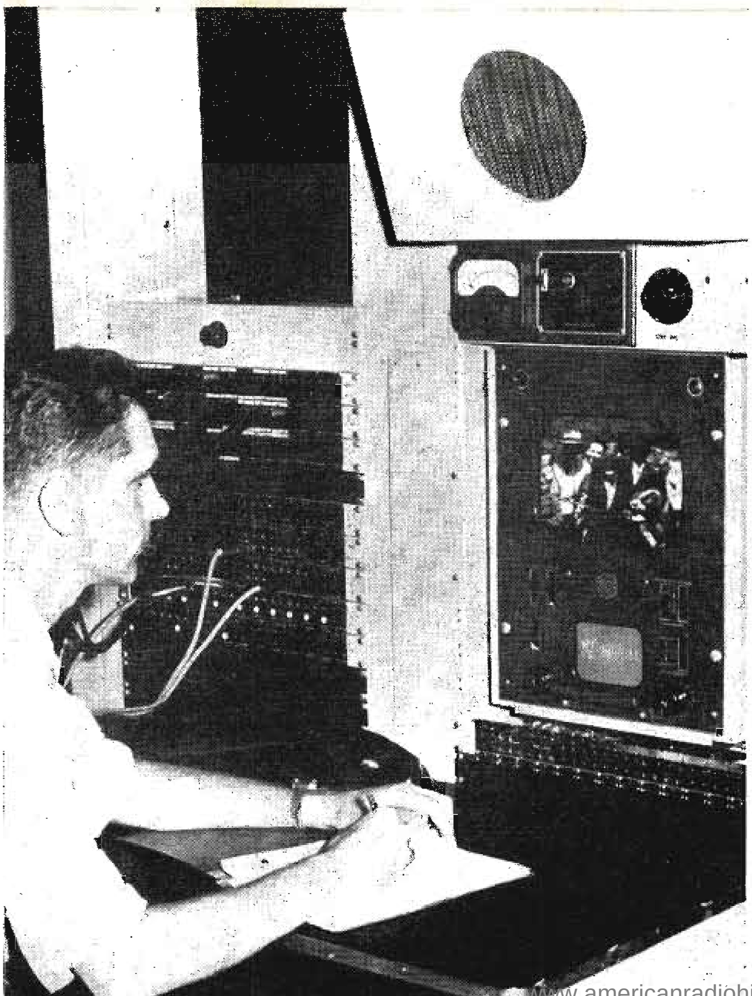
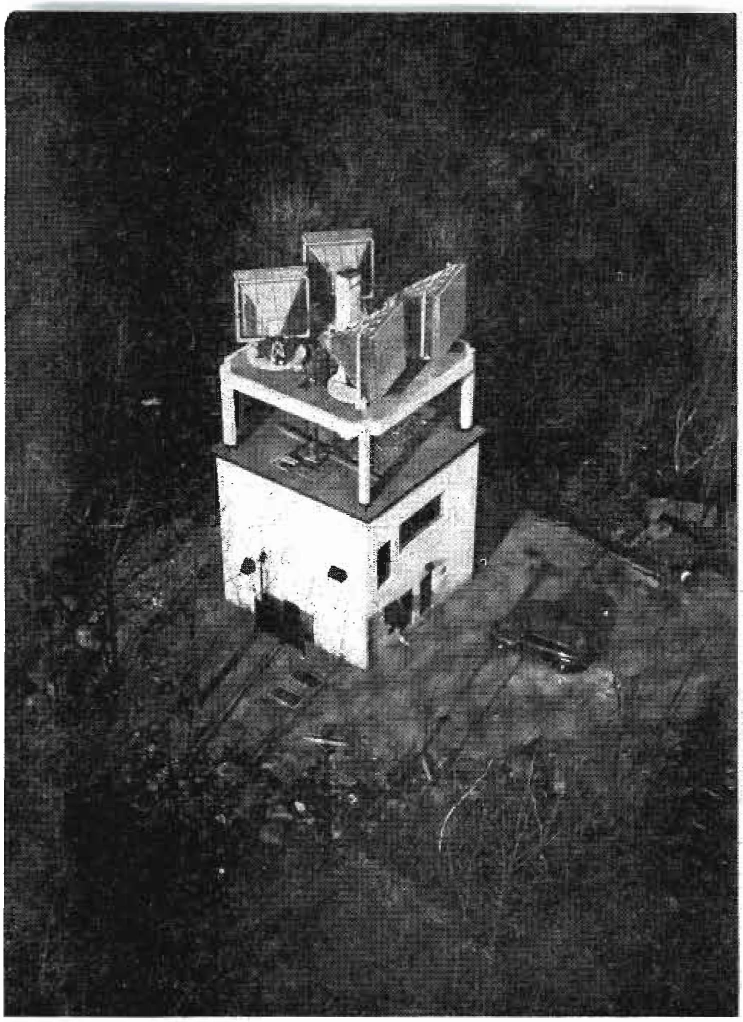
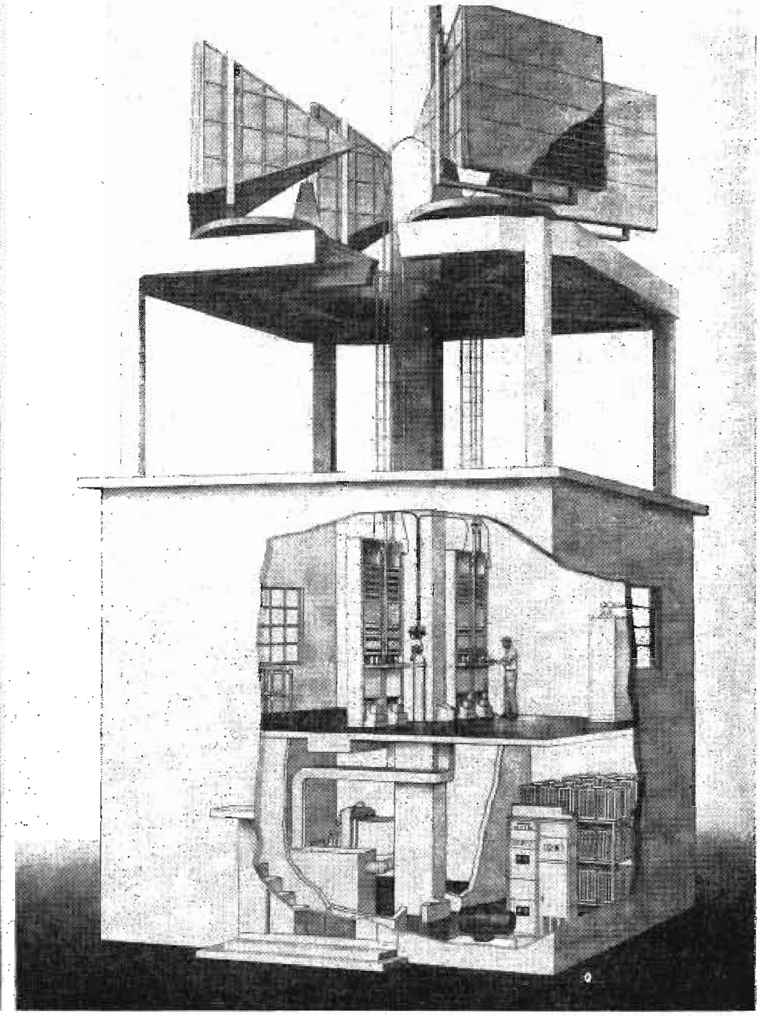
In control centers along television networks, Bell System technicians check picture and sound quality on monitoring equipment



Cable terminating equipment contains amplifiers, regulators and equalizers. Dial pilot indicators show frequency levels in lines

(Left) Typical Bell System microwave relay station used for TV transmission over some 360 route miles. (Right) Cut away view shows location of emergency power equipment and storage batteries on first floor, radio equipment on second, and directional antennas on second roof

EAST AND MID-WEST TV NETWORK (Continued)

Philadelphia to Wilmington; Buffalo to Rochester; Milwaukee to Madison, Wis. By the end of 1950, it is likely that certain cities along the paths of the main video channels will be hooked in; these are Hartford, Conn.; Reading, York, Harrisburg, Johnstown, Youngstown and Erie, Penna.; Akron, Ohio; and Fort Wayne, Ind.

Chain television broadcasting had its inception in the Fall of 1937 with the opening of a 95-mile coaxial cable between New York and Philadelphia. In the next few years, many important developments were worked out over this cable, which was the first of its kind and frankly of experimental nature. Excellent progress was made on the design and construction of broad-band amplifiers, repeaters, all sorts of terminal and test equipment, etc. When the war broke out, the television program was halted and the cable was used only for general telephone service. When hostilities ended, the TV activities were quickly resumed. On February 12th, 1946, regular network television transmission between Washington and New York was inaugurated for use by broadcasters without charge. Services at the Lincoln Memorial were televised and transmitted over coax cable to NBC, CBS and Dumont stations in New York. Baltimore was added to the chain in October 1946. Using radio relay, Bell System engineers extended the New York-Washington network northward to Boston in November, 1947. To the south, Richmond was tied in by coax a few months later.

The free experimental service was discontinued in the spring of 1948. On May 1st of that year, the Bell System television facilities went on a commercial basis. The television boom was on. During the first month, broadcasters used the channels an average of four hours a day, but by December they were up to thirteen hours a day.

The engineering problems in the commercial establishment of the coaxial cable have been mechanical as well as electrical. To minimize the chances for breaks, the cable is entirely underground, where it is secure from storms, fires, falling tree limbs and stray shots from hunters' rifles. In open terrain, it is buried directly in the soil, by means of monstrous 27-ton plowshares built especially for the purpose. In cities, or under highways and railroads, it is placed in conduit. However, like all cables, it is subject to physical abuse and punishment, sometimes from insignificant and unexpected sources. The lowly gopher, for instance, with his strong jaws and sharp teeth, has caused a lot of trouble because he finds the lead cable and its many wrappings to be both edible and vulnerable. Tough steel tape now discourages this nibbling.

The cost of the coax itself, plus the cost of installation and maintenance, must by now have reached astronomical values. The Bell Sys-

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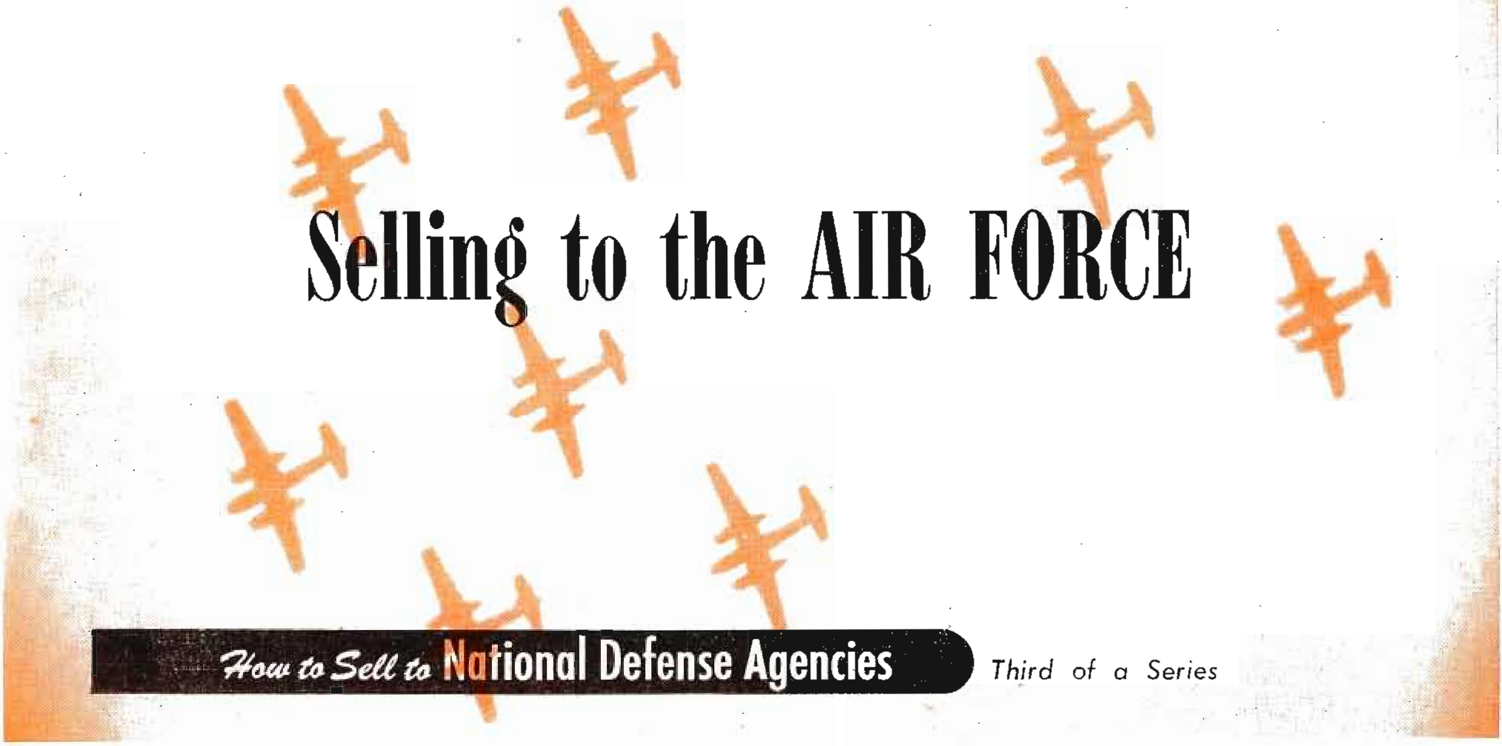

Selling to the AIR FORCE

How to Sell to National Defense Agencies *Third of a Series*

Millions of dollars per year will be spent on communications equipment for the Air Corps' 70 combat groups and 400,000 personnel

New "streamlined" procedures and operations of seven field procurement offices act to simplify and speed-up purchases of equipment and "experimental capacity"

By ***ALFRED E. KUENZLI,*** *Editor, Technical Data Digest, Wright-Patterson A. F. Base, Dayton, Ohio*

THE Air Force is currently buying electronics and communications equipment in quantities totaling millions of dollars per year, and major projects of the future, arising out of electronic development and the increasing use of new devices, will increase the proportions of Air Force procurement, already of big business magnitude, even more.

The Air Materiel Command, with headquarters at Wright-Patterson Air Force Base, Dayton, Ohio, and with field offices across the nation, is charged with procuring and maintaining the mass of major equipment of every description required by the Air Force. In addition to the responsibility of maintaining existing air units at the level of current equipment development, AMC must also bring into being the aircraft and equipment necessary to the recently authorized increase in Air Force strength which today numbers some 70 combat groups and 400,000 personnel.

Main contact point with manufacturers and their representatives at Headquarters, Air Materiel Command in Dayton is the Contractors Relations Office of the Directorate, Procurement and Industrial Planning. Here has been established an efficient information and guide center where new representatives from industry are all but "led by the hand" to the proper contacts which they should make during a visit to AMC at Wright-Patterson Air Force Base.

The paneled reception room of the Contractors Relations Office is devoted entirely to the needs of visiting representatives and contains desk space, telephones for field and outside calls, and telegram facilities. On the walls are bulletin boards which display current "Invitations for Bids" — sheets which describe items of equipment and material which the Air Force desires to procure. Pertinent drawings and specifications for each item are given in the "bid sets", and copies are filed in the reception room. Authorized representatives of manufacturers, when they wish to bid on an item, may take a "package" with them containing detailed information or may request that this be mailed to the home office. It is advisable that, following the representative's return to the company and after careful examination of the requirements and specifications, correspondence be directed to the Services Section of the Procurement Division stating the reason if a bid is not to be submitted. This will indicate continuing interest on the part of the company, and it will be possible for the company to then continue to receive bid sets regularly.

The bulletin boards contain Invitations for Bids for central Air Force procurements as well as for "local purchases" by Wright-Patterson Air Force Base. The number of specific requirements posted at one time may vary from 10 to 150 or more depending upon various factors, including time of year, development projects, etc.

The procedure for a visiting representative to AMC is now clear-cut and simplified to the point of all-possible economy of time and detail both for the representative and for

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the government employees who receive and interview him. First step for the visitor is to check in at the Wright Field reception center where he is issued a gate pass for the day. Then he enters the Contractors Relations Office in Building 15. If the contractor's business is with the Engineering Division, and he is familiar with his proper point of contact, he may make his own appointment directly from the reception gate with any of the laboratories or subdivisions of that Division. If the contractor or representative does not know where he should go in the Engineering Division, the Contractors Relations Office will quickly classify his products or services and make an appointment for him with the particular laboratory or with the buyer of that item or service.

All contacts with the Procurement Division and the Industrial Planning Division are by appointment only, through the Contractors Relations Office, but appointments usually can be arranged immediately or within a reasonable period. An advance telephone call from downtown Dayton will result in the sending of appointment cards to the reception center to await the visitor's arrival.

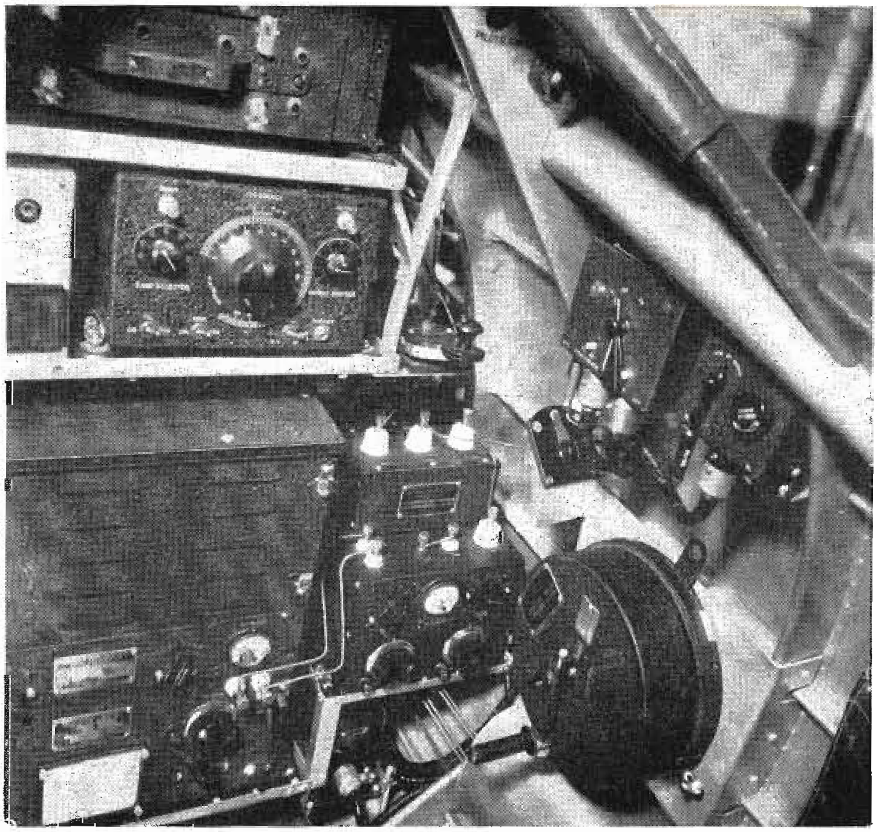
The Air Force buys essentially two things. It buys manufactured items, and it buys experimental capacity.

The AMC Procurement Division is divided into three sections: the Aircraft and Missiles Section, the Aeronautical Equipment Section, and the Research and Materiel Section. One of the branches under the Aeronautical Equipment Section is broken down into Airborne Bombing Radar, Ground Search Radar, Airborne and Ground Communications, Ground Navigation GCA, Airborne Navigation, and Miscellaneous Electrical Equipment. Another Branch is Accessories, which includes a Flight Navigation Instruments Unit, Engine Instruments Unit, Auto Pilot Unit, Oxygen System Unit, Aircraft Accessories Unit, Flight Navigation Trainers, Landing Gear Systems, Electrical Systems (DC), and Electrical and Generating Systems (AC). Other branches of the Aeronautical Equipment Section also purchase electronic equipment and some other related products.

The Research and Materiel Section places research contracts, defined as those in which "no end product is in sight", and also contracts for such specialized subjects as schooling and factory familiarization.

Over each group of specific products and specific services are the buyers who are charged with procuring those specific categories and with a complete and intimate knowledge of the commodities under the individual's responsibility. Each buyer is a contracting officer who has within his control all the operations and authority leading the signing of a final contract.

Part of the extensive radio equipment that is carried by Army Airways Communication System (AACS) planes. This particular installation shows arrangement in Curtiss A-12

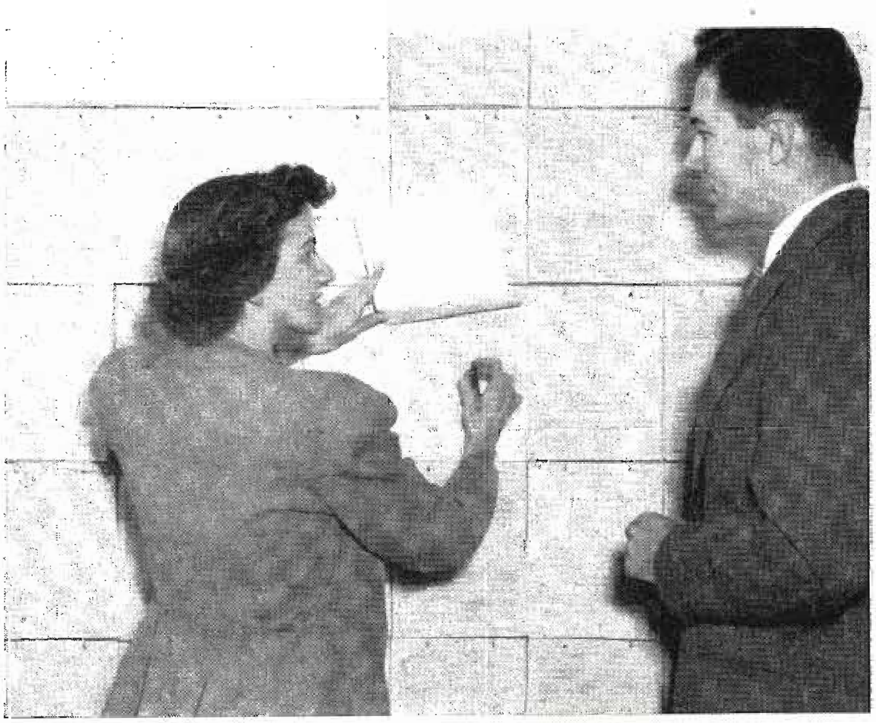


Industrial Planning Division

An important step in the process of selling to the Air Force comes upon contact with the Industrial Planning Division during the initial visit. This is really the first step after the visitor passes through the gate at Wright Field and into the Contractors Relations Office. He is sent to the Facilities Branch of the Resources Planning Section, Industrial Planning Division (in the same building) where completion of seven-page "source of supply" forms is explained. These may be obtained from the nearest Procurement Field Office prior to or following the visit. The forms give the Industrial Planning Division information on the manufacturer's financial standing, facilities, and capacity — information which can be utilized in obtaining manufacturers for additional production for current programs or emergency programs. The accumulated data also are useful in lending assistance to Air Force prime contractors seeking additional sources for subcontracting.

Following submission of properly prepared forms, and the completion of a plant survey, the company may be established as a source of supply and be placed on the bidders' list. The manufacturer then receives information regularly regarding purchase requirements in the specific categories he has outlined, and he may enter into contract negotiations or submit bids.

Two of the four copies of these forms go to an important Air Force point of contact with industry — the Procurement Field Offices. The other two copies of the "source of supply" forms remain in the contractor's files — one of which may be used to satisfy requests for similar information by representatives of the Army or Navy. The forms



Bulletin board in Contractors Relations Office displaying current "Invitations for Bids" Business representatives may take copies or have them forwarded to home office

and procedure for this purpose are relatively new, having been placed in operation on August 30, 1948 following a directive of the Munitions Board in Washington, D. C.

During the war there were approximately 37,000 manufacturers registered but 20,000 of these went out of business or affiliated with other companies; therefore, it has been necessary to make new surveys and records of industrial capacity.

The Air Force Procurement Field Offices are closely controlled extensions of the Procurement and Industrial Planning Directorate and serve seven districts across the country. They are located in Boston, New York, Dayton, Detroit, Chicago, Fort Worth, and Los Angeles. Inspectors, industrial planning specialists, and production specialists attached to these offices help to expedite and control the flow of materials required by the Air Force. Regular contacts with the nearest PFO should pay dividends.

In the process by which the manufacturer becomes approved as a source of supply, his product or products may be tested by AMC laboratories, or the specific laboratory concerned with the product may analyze it to determine not only its quality and conformance to specifications, but whether the equipment is a new type that conforms to the requirements of current development. If this is the case, the laboratory may initiate a Purchase Request.

Negotiated contracts may occur when purchases are not in excess of $1000; when a manufacturer is the sole source of supply; for highly specialized or technical services; in the case of national emergency; for experimental, development, or research work; and in other circumstances where negotiation is considered more practical than formal advertising procedure.

Most Air Force procurement, however, is accomplished on a competitive bid basis. The Invitations for Bids contain the time of day and date that all bids will be opened and at the appointed hour, all bids and prices are unsealed and read publicly in the Bid Unit of the Procurement Division.

All major purchases are reviewed by the Procurement Committee which is directly responsible to the Director, Procurement and Industrial Planning.

Following the opening of bids and subsequent award of contract, the results of procurements and abstracts of bids, including names of bidders and prices, may be obtained on request through the mail from the Contractors Relations Office.

Correspondence pertaining to any

(*Continued on page* 55)

Potential Air Force Suppliers Must Furnish This Information

1. **General**

(a) Give name and address of parent company and location of plants.

(b) List subsidiaries or divisions.

(c) Specify financial rating as listed in Dun & Bradstreet and/or Thomas' Register.

(d) Plant security; alarm system, guard force, fire alarms, sprinkler system.

2. **Production Data**

(a) Acres of real estate and floor area of plant, specifying; area in use, storage area, (outdoor and indoor), area available for expansion.

(b) List products now being produced by your company.

(c) List major items procured from subcontractors excluding basic material.

(d) If company was engaged in war production during World War II, describe products and volume produced.

(e) Describe transportation facilities; railroad, truck, water (inland or deep sea) and dock frontage, and nearest suitable cargo airport.

(f) What type of power and fuel is used?

(g) How many people do you employ? Give job number in each classification.

(h) Is tool department capable of producing jigs, dies, and fixtures for present products?

(i) List general classes of equipment on hand. (Detailed listing not required)

(j) Name other government agencies which are being supplied by your company at the present time.

3. **Research**

(a) Describe size and capabilities of engineering department.

(b) State whether company is interested in research and development work.

(c) List laboratories and special equipment therein.

(d) Describe past or present research and development work.

(e) Describe past or present research conducted for the government.

Addresses of Air Force Procurement Field Offices

BOSTON
Boston Army Air Base
Boston 10, Mass.

DETROIT
W. Warren & Lonyo Aves.
Detroit 32, Michigan

NEW YORK
67 Broad Street
New York 4, N. Y.

CHICAGO
39 S. LaSalle St.
Chicago 3, Illinois

LOS ANGELES
1206 Santee St.
Los Angeles 54, Calif.

FORT WORTH
Gov't. Aircraft Plant No. 4
Fort Worth 1, Texas

DAYTON
Wright-Patterson Air Force Base
Dayton, Ohio
Attn: MCPPXV

An Examination of Performance Capabilities

Ultimate performance limits, selectivity, and fidelity characteristics analyzed

By GEORGE V. ELTGROTH, Vice President, Eckert-Mauchly Computer Corp., Philadelphia, Pa.

THE superregenerative receiver was developed in 1921 by Major E. H. Armstrong, and the circuits presented by him in his original U. S. patent No. 1,424,065 include most of those commonly encountered at present. For a time there was a considerable amount of work done with this type of receiver, but it has failed to gain wide commercial application. The failure of the superregenerative receiver to become popular with the engineering profession is largely due to the difficulties found in predicting the performance which can be obtained with a given set of components. Among the criticisms leveled at the superregenerative receiver are excessively broad tuning, noisiness in the absence of signal, and the property, which it possesses, of radiating energy. The superregenerative receiver, as will be seen, is an extremely sensitive device whose operation, in the absence of signal, is controlled by the random noise voltages existing in the tuned circuit of the receiver. When a signal of sufficient strength is received, the effect of these noise voltages is overridden and reception becomes quiet. In its noisiness, the superregenerative receiver does not differ from any highly sensitive receiver capable of producing outputs in response to the thermal agitation voltages present in all bodies.

All receivers having oscillating circuits radiate energy to a greater or lesser extent, and this is true of the presently popular small superheterodyne receiver having a combined mixer and oscillator as the first stage. The difficulty is eliminated in the superheterodyne by the insertion of a radio frequency isolation stage which contributes additional selectivity as well as minimizing the radiation energy at the oscillator frequency. This same expedient may be employed in the case of the superregenerative receiver.

It is the purpose of this paper to determine and set forth such ultimate limits to indicate accurately the maximum performance that can ever be expected of this type of receiver and the major portion of this presentation is connected with the determination of selectivity and fidelity characteristics.

Principles of Operation

A superregenerative receiver consists essentially of a resonant circuit, a vacuum tube regeneratively coupled to said resonant circuit, and means for periodically varying the regeneration in the circuit between a value sufficient to cause self-oscillation and a value insufficient to maintain independent oscillations in the tuned circuit. The condition when self-oscillation occurs may be called the negative loss condition, and the condition when self-oscillation cannot occur and oscillations in the circuit die away in the absence of external excitation may be called the positive loss condition. As the circuit regeneration is varied, it must obviously pass through the state in which the circuit losses are perfectly balanced, i.e., the zero loss state. While in this state, the circuit may be said to have infinite Q, and it is then that the maximum discrimination against signal frequencies differing from the resonant frequency of the tuned circuit is developed. The discriminating ability or selectivity of a resonant circuit is diminished by the presence of losses in the circuit, be they positive or negative.

The accepted practice in superregenerative receivers is to produce the necessary periodic changes in regeneration by alternating voltages applied to an electrode of the vacuum tube. As the regeneration control voltage intermittently causes the oscillating voltages in the resonant circuit to decay, or be quenched, by driving the circuit into the positive loss region, it is commonly termed the quench voltage, and its frequency is designated as the quench frequency. When the quench voltages are derived from the operation of the regenerative amplifier itself, the receiver is said to be self-quenched, while a superregenerative amplifier in which the quench voltage is obtained from an independent source is said to be separately quenched. In general, it may be said that the quench frequency in a self-quenched superregenerative amplifier will be a function of the input signal intensity and that it is fairly difficult to control the quench wave form, while in the separately quenched amplifier the quench frequency is independent of the input signal strength and its wave form may be shaped to suit operating requirements without undue difficulty. In this paper, attention is confined to the separately quenched amplifier.

The three states, positive loss, zero loss, and negative loss are traversed in sequence during the quench cycle. In the positive loss period, oscillations existing in the circuit which are unsupported by impressed signal energy die away exponentially as in Fig. 3 and the circuit is thus cleared of its previous history to prepare it for the reception of new message data. The circuit next passes into the zero loss period, during which the impressed signal energy builds up voltages across the circuit which depend in a rather complex manner on time and the freqency and phase of the signal voltage at the time when the transition into the zero loss region occurred. One of the possible forms of voltage variation during this interval is shown in Fig. 4. The zero loss

# of Superregenerative Receivers

First of Two Parts

period is followed by the negative loss period in which oscillations build up exponentially in the tuned circuit to a final value linearly related to the envelope of the voltage wave in the circuit at the beginning of the negative loss period, and exponentially related to the negative resistance in the circuit and the duration of the negative loss condition. Oscillations in the circuit at the end of the negative loss or build-up period are usually from 50,000 to 100,000 times greater than those existing at the beginning thereof. The build-up envelope may be represented by the expression $E = Ae^{at}$ in which "A" represents the strength of the circuit oscillations at the beginning of the build-up period (A in the absence of signal may have a minimum value of approximately 2 microvolts due to thermal agitation voltages and in the presence of a signal will have a value controlled by said signal in a manner to be further examined) and e^{at} is the build-up or amplification factor which, as noted above, may have a value between 50,000 and 100,000 and is controlled by the magnitude of "a", the decrement factor, and "t", the duration of the build-up or negative loss period.

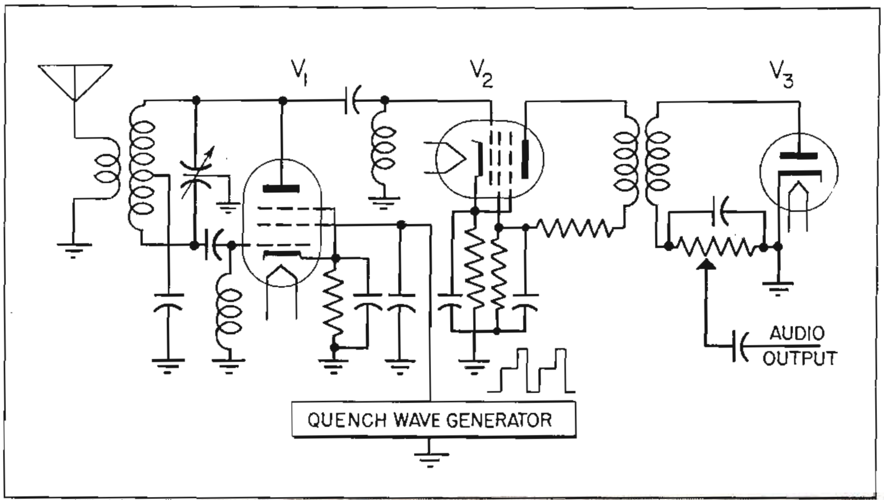


Fig. 1: Schematic diagram of superregenerative receiver with peak actuated detector

Two Classes of Receivers

Now, it is clear that if the build-up period be very long, the oscillations may reach a value beyond the capacity of the tube to respond linearly, due to the flow of grid current, for example. In this respect superregenerative receivers may also be divided into two classes. In one class oscillations are permitted to build up to a magnitude causing the tube action to become non-linear, whereupon no further increase occurs with time. Because, under these conditions, the anode current increments are logarithmically related to the signal intensity, this is designated the logarithmic mode of operation. In the other class, the oscillation magnitude is always held to limits within the linear response region of the tube and the oscillation amplitude at the end of the negative loss period is linearly related to the input signal strength. The second type of operation is therefore called the linear mode. The work in this paper is confined to a consideration of the linear mode since a determination of the ultimate limit of selectivity performance is desired and this mode of operation normally affords better performance in this respect than the logarithmic mode.

From the above presentation, it is evident that there are three functions successively performed during any quench style. First, the circuit is cleared of stored energy in preparation for the receipt of a message sample; this is the positive loss or decay period. Second, the circuit selects the signal at the desired frequency and stores circulating energy derived therefrom; this is the zero loss period. Thirdly, the circuit amplifies the selected signal by building up the energy in the circuit exponentially under the control of the energy level in the circuit at the end of the zero loss period; this is the build-up or negative loss period. In view of the diverse functions of the various portions of the quench operating cycle, it is only reasonable to expect that the characteristics of the receiver will depend to a certain extent upon the fraction of the quench cycle allotted to each of the three states. As the quench wave is a voltage wave, and each of the three states corresponds to a different voltage level, a change in the fraction of a quench period apportioned to a given state corresponds to a change in the wave form of the quench voltage wave. If a major portion of the quench voltage wave places the receiver in the zero loss state, a more selective receiver would be expected than when the quench voltage wave causes the circuit to traverse the zero loss region quickly, and thus there are explained some of the troublesome variations in selectivity obtainable with a given set of components at a given quench frequency; they were caused by nothing more or less than irregularities in the quench wave form. In design, we may make up for a short time allotted to the decay period by providing means for heavily loading the resonant circuit during this interval, as shown by Armstrong in his original patent. We may also make up for a short time devoted to the build-up period by increasing the positive feedback factor. There is, however, no substitute for time spent in the zero loss

(*Please turn to next page*)

state in providing selectivity, and for this reason, a highly selective superregenerative receiver must have a quench wave form such that a major portion of the quench period is passed in the zero loss state.

Linear Mode Receiver

In the subsequent development of performance data, a linear mode receiver of the type shown in Fig. 1 has been assumed. In this circuit, the tube V1, of the pentode type, is regeneratively connected to a simple tuned circuit. A quench wave of the idealized form shown in Fig. 2 is impressed on the screen grid from any suitable generator and varies the gain of the tube successively through values placing the circuit in the decay state, the zero loss state and the build-up state. During wave section 1 of Fig. 2, the screen voltage is reduced to zero and oscillations in the circuit die away as shown in Fig. 3. Wave section 2 elevates the screen potential so that the losses of the tuned circuit are just balanced and voltages build up in the tuned circuit under the action on the impressed signal. When the impressed energy is at the resonance frequency of the tuned circuit the oscillations build up as in Fig. 4. Wave section 3 next drives the screen sufficiently positive to cause the tube to appear to the tuned circuit as a relatively low negative resistance shunt causing exponential build-up of oscillations as shown in Fig. 5. Figs. 4 and 5 are not drawn to scale but are merely presented to indicate in a general manner the events occurring within the circuits. To scale them would be impractical since the initial value of the expanding oscillation train in Fig. 5 is normally only 1/100,000 of the final value thereof and this initial value, in turn, is equal to the final value of the expanding oscillation train in Fig. 4.

Voltages appearing across the input tuned circuit are impressed on the control grid of the following amplifier V2 via a coupling capacitor, and the amplified output of V2 is then impressed on an aperiodic coupling transformer whose secondary is connected to the diode detector V3 providing across the capacitor and resistance combination connected in the cathode-anode circuit a voltage proportional to the peak radio frequency voltage appearing across the secondary of the aperiodic transformer. The voltage appearing across the audio output potentiometer is therefore controlled by the amplitude of the RF voltage at the time t_0 in the quench cycle. For practical purposes, this voltage, which is the peak attained at the end of the build-up period is controlled solely by the conditions in the tuned circuit at the time t_2. How it is controlled by these conditions will now be examined. Consider the circuit, Fig. 6, in which L and C represent the inductance and capacity of the tuned circuit and R is the shunt resistance presented by the tube V1. In the interval t_2-t_0 R is numerically negative. Solution of the circuit equations shows that the current through the induction is:

$$i = \epsilon^{-\frac{t}{RC}}(C_1 \sin \omega_0 t + C_2 \cos \omega_0 t) \ldots\ldots (1)$$

the constants being determined by the initial conditions. If, initially, the voltage across the capacitor is V and the current through the coil is zero (all energy of the circuit stored

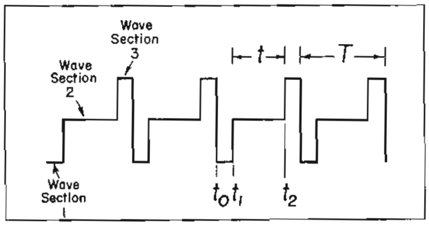


Fig. 2: Idealized quench wave form employed on screen grid for the purpose of analysis

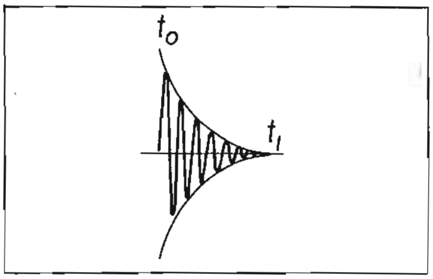


Fig. 3: RF circuit voltages—wave section 1

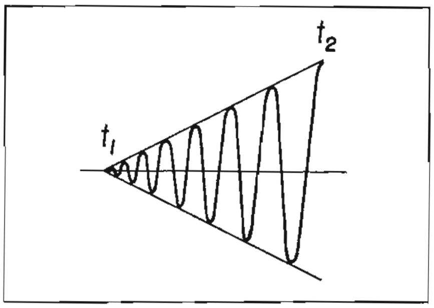


Fig. 4: RF circuit voltages—wave section 2

in the capacitor) then $C_2 = 0$ so that

$$i = C_1 \epsilon^{-\frac{t}{2RC}} \sin \omega_0 t$$

The voltage across the circuit is, of course,

$$L\frac{di}{dt} = Lc_1 \epsilon^{-\frac{t}{2RC}} \left(\omega_0 \cos \omega_0 t - \frac{1}{2RC} \sin \omega_0 t\right)$$

This has the value V when $t = 0$; $c_1 = V/\omega L$ and the voltage across the circuit is

$$E = V\epsilon^{-\frac{t}{2RC}} (\cos \omega_0 t - \frac{1}{2\omega_0 RC} \sin \omega_0 t$$

the envelope of this oscillatory voltage being

$$E = V\epsilon^{-\frac{t}{2RC}} \sqrt{1 + \frac{1}{4\omega_0^2 R^2 C^2}} \ldots\ldots (2)$$

An evaluation of the importance of the last term under the square root sign requires consideration of the usually encountered ranges of operating parameters. During the build-up period, R is negative and at the termination of this period the oscillation amplitude may be 100,000 times as great as that at the time t_2. The circuit is permitted to execute 20 or more cycles of oscillation during the build-up, usually more. In the expression, $e^{t/2RC}$, therefore, (note that R is here taken negative) $t = 20/f = 40\pi/\omega_0$. If $e^{t/RC} = 100{,}000$; $t/2RC = 40\pi/2\omega_0 RC = 11.5$; $1/\omega_0 RC = 0.0915$, showing that (2) may be written without appreciable error as

$$E = V\epsilon^{\frac{-t}{2RC}} \ldots\ldots (3)$$

The exponential term in this expression is a constant fixed by the receiver design and the quench wave form and it is now evident that the peak amplitude of the oscillation envelope at time t_0 is proportional to the voltage in the resonant circuit at the time the shunt resistance presented by the tube becomes negative, *provided* that the voltage in the tuned circuit has its maximum value at the time the resistance becomes negative. The voltage across the capacitor at the time the current through the inductance becomes zero is equal to the value of the envelope of the oscillations occurring in the circuit under these conditions.

It will now be shown that this is true for the practical operating range, whatever the start angle, by considering the other extreme of starting condition, that in which all the energy is stored in the inductance and the voltage across the capacitor is zero. The current in this case is chosen to correspond to the same oscillation envelope amplitude V. From the relation $LI^2/2 = CV^2/2$ it is found that the current at the time $t = 0$ is: $I = -(\sqrt{C/L})(V)$. Referring now to equation (1) and

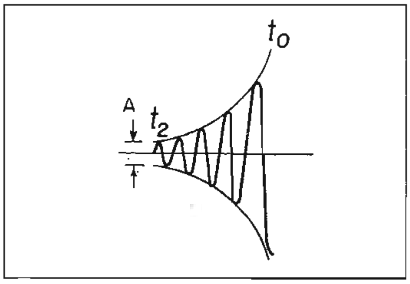


Fig. 5: RF circuit voltages—wave section 3

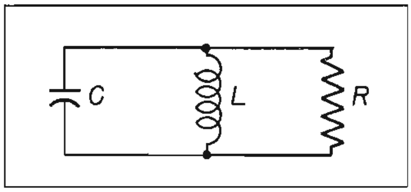


Fig. 6: Basic circuit for analysis (Fig. 1)

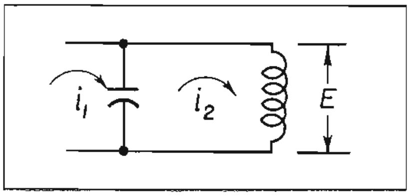


Fig. 7: Equivalent circuit for analyzing response to signal currents at resonance

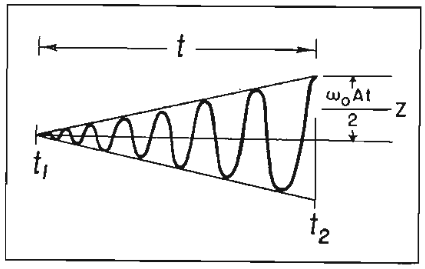


Fig. 8: Diagram of linear amplitude increase in oscillation voltage across circuit (Fig. 7)

evaluating the constants for the new boundary conditions: $C_2 = -(\sqrt{C/L})(V)$, derived from the insertion of the initial current value.

$$L\frac{di}{dt} = L\varepsilon^{-\frac{t}{2RC}}\left(\omega_0 C_1 \cos\omega_0 t - \frac{C}{2RC}\sin\omega_0 t - \omega_0 C_2 \sin\omega_0 t - \frac{C_2}{2RC}\cos\omega_0 t\right)$$

which is zero when $t = 0$, so that $C_1 = C_2/2\omega_0 RC = -(\sqrt{C/L}/2\omega_0 RC)(V)$.

Upon introduction of these constants, the voltage across the circuit is found to be expressed by:

$$E = V\varepsilon^{-\frac{t}{2RC}}\left(\omega_0\sqrt{LC} + \frac{\sqrt{LC}}{4\omega_0 R^2C^2}\right)\sin\omega t$$

the envelope of which is:

$$E = V\varepsilon^{-\frac{t}{2RC}}\left(\omega_0\sqrt{LC} + \frac{\sqrt{LC}}{4\omega_0 R^2C^2}\right) \ldots\ldots(4)$$

Now ω_0 is normally very nearly equal to $1/\sqrt{LC}$ and upon making this substitution (4) becomes:

$$E = V\varepsilon^{-\frac{t}{2RC}}\left(1 + \frac{1}{4\omega_0^2 R^2C^2}\right)$$

which, in view of the value found previously for the second term in parenthesis, may be written without excessive error as $Ve^{-t/2RC}$, an expression identical with (3). It may be considered, therefore, that the potentials delivered by the detector V3 are proportional to the envelope of the oscillation amplitude existing in the tuned circuit connected to V1 at the moment t_2 when the circuit passes into the negative loss region. In the absence of signal, the voltage existing in the circuit at the time t_2 is determined by the thermal agitation voltages and, since these vary with time, so also does the output of the detector V3 vary with time, giving rise to the familiar hissing noise. With signal present, the build-up process is under the control of an unvarying or intelligence modulated envelope voltage and the noise output vanishes. As any tuned circuit having negative losses builds up oscillations at the resonant frequency, all superregenerative receivers in which the detector is permitted to respond to these voltages have noise level sensitivity. The noise encountered in superregenerative equipment is merely that to be found in any highly sensitive receiver without squelch provisions. This is borne out by the experimental fact that the sensitivity of superregenerative receiving equipment is, when measured for same signal-to-noise ratio, hardly distinguishable from that of well designed conventional receiving equipment.

It has now been shown that the detector output voltage is directly controlled by the envelope of the voltage in the tuned circuit connected to the tube V1 at the time when the circuit losses become negative, which is at t_2. As conditions at t_2 determine the subsequent circuit action, practically independently of later stimuli, it is convenient to refer to this instant as the pick-up or ignition point, borrowing here from the gas tube terminology. Because the envelope voltages at the pick-up point directly control the detector voltage, in determining the selectivity characteristic of the receiver it will be sufficient to compare the circuit voltages existing at the pick-up point for various input frequencies. For reference, the response of the circuit to currents at the circuit resonance frequency is found.

Performance of Tuned Circuit

It is assumed that the circuit connected to tube V1 has been entirely cleared of stored energy during the decay period and that the signal voltages begin to build up from zero at the time t_1 with the circuit in the zero loss condition. The effect of deviation from this ideal condition will be later discussed. The performance of the tuned circuit is taken as equivalent to that of such a circuit fed from a constant current source, this being justified by the normally loose antenna coupling and by the practice of inserting a high plate impedance buffer amplifier between the antenna stage and the superregenerator stage.

Writing the circuit equation for Fig. 7 results in the expression: $(d^2i_2/dt^2) + (i_2/LC) = i/LC$. The following facts are known about the circuit shown; since the circuit is entirely cleared of energy at the time $t = 0$, i_2 and E both have the zero value at this instant, the resonant angular velocity of the circuit is ω_0, which is also the angular velocity of the impressed current i_1, and for convenience an arbitrary start angle α is assumed for the current i_1. Thus, $i_1 = \omega_0^2 A \sin(\omega_0 t + \alpha)$, permitting the previous equation to be written: $(d^2i_2/dt^2) + (i_2/LC) = \omega_0^2 A \sin(\omega_0 t + \alpha) = D^2 + \omega_0^2$, whose complementary solution is $i_2 = c_1 \sin\omega_0 t + c_2 \cos\omega_0 t$. The particular solution is derived by the employment of the relation

$$\frac{\sin(\omega x + \alpha)}{\phi(D^2)} = \frac{\sin(\omega x + \alpha)}{\phi(-\omega^2)} \ldots\ldots(5)$$

$$i_2 = \frac{\omega_0^2 A \sin(\omega_0 t + \alpha)}{D^2 + \omega_0^2}$$

which becomes indeterminate upon making the substitution indicated by equation (5). The indeterminacy is resolved by employing for the angular velocity of the impressed current $\omega_0 th$ rather than ω_0, letting h approach zero in the resulting expression. Thus

$$i_2 = \frac{\omega_0^2 A \sin[(\omega_0 + h)t + \alpha]}{-(\omega_0 + h)^2 + \omega_0^2}$$

$$i_2 = \frac{\omega_0^2 A}{-2\omega_0 h - h^2}\left[\sin(\omega_0 t + \alpha)\cos ht + \cos(\omega_0 t + \alpha)\sin ht\right]$$

for which may be written, as "h" approaches zero,

$$i_2 = \frac{\omega_0 A}{2h}\left[\sin(\omega_0 t + \alpha) + ht\cos(\omega_0 t + \alpha)\right]$$

The complete solution for i_2 is then:

$$C_2 = C_1 \sin\omega_0 t + C_2 \cos\omega_0 t - \frac{\omega A}{2h}\sin(\omega_0 t + \alpha) - \frac{\omega_0 At}{2}\cos(\omega_0 t + \alpha) \ldots\ldots(6)$$

in which the constants have yet to

(*Continued on page 57*)

Antenna Input Systems

Features of signal transfer in the four general types of tuner circuits analyzed

By **D. E. FOSTER,** *Vice President, Hazeltine Research Inc. of California*

THERE have been many types of circuits used and still more proposed for connecting the transmission line input from the antenna to the input of the first tube. This paper will not attempt to cover all such specific circuits that have been proposed but will deal with the four general types into which these circuits fall. These are: (a) Tuned Input to tube grid, (b) Input to grid and cathode, (c) Cathode input, (d) Push-pull grid input. In considering all of these systems it will be assumed that the signal input is through a 300-ohm transmission line from the antenna.

Fig. 1 shows a typical circuit for connecting the antenna input to the grid of a pentode tube. Since a broad pass band of approximately 6 MC width is desired, no physical capacitance is used; the circuit capacitance being that of the tube input, distributed capacitance of the coil and associated wiring. Since the capacitance is not from a physically added capacitor it is shown dotted. Similarly the circuit damping, being primarily that due to the tube input conductance is shown dotted at R_2. With some tube types at the lower frequencies a physical resistor is sometimes added to achieve the desired bandwidth.

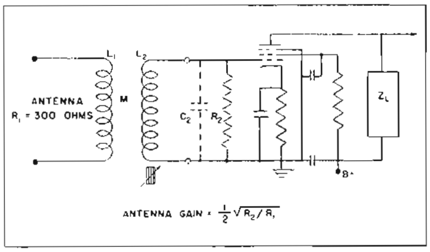


Fig. 1: Antenna input to tube grid circuit

The gain is that from antenna voltage to the tube grid and applies when the mutual inductance is adjusted for correct impedance match. The factor 1/2 arises because antenna gain is in terms of open circuit voltage and the transmission line impedance appears in series with the open circuit voltage.

The circles indicate the points in the circuit normally switched for selection of the several channels. As indicated, a movable core, usually of brass, is commonly used in this circuit to adjust to the center of the desired channel.

With many types of tubes the input resistance on the higher channels is so low that a greater than desired bandwidth is obtained. A bandwidth of 5.5 to 6.5 MC is ordinarily desired in the RF system but on the higher channels the tube input conductance may give bandwidths four to five times as great. One means of obtaining narrower bandwidths is shown in Fig. 2. Here a series capacitor C_1 is added to provide an impedance transformation in conjunction with the tube input capacitance C_2. The impedance and voltage ratios apply only when, as is normally the case, the reactance of C_2 is appreciably smaller than the resistance R_2. The use of a series capacitor has a further advantage in that it makes L_2 larger, as L_2 frequently becomes unmanageably small at the higher frequencies.

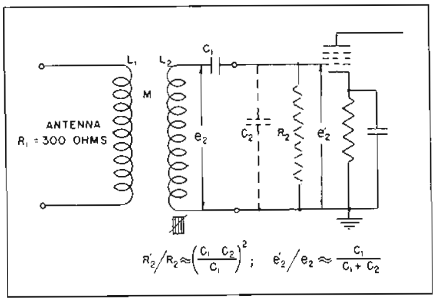


Fig. 2: Using series capacitor (C_1) to obtain narrower bandwidths at high frequencies

In Fig. 3 the signal as applied to both grid and cathode permits a balanced input. Coil L_1 provides a center tap ground and is designed to tune out the tube capacitance so that the input impedance will be primarily resistive. It is usually necessary to add a resistor R_1 in parallel with the tube input conductance represented by R_2 to give an average input resistance of 300 ohms over the entire television range. Because of the low resistance damping, the bandwidth will be large, of the order of 70 MC. However, more uniform gain will be obtained if a different value of L_1 is used for the high band than for the low band. L_1 is preferably resonant in the center of each band. In order to make the input conductance of the tube more uniform with frequency, an unbypassed cathode resistor R_3 has often been used with this circuit, although this results in some decrease in gain from the resultant degeneration. As indicated, when the loading due to R_1 and R_3 is 300 ohms the antenna gain is 1/2, i.e. a loss of 6 DB. This is the loss only from the antenna to the tube input and does not include any loss

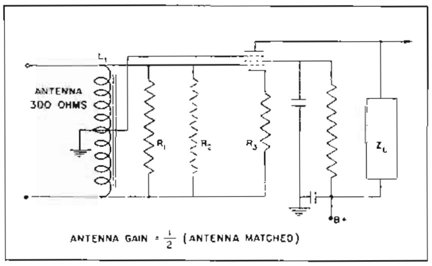


Fig. 3: Balanced input type circuit where signal is supplied to both grid and cathode

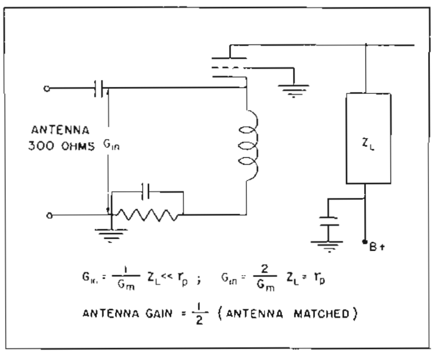


Fig. 4: Grounded grid triode type circuit

for Television Receivers

through the tube, due to use of R_3 unbypassed.

A grounded grid triode with input to the cathode has been used in some television receivers. The basic circut is shown in Fig. 4. This circuit has the advantage of low input tube noise since it is a triode but has the difficulty of being unbalanced which tends to increase susceptibility to ignition noise and some other types of interference and may give inferior performance on folded dipole antennas where the center of the dipole is grounded. There is a further disadvantage in low gain due to degenerative effect of the cathode load. As indicated, the "gain" from antenna to tube input is −6 DB, the same as for Fig. 3. This again does not include the further loss in the tube from degeneration.

Since this circuit uses a triode the plate impedance may not be very large compared to the load impedance, as is the case with pentodes. The plate impedance under commonly used operating conditions will be of the order of 15,000 ohms. Since the load impedance cannot be higher than the input resistance of the following tube, which in the high band may be less than 1000 ohms, the first expression for input conductance, the case where the load impedance is much smaller than the plate impedance, is the condition which normally applies. As the load impedance approaches the plate impedance in magnitude the input impedance increases, reaching $2/G_m$ when Z_L equals r_p as shown by the second expression.

A type of input system which has been used on several television models is shown in Fig. 5. This is a push-pull system, hence has balanced input and is low in noise due to use of triodes. Because the tubes are triodes, neutralization is necessary to prevent regeneration. The neutralizing capacitors are shown as C_1 and C_2. Resistors R_1 and R_2 are chosen to make the input impedance as near as possible 300 ohms over the television range, taking into account the tube input conductance. As in other types of fixed tuned input circuits there is 6 DB loss from the antenna to grid input.

There is one type of spurious response which has given some difficulty on television receivers that has not been encountered on other types of receivers. The conditions under which this occurs are shown in Fig. 6. If the receiver is tuned to channel 6, where the picture carrier is at 83.25 MC, with a picture IF of 26.25 MC the oscillator will be at 109.5 MC. If any of this oscillator energy is present on the RF grid and a signal at 193.25 MC is also present from a channel 10 station, a beat will occur between the resultant of the channel to signal and oscillator and the channel 6 signal.

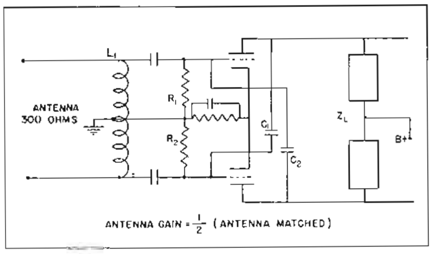


Fig. 5: Push-pull triode input system

TUNE TO CHANNEL 6

Channel 6	Picture carrier	83.25 MC
	Oscillator	109.5
Channel 10	Picture carrier	193.25 MC
Channel 6	Oscillator	109.5
		83.75 MC

OTHER COMBINATIONS

Tune to Channel	"Image" Interference	
2	Channel 8	Sound
	Channel 9	Picture
3	Channel 10	Sound
	Channel 11	Picture
4	Channel 12	Sound
	Channel 13	Picture
	Direct Interference	
5	Channel 8	Picture
	Channel 7	Sound
6	Channel 10	Picture
	Channel 9	Sound

Fig. 6: Table of spurious responses that occur with oscillator energy on RF grid

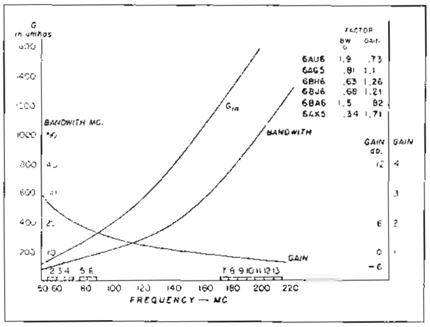


Fig. 7: Gain, bandwidth vs. frequency curves for several pentode tube types used in TV

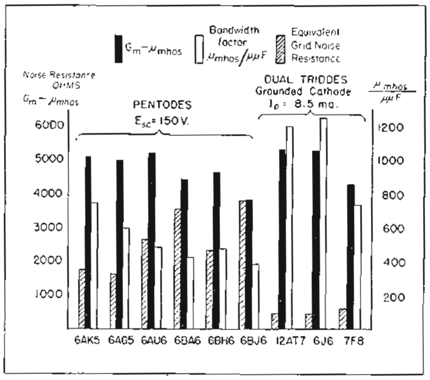


Fig. 8: Comparison of bandwidth factor, noise and transconductance for nine types of tubes

In the case shown, the spurious resultant is very close to the desired picture carrier so that subsequent selectivity has no effect. This type of response is particularly likely with untuned input systems since then there is no attenuation of the interfering signal on the RF grid. To prevent this type spurious response care should be taken in design to see that there is a negligible amount of oscillator energy on the RF grid.

Fig. 6 also shows other possible combinations which can result in a beat falling within the IF pass-band. Those marked "image" are cases where the resultant of the oscillator on the desired channel and the interfering signal is located above the oscillator by the IF. These are in general less serious than those falling directly in the desired channel because the RF circuits will, as in the case of ordinary image response, attenuate the undesired resultant. With a higher IF this type of response is less likely but may still be present. For example, with a picture IF of 45.7 MC the picture carrier of channel 8 can interfere on channel 4, the sound carrier on channel 11 can interfere with channel 5 and the sound carrier of channel 13 can interfere with channel 6.

The input conductance, and its influence on gain and bandwidth over the television range for several of the types of pentode tubes most commonly used in television receivers, is shown in Fig. 7. The curves do not apply to any specific type but to a hypothetical tube having an input conductance of 400 micromhos at 100 MC. By multiply-

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ing the values for any frequency, as shown on the curves, by the factor opposite the tube type the value of interest for that type tube may be found. One factor applies to both bandwidth and input conductance since these vary as the first power of input resistance. Another factor applies to gain since that varies as the square root of the input resistance.

The curves apply to the tuned circuit input of Fig. 1 and are calculated for matched input. This means that the bandwidth is twice as great as would be the case if the primary (antenna) resistance were not coupled into the secondary. The bandwidth obtains a secondary capacitance of 10 μμf which is a typical value for television receivers. The bandwidth is that for 3 DB attenuation as given by the well known expression applying to a single tuned circuit, $G = \Delta\omega C$; where G is total circuit conductance, $\Delta\omega$ is 2π times bandwidth, and C is tuned circuit capacitance.

Other tube characteristics of interest are transconductance, bandwidth factor and fluctuation noise. These are shown for several tube types in Fig. 8. The bandwidth factor is an approximate measure of the merit of the tube in a wide band amplifier and is equal to the ratio of transconductance to the sum of the input and output capacitances. The measure of noise is the equivalent grid noise resistance. From this resistance the RMS noise voltage at the input of the tube equivalent to the noise actually produced by the tube at ordinary room temperatures may be found from the expression $E = 4.0\sqrt{R\Delta f}$; where E is noise voltage in microvolts, R is noise equivalent resistance in kilohms, and Δf is bandwidth in megacycles.

The values for triodes are for a grounded cathode connection but the relative merit would be substantially the same for the grounded grid connection. In order to compare the triodes the data is for the same plate current for each type. Similarly for pentodes the data is for a screen potential of 150 volts and normal bias for each tube. In determining the bandwidth factor for triodes the added input capacitance due to the Miller effect of the grid-plate capacitance must be taken into account. The data shown are for a multiplying factor of one for C_{gp}, corresponding to the approximate factor when the tube is used with low RF plate load such as in a converter for example.

In considering input systems the effect of such systems on the gain of the first tube must be taken into account. In Fig. 9 is shown a pentode amplifier followed by a single tuned circuit and without cathode degeneration. In such cases the common gain expression $G_m Z_L$ applies. The plate is usually shunt fed by a resistor indicated by R_p on the figure. Even for moderately low resistance values of 5000 to 10,000 ohms the effect of this shunt feed on the load impedance is small because the input conductance of the following tube has so much more effect over most of the frequency range. The following tube is nor-

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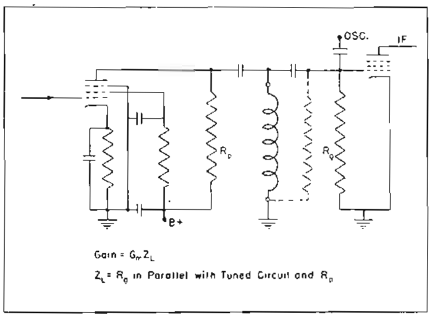


Fig. 9: Pentode RF amplier, without cathode degeneration, followed by a tuned circuit

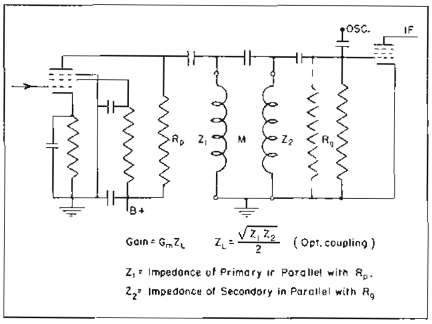


Fig. 10: Fixed tuned inputs use pair of tuned circuits between RF and converter tubes

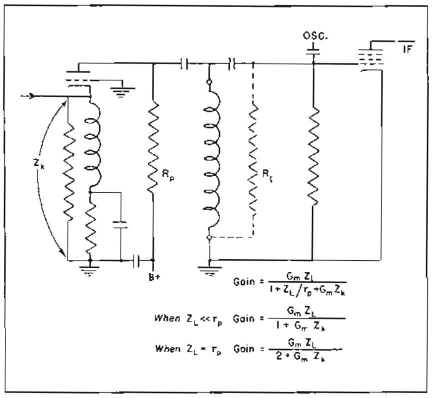


Fig. 11: Grounded grid triode circuit suffers degeneration losses in cathode lead

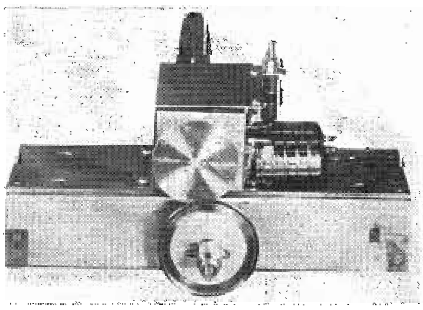
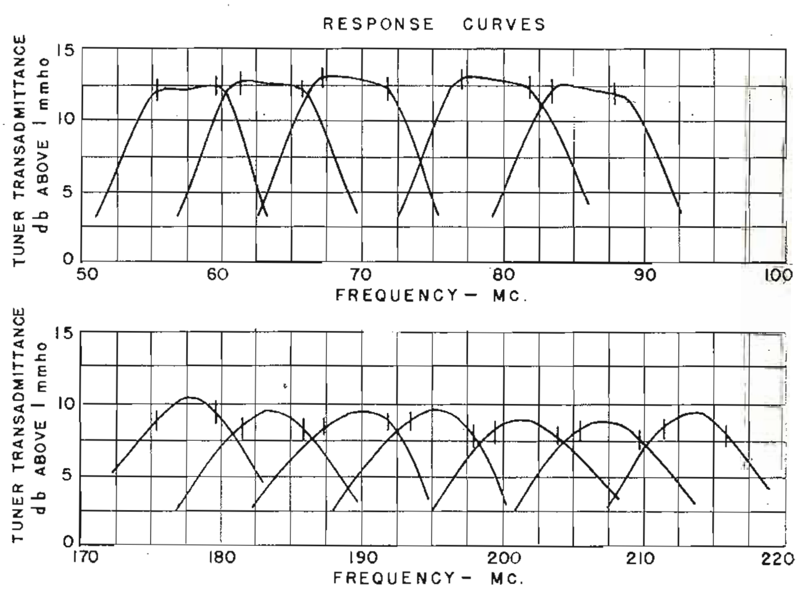


Fig. 12: New Hazeltine tuner shown above incorporates design principles discussed

Fig. 13: Response curves measured on commercial tuner of the type shown at left



Oscillator and Mixer Circuits for TV Receivers

Low noise, conversion efficiency, adequate bandwidth, selectivity contribution, and degree of re-radiation are limiting factors for optimum performance

By F. R. NORTON, Principal Research Engineer, Bendix Radio Div., Baltimore, Md.

AMERICAN television requirements have led to the universal use of superheterodyne receivers with the oscillator on the high side of the desired channel, at least on the low channels (54 to 88 MC). With conventional IF design, a separate sound IF amplifier is used and sound traps are placed in the picture IF, hence the oscillator spacing must be the same on all channels. With inter-carrier sound there must be a 4.5 MC sound trap in the video output and there is often no adjacent sound trap so the IF response can be made symmetrical and the oscillator placed on the low side of the upper channel carriers, if desired.

For different IF choices the oscillator frequency range is somewhat different but in any case the oscillator stability is a serious problem. If the oscillator top frequency is 258.55 MC (channel 13 sound carrier of 215.75 MC plus 42.8 MC, proposed RMA sound IF) and the sound IF band is not over 600 KC wide, then the maximum allowable drift from center is less than 0.1%. Crystal oscillators are not used because several crystal oscillators are too expensive for a home receiver and for the 12 channels, the oscillator frequency spacings do not lend themselves to a simple crystal saver scheme. A two terminal L-C oscillator is generally used to simplify switching. If station switching or pushbutton resetability be considered along with variations in temperature, tube and circuit drift, and power supply variation, it is obvious that unless inter-carrier sound be used either some form of AFC or a manual fine tuning control must be used.

At present most commercial TV receivers do use a manual fine tuning control since it is difficult to design a suitable AFC circuit and it is likely to be more expensive in manufacture than the manual fine tuning. Generally one or more negative temperature coefficient capacitors are used in the oscillator circuit to compensate for other positive coefficient circuit elements.

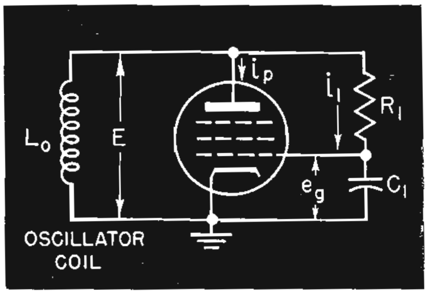


Fig. 1: Simplified schematic diagram to show AC paths in reactance control tube circuit

An AFC circuit must be carefully designed or the additional loading which it introduces may stop the oscillator, especially on the high channels. A reactance control tube, when shunted across an oscillator, can be made to simulate a variable reactance by drawing a variable plate current in quadrature with the oscillator. This effective reactance is varied by changing the bias and hence the transconductance of the control tube.

Fig. 1 shows a simplified schematic omitting DC potentials. Assume r_p, the plate resistance, much larger than R_1 and R_1 much greater than $1/j\omega C_1$, and that the resistance of L_0 is negligible. Then $e_g = i_1/j\omega C_1$ and $i_1 = E - e_g/R_1 = E/R_1$ approximately, so $e_g = E/j\omega C_1 R_1$.

Then $i_p = e_g G_m = EG_m/j\omega C_1 R_1$ where G_m = transconductance of the tube.

Then $Z_0 = E/i_p = j\omega C_1 R_1/G_m$ is the effective plate impedance of the tube, or $L_1 = R_1 C_1/G_m$ is the effective inductance induced by the control tube.

Several other networks, for example an auxiliary inductance and resistance, can be used at any one frequency, or over a restricted range, to shift the phase of the oscillator voltage applied to the grid of the reactance tube. But over the frequency range needed in TV a single inductance is not suitable for use in such a network, and so a simple R and C network is preferable. At 250 MC the input capacitance of the tube grid itself has such low reactance that no external capacitor need be used for C_1. The position of R_1 and C_1 can also be reversed, using a triode for example with the grid-plate capacitance for C_1 and a grid resistor of 100 ohms or so for R_1.

One commercial TV design uses the oscillator shown in Fig. 2 with a two terminal tuning coil in a turret with a shunt feed coil. The second section of the 6J6 tube is used as a reactance control tube to maintain automatic frequency control and so eliminate the necessity for a fine tuning control. The sound discriminator (or ratio detector) output is filtered and the DC component provides the bias for the grid of the reactance control tube. If the local oscillator tends to drift in frequency the change in sound IF average carrier frequency produces a change in AFC bias which restores the 6J6 oscillator to the correct frequency.

The above discussion has assumed an unbalanced oscillator circuit. A balanced oscillator can be quite easily frequency controlled by a balanced (twin-triode) reactance control tube, but such a design is expensive. If an unbalanced reactance control tube circuit is used, it tends to unbalance the oscillator and is less satisfactory.

We venture to predict that inter-carrier sound will grow in popularity and if suitable transmitter standards are adopted by the broadcasters to avoid picture over-modulation or phase modulation, there will be no

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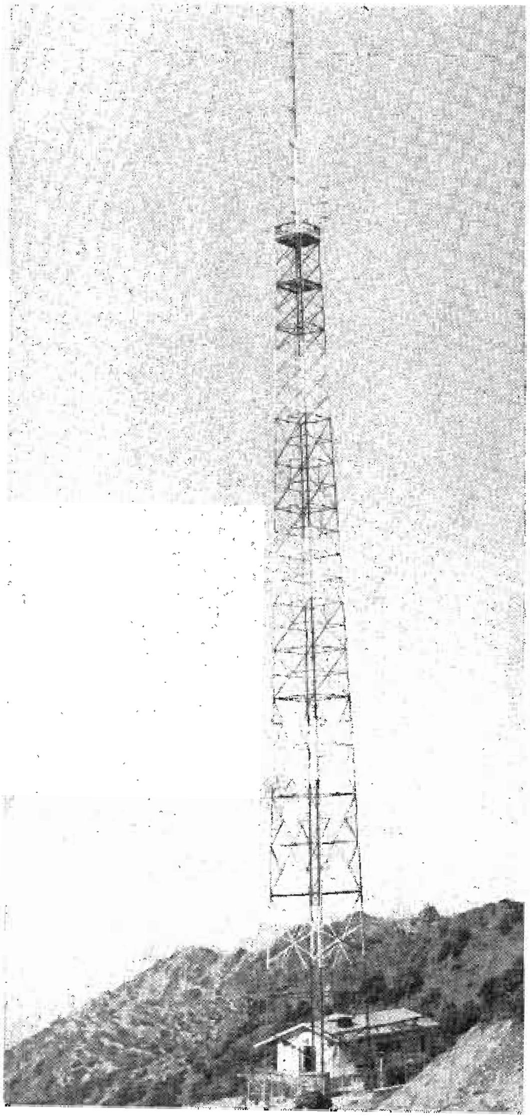
KSBR Represents New Approach to FM Broadcasting

Aerial view of transmitter installation atop Mt. Diablo. Horizon line is snow covered Sierra-Nevada Mountain Range some 150 miles distant

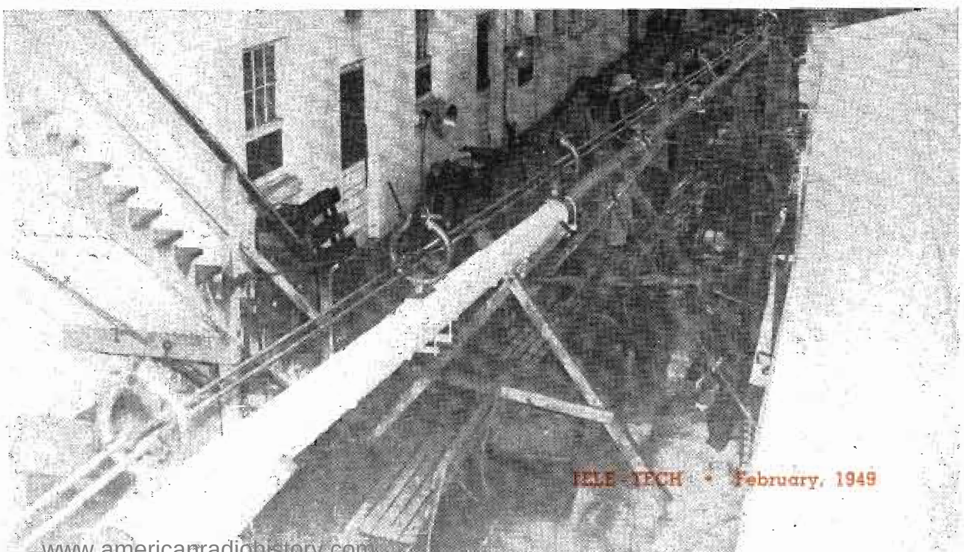


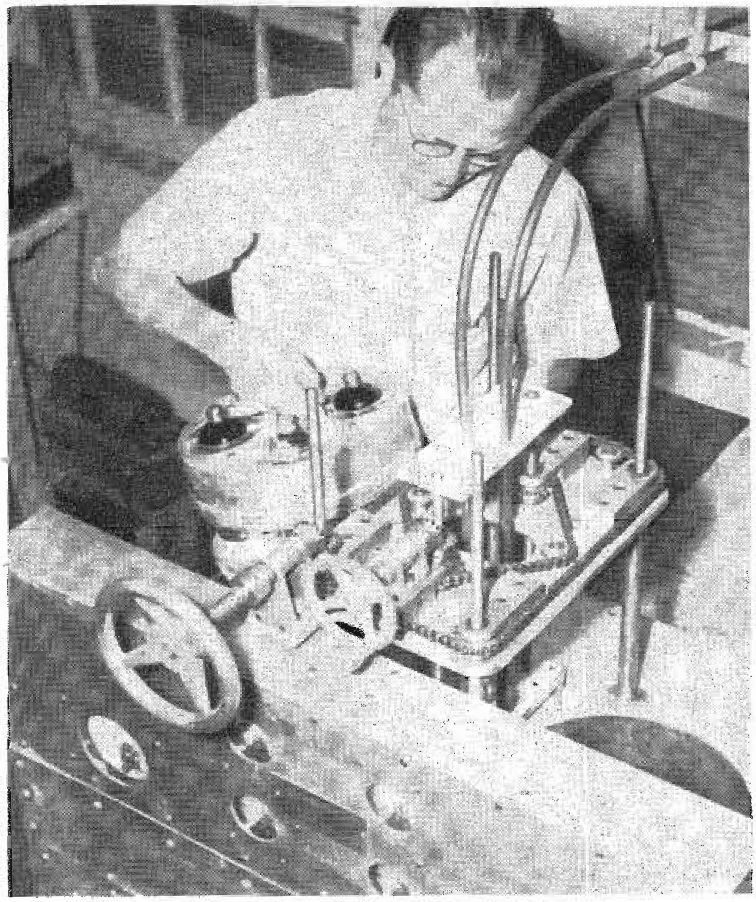
WITH studios located in San Bruno and the transmitter located atop 3849 ft. Mount Diablo some 32 air miles away, station KSBR's effective radiated power of 250 KW at 101.5 MC provides FM service to approximately 4 million residents in 35 of California's 58 counties. Communication between the studios and the transmitter site is carried on entirely by air, with a radio telephone link being used to instruct operating personnel and a 15-watt ST microwave link operating at 940.5 MC, being used to convey program material. It is this latter feature which gives KSBR the "new look" in FM broadcasting since the installation demonstrates the feasibility of choosing a transmitter site location mainly on the basis of maximum area to be covered as contrasted to many stations whose transmitter sites have been chosen in view of existing tower installations, availability of utilities, etc.

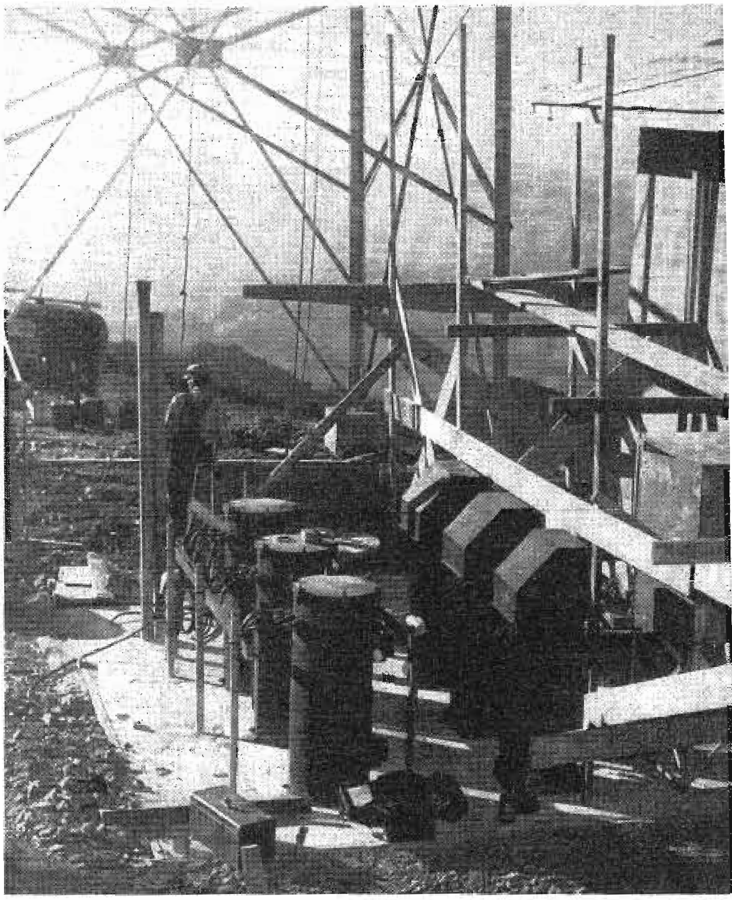
The transmitter atop Mount Diablo was designed and built by Eitel McCullough using two of their type 3X125003A3 triodes in the final amplifier of the 50 KW transmitter.

Seven "doughnuts", full wave spaced, comprise the transmitting antenna which measures approximately 80 ft. overall. An open wire type transmission line carries the signal up the 280-ft. tower to the antenna with points of zero RF potential being used for fastening.

Left: 80-ft. antenna composed of seven full-wave spaced "doughnuts" mounted on 280-ft tower
Below: Antenna during pre-tuning operations. Note use of open wire type transmission line





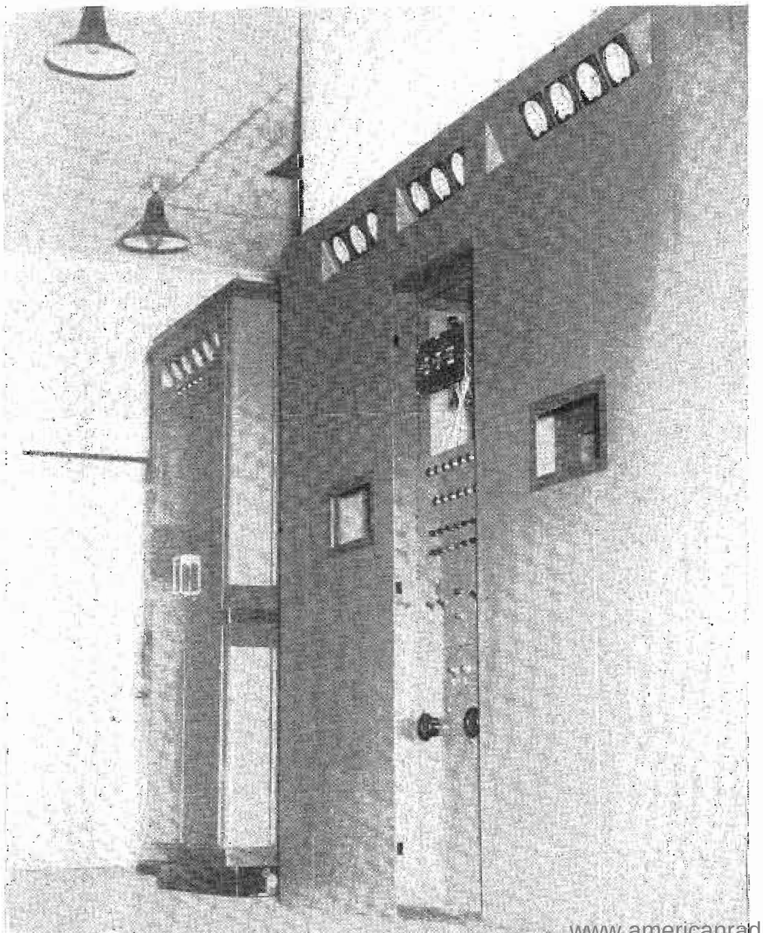


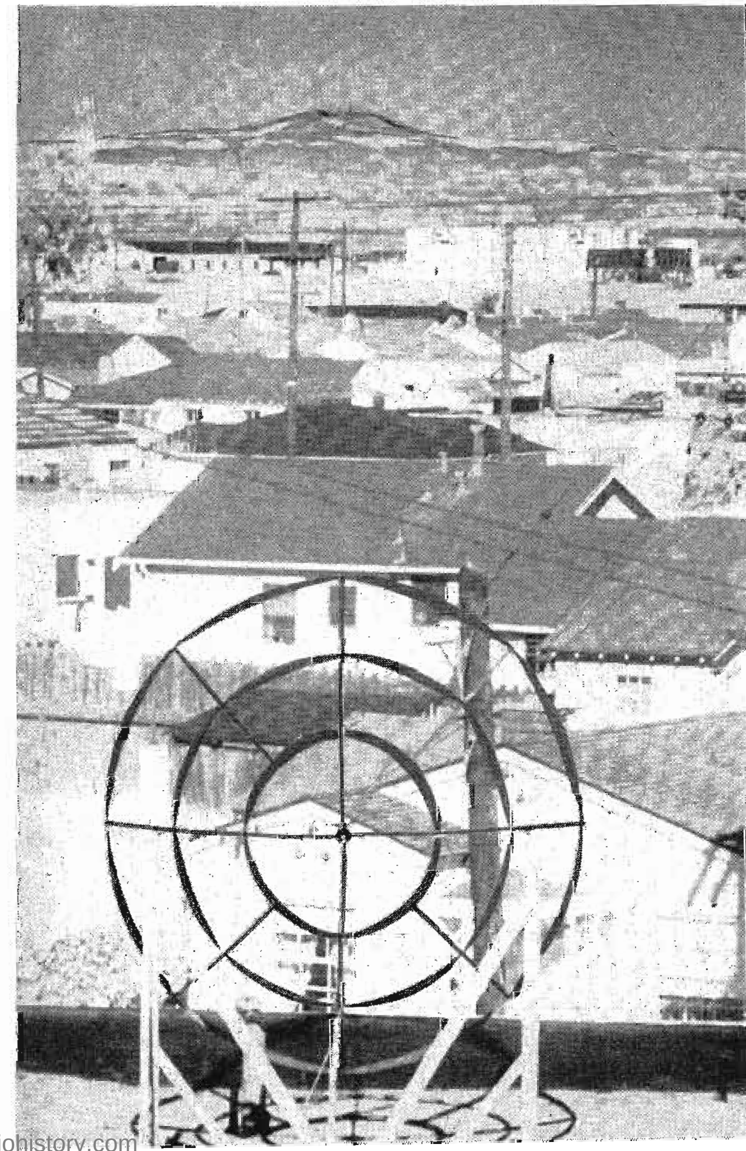
Above-left: Installing Eimac 3X12500A3 triode in 50 KW amplifier

Above-right: 150 KW power sub-station located at transmitter site

Below-left: Transmitter panel view includes 50 KW final amp. (center), 10 and 3 KW driver stages (right) REL modulator (rear)

Below-right: STL transmitting antenna atop San Bruno studio aimed at transmitter site (barely visible on horizon) 32 miles away





Overall Systems Planning for

Voice carriers, multiplexed circuits and microwave relay links when properly integrated provide far more service on wire lines with small, less costly equipment

By ***HOWARD H. SMITH,*** *Telephone Systems Engineer, Federal Telephone & Radio Corp.*

FROM the earliest days of telegraphy, when the demands upon a line exceeded its capacity, attempts were made to multiplex circuits, i.e. transmit more than one channel simultaneously over a single transmission path. Starting with very cumbersome and expensive equipment for multiplexing only one channel — limited in usefulness to long lines — the art has made substantial advances so that to date three channels or more may be multiplexed at a fraction of the cost and size, meeting the economical requirements of even short lines. A great field of application exists for such circuits by public utilities, railroads, government services and private industrial and utility enterprises, such as power networks, oil lines, and mining enterprises.

Simultaneous transmission of a multiplicity of channels may be accomplished in one of two ways. One system, known as the frequency-division method, identifies each channel with a separate sub-carrier frequency. Each message circuit modulates the sub-carrier identified with its channel. The modulated sub-carriers are then combined directly for wire transmission. At the receiver terminal, these channels are then separated by frequency selection and the sub-carrier filtered out, restoring the original signal.

The second system of multiplexing is known as time-division multiplexing. In this case, samples of each channel are transmitted in time sequence. That is, the instantaneous amplitude of the first channel signal is transmitted. Then the instantaneous amplitude of the second channel signal is transmitted. When all channels are sampled, the process is repeated. The frequency of sampling is sufficiently large — 8,000 times a second for voice frequencies — so that the listener hears "continuous" sound.

The time division method of multiplexing is not generally applicable to wire transmission systems and the equipments to be described in this article all employ frequency division. Before delving into a description of this equipment, however, a brief review of some of the more important theoretical and practical considerations governing the design and installation of frequency division carrier systems is necessary.

For good quality speech transmission, a modulation bandwidth of 300 to 2700 cps is required. When a wire line is to be multiplexed for additional speech channels, the frequency spectrum above the normal telephone circuit must be used. For carrier transmission of a conversation in both directions over a single

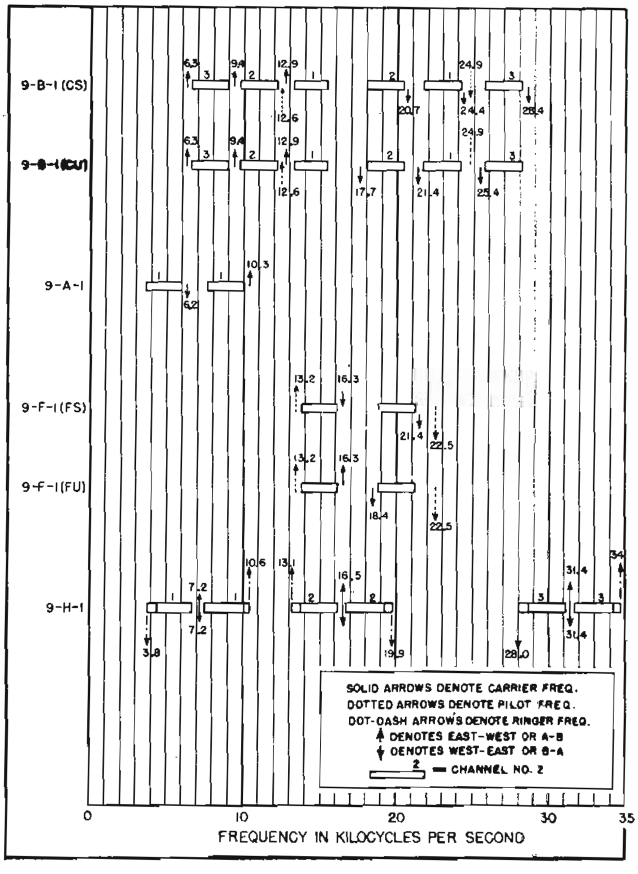
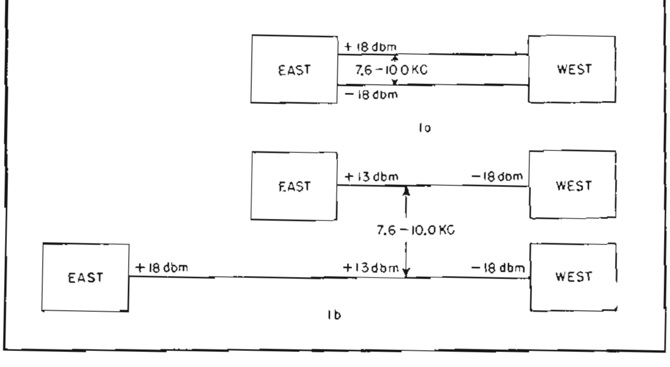


Fig. 2: Standard carrier frequency system for wire transmission developed to minimize cross-talk between carriers on adjacent pairs and to standardize components

Fig. 1: (a) Illustrates carrier transmission over adjacent pairs with difference in signal level and (b) adjusting signal level of one carrier to be equal to that of another carrier on adjacent pair



Multi-Channel Telephone Carriers

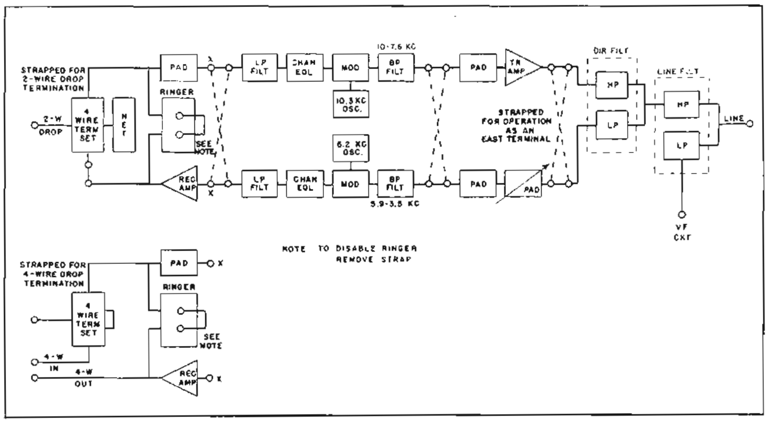


Fig. 3: Block diagram of FTR 9-A-1 single channel carrier telephone system.

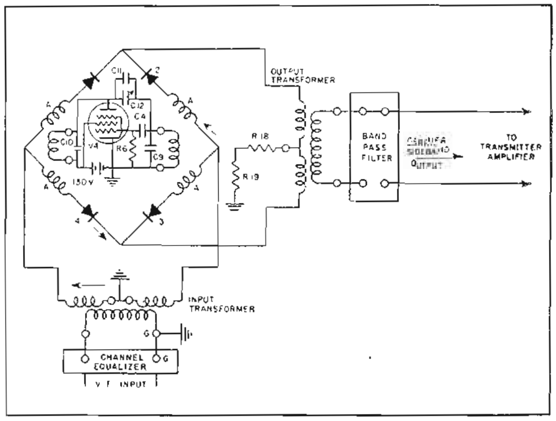


Fig. 4: Schematic diagram of the modulator unit

pair of wires, different carrier frequencies must be utilized for each direction so that the input signal may be separated from the output at the terminal. Since carrier-suppressed, single-sideband operation is generally employed, the lowest frequencies for transmission of a single channel would be 3 to 6 KC in one direction and 6 to 9 KC in the other.

Each such unidirectional channel assumes that an ideal filter is used, but such a filter can only be approached in practice, and the closer it does achieve these characteristics, the more expensive and bulky the filter becomes. Hence from an economical filter design viewpoint it is desirable to separate the channel sidebands as much as possible, thus permitting a more gradual cut-off characteristic and a cheaper design.

On the other hand the transmission characteristics of a cable or open-wire line are such that the attenuation of the signal increases as the frequency increases, due mainly to its capacity. From this viewpoint, therefore, it is desirable to space the carriers as close as possible, particularly since additional channels will have to be multiplexed at even higher frequencies. The engineer must therefore effect a compromise between economical filter design and frequency spectrum conservation. It should be noted also that for the same filter cost, the spacing between channels must increase with carrier frequency, so that for low carrier frequencies the spacing can be smaller than those used for higher carrier frequencies.

Another reason for trying to keep the carrier frequencies as low as possible is to minimize crosstalk. Many telephone lines contain five pairs of wires. Obviously some coupling must exist between these lines, so that if two are multiplexed at the same carrier frequency — usually true due to standardization — crosstalk between the two systems will result. Since this coupling is mainly capacitive, the degree of crosstalk increases with frequency.

Crosstalk Reduction Methods

There are a number of methods, employed concurrently, designed to reduce crosstalk due to this effect. In one, the coupling is minimized as much as possible by transposing the telephone lines. This materially reduces the capacitance between any two pairs of wires but as the number of channels multiplexed increases, the transposition problem becomes more complex in that wires must be transposed at increasingly smaller and more critical intervals.

To further reduce crosstalk, the operation of all the multiplex systems used on a particular line are integrated so that no large level differences exist at any point between carriers on the same frequency. Two rules are observed to assure proper integration. First, all terminals at one end are known as East terminals and at the other end are known as West terminals. All carriers going from E-W are on the same set of frequencies, and likewise all carriers going from W-E are on the same frequencies — the latter set of frequencies being different from the former.

The reason for operating the E-W carrier at a different frequency from the W-E carrier can best be understood by reference to Fig. 1a. In this case, contrary to the above, the E-W carrier of one multiplex system is operating at the same frequency as the W-E carrier of another system transmitted over an adjacent pair of wires. Since the transmitting terminal of one system occurs at the same point as the receiving ter-

(*Please turn to next page*)

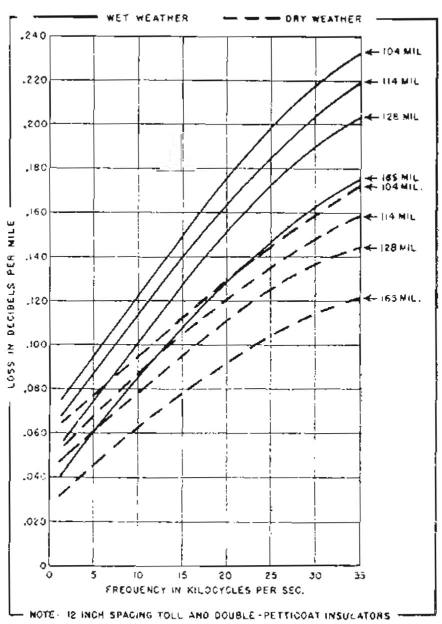


Fig. 5: Attenuation vs. frequency of open wire lines in wet and dry weather conditions

minal of the other, the signal level on one pair of wires (transmitting) is +18 DBM, while the signal level on the other (receiving) is −18 DBM. This means that there is a difference in signal level of 36 DB between the two. Hence, in order to establish a crosstalk level of −60 DB in the receiving line, coupling must be reduced so that there is a 96 DB drop between the two lines. Of course, if the two signals were of the same level, only a 60 DB drop would be required.

The only way to maintain all same-frequency carriers at equal levels is to have E-W transmission operate at different frequencies from W-E. Furthermore, as shown in Fig. 1b, when the initiating point of one system does not coincide with that of another, the levels of the two are adjusted so that they are equal over that position of the line traversed by both.

In order to obtain the advantage of using standard filters and modems (modulator-demodulators) and yet avoid excessive crosstalk, an inverted speech frequency system is sometimes employed. In this system, the same frequency band is used by two carriers, but one operates with the lower sideband while the other utilizes the upper sideband. For example, if an 18.0 to 20.4 KC band is used, one carrier will operate at 17.7 KC plus the upper sideband, while the other carrier will operate at 20.7 KC and use the lower sideband. Hence, a 500 cycle crosstalk signal of the first carrier will be heard as a 2500 cycle signal in the second carrier. This inverted speech frequency is unintelligible, and, hence, can be considered as noise rather than the more critical crosstalk.

As a result of the factors discussed above, a standardized frequency system for telephone lines has been developed. This system—up to three channels—is shown in Fig. 2. As can be noted in this figure, two sets of frequencies are presented, one identified as the "U" series and the other as the "S" series. Both series employ the same frequency bands, but utilize speech inversion in the upper frequency bands where crosstalk is more prevalent.

Another source of crosstalk, other than that due to coupling between lines or filter design, is distortion arising in repeater amplifiers. It is obvious that the introduction of second and third harmonics of a low carrier frequency may produce an unwanted signal in the higher carrier frequencies. Thus, for example, the second harmonic of a 7.5 KC signal would appear in the 12.9 to 15.9 KC band and the third harmonic in the 21.4 to 24.4 KC band. Crosstalk due to this factor increases as more repeaters are used in tandem, and hence, a very careful amplifier design is required for very long line equipment.

Long and Short Haul Types

Carrier telephone equipments fall into two general categories, long haul and short haul types. The long haul equipment, in turn, is subdivided into single, three and more than three channel units. In determining which of these units to use a number of factors must be considered including length of line to be multiplexed, its long range service requirements, and the relative costs of the additional units.

Where the addition of a single channel is calculated to meet the requirements of a particular long line for a period of years, the FTR 9-A-1 single channel carrier should be employed. This system provides an additional two-way telephone channel over a single pair of wires and may be operated on any line

Fig. 6: Block diagram of FTR 9-B-1 three channel carrier telephone terminal. Strapping determines whether the terminal is West or East

signal level input as the number of repeaters is increased. An empirical formula relating the number of repeaters to signal level is 2 DB increase in signal level at the receiver for each repeater utilized. Thus, if −18 DBM receiver input would normally be used for a no repeater system, −16 DBM input would be used for a one repeater system, −14 DBM for a two repeater system and so on.

Single Channel Equipment

The second-story single-channel equipment FTR 9-F-1, is designed to add another two-way telephone channel to an existing installation already using a single channel carrier telephone system such as the 9-A-1. It bridges the gap between available single and three channel carrier systems where traffic considerations require an additional channel but do not justify the installation of a three channel system.

The 9-F-1 operates on 18.7 to 21.1

facilities for superimposing three additional two-way telephone channels upon any existing open-wire voice-frequency circuit not employing carriers. The frequency bands utilized by this system are so selected that a minimum of crosstalk will exist between it and 9-A-1 or 9-F-1 carriers. "CS" and "CU" frequencies are available at the higher frequency bands of 18.0 to 20.5 KC, 21.7 to 24.2 KC, and 25.7 to 28.2 KC as indicated in Fig. 2.

Fig. 6 is a block diagram of a 9-B-1 terminal — either West or East depending upon the strapping. The operation of each channel is similar to that of the 9-A-1 equipment with the exception that, to prevent interchannel modulation, a peak limiter is inserted in each channel to suppress peak voltage which might overload the transmitting amplifier. Common transmitting and receiving amplifiers are used for all three channels, thus saving equipment, space and cost. As in the 9-A-1 the output of each

KC at the East terminal. These frequencies are generated by a highly stable oscillator included in the transmitting circuit of the pilot unit.

From the oscillator the pilot channel output is fed to an attenuation pad, which adjusts the output level, as measured at the line terminals, to +8 DBM for a West unit, and to +5 DBM for an East terminal, or 10 DB below the signal level. The pilot frequency passes through the pilot transmitting band - pass filter, bridged across the input to the transmitting amplifier, through the directional and line filters and is transmitted over the line.

Pilot Receiving Circuit

The receiving circuit of the automatic pilot consists of a receiving band-pass filter, a one-stage amplifier and control circuit. The pilot receiving circuit is inserted in the receiving branch of the terminal at the output of the carrier amplifier by means of the pilot channel band-pass filter and is connected through the pilot amplifier and pilot control to the feedback circuit in the receiv-

Latest Radio and Communications News Developments Summarized by Tele-Tech's Washington Bureau

WASHINGTON NEWS LETTER

FCC APPROPRIATION SLIGHTLY DECREASED—Even though the FCC has stressed in its recent annual reports that the radio, electronic and communication fields are never static and there has been an unprecedented expansion in radio and electronics last year, the Federal Budget Bureau unfortunately did not see eye to eye with the Commission in the matter of funds and President Truman, in his budget message, alloted $6,634,000 for the fiscal year beginning July 1, a decrease of $84,000 under the current appropriations. During the coming fiscal year from July 1, 1949 to June 30, 1950, broadcast activities will center on television, and technological developments in television have created major problems in frequency assignments.

AM, FM DOWN, TV SURGES UP—It is anticipated that applications for new standard AM broadcasting stations and for FM will decline during the coming year as a result of the tremendous potentialities of video. Application processing of television, which will be resumed during the spring, in all probability will absorb by far the major time of the FCC staff in order to make a nationwide blueprint of adequate video service in a successful form.

FCC DIVIDED INTO THREE PANELS; HYDE TO HEAD BROADCAST GROUP; WEBSTER MOBILE—In a new realignment of the FCC, three semi-autonomous panels with primary authority in their respective fields of broadcasting-television, common carrier (telephone, telegraph and international communications); and the mobile special and safety radio services have been established. Commissioner Rosel H. Hyde, who had been with the old Radio Commission and the FCC since 1929 as an attorney and general counsel, has been designated head of the broadcasting-FM-television panel, while the FCC's woman member, Miss Frieda B. Hennock, and Commissioner George E. Sterling, are the other two broadcast panel members. Commissioner E. M. Webster, leading authority of the FCC in mobile safety and special radio services heads the panel in that field.

PANEL PLAN SHOULD SPEED ACTION and it certainly should expedite the handling of the deluge of applications in the mobile field where the Commission has been inundated with approximately 58,000 applications during last year, exemplifying the tremendous interest in mobile radio and the state of flux of these services. Although the present panel plan calls for appeals to the full Commission from any controverted panel decision, it is anticipated that as the new panel system gets working, the full Commission will not have too burdensome an appeal load. The FCC Chairman, Wayne Coy, will not serve on any panel except as an alternate during absences of others, but will concentrate on directing the administrative functions of the Commission.

SPECTRUM REALLOCATIONS CONTINUE MAJOR FCC TASK—Spectrum reallocation will continue through this year and 1950 to be one of the major tasks of the FCC. In fact early in February it is anticipated that a principal "headache" problem will be cut away by the Commission—the reallocation of the frequencies, particularly those in the 152-162 MC band, to the mobile radio services. A subject of intensive study by the FCC engineering and legal staffs during the fall and early winter months, the assignment of the frequencies for the mobile, safety and special radio services, ranging over a vast number of industries and groups of users, had neared finalization during January

FIFTY PERCENT MORE REQUESTS THAN SPACE—To illustrate how difficult the task was for the FCC, the Commission staff experts have to find a place in the spectrum for applicants for a total of 15,000 KC in a space of 10 MC (152-162 MC) or 10,000 KC. In other words there were 50% more requests than the alloted space. To determine the mobile radio allocations the FCC had to clear its decisions with the armed services and other government agencies and even with the International Telecommunications Union because the assignments in the mobile radio bands affect global aviation and maritime mobile services.

BRITISH REALIZE HUGE TV GROWTH IN U. S.—The free and competitive enterprise system in the United States is credited by the British broadcasting and radio manufacturing observers as having "left behind" television development in England. Even though the British feel their 405-line and their future 625-line TV equipment are ahead of the American video standards, it was an interesting commentary that the recent annual meeting of the Electric & Musical Industries, Ltd., the largest British Empire radio-electronic manufacturing company, brought out how the American television development had gone ahead with so much greater vigor than in England. Sir Ernest Fisk, Deputy Chairman and Managing Director of E.M.I., cited that the United States had established 30 stations in two years against two TV stations in England in seven years.

ROLAND C. DAVIES
National Press Building — *Washington Editor*

TELE-TECH's NEWSCAST

RMA Equipment Sales

Sales of radio and television transmitting and communications equipment by RMA member-companies in the third quarter of 1948 totalled $34,021,278, the Radio Manufacturers Association reported today. Sales for the three quarters of 1948 amounted to $111,228,411.

Television equipment, including studio, antenna, and associated apparatus, represented sales of $5,256,465 out of the total civilian broadcast transmitting equipment sales in the third quarter and brought the total sales of this type of TV apparatus to $10,216,387 for the three quarters of 1948. FM transmitting equipment sales amounted to $833,897 in the third quarter and AM equipment sales totalled $681,912 for the same period. AM and FM antenna equipment totalled $255,236 and studio apparatus amounted to $923,800 in the third quarter. Miscellaneous broadcast transmitting equipment sales of $255,444 were reported and export sales of broadcast apparatus amounted to $495,974.

U. S. Government purchases of communications and radio equipment in the third quarter totalled $21,936,129, or 64% of the transmitting apparatus sales of RMA member-companies in the period. For the nine months' period, government business amounted to $76,064,818. Included in the government purchases was radar apparatus valued at $16,142,383 and $56,316,469 for the third quarter and nine months, respectively.

Palmer Craig Named Philco Engineering Director

The appointment of Palmer M. Craig as director of engineering, electronics division of the engineering department, Philco Corp., as well as six chief engineers responsible for major product development in this division, has been announced by David B. Smith, vice president in charge of research and engineering. Craig, who has been with Philco for 15 years, served as chief engineer in charge of radar and military radio development during the war and was named chief engineer of the company's radio division in 1943.

To handle the expanding work in television-receiver development, Sterling C. Spielman has been made chief engineer. He has had 15 years of radio, radar and television engineering experience with Philco. Reporting to him will be three basic groups, including a television receiver design section, an advanced development section and a field engineering group.

In the field of home radio, in which Philco has led the industry as the largest producer since 1930, Luke E. Closson has been named chief engineer. Also credited with 15 years of engineering experience with the company, he has made important contributions in auto radio and radar design as well as in home set development.

Responsible for the development of auto radio, another field in which

Palmer M. Craig

Philco has pioneered for many years, is chief engineer Arthur V. Nichol. He has been with Philco for 18 years and developed the first practical radios for automobiles, concentrating in this field ever since 1930 except for valuable wartime work in airborne radar design.

Heading a relatively new phase of the company's development activities, the design of specialized government and industrial electronics equipment, is Dr. James F. Koehler as chief engineer. After outstanding service in the Navy's airborne radar development program during the war, he joined Philco to coordinate military research and engineering projects.

New mechanical engineering development for the electronics division, including Philco phonograph mechanisms and other mechanical devices, will be handled under the direction of Bertram P. Haines as chief mechanical engineer. He has been with the company for 14 years, with experience in factory engineering, auto radio design, as chief engineer of the wartime crystal division, and in recent years section engineer responsible for phonograph development.

Development of television and radio cabinets for production, including the wide variety of table models and console combinations manufactured by Philco, will be headed by W. Linton Getz, named chief furniture engineer, after many years as an engineering and production executive in the furniture industry.

New TV Society President

Cameron Pierce, ABC Television Operations supervisor in Hollywood, California, was elected president of the Society of Television Engineers of Los Angeles at the regular monthly meeting and annual election of the group, December 28, at Brittingham's Restaurant in Hollywood.

Chicago Electronics Conference

The 1949 National Electronics Conference will be held September 26 through 28 at the Edgewater Beach Hotel in Chicago, according to an announcement by G. H. Fett, professor of electrical engineering, Univ. of Illinois and newly-elected president of the conference. A. W. Graf, Chicago patent attorney, was named chairman of the board of directors.

New officers and directors, in addition to Fett and Graf, are: Executive vice president, O. D. Westerberg, electrical engineer, Commonwealth Edison Co., Chicago; secretary, Karl Kramer, Jensen Mfg. Co., Chicago; treasurer, Dr. R. R. Buss, assistant professor of electrical engineering, Northwestern Univ., Evanston.

Committee chairmen, also conference directors, for the 1949 meeting are:

Program—Dr. L. T. DeVore, professor of electrical engineering, University of Illinois, Urbana.

Publicity—James W. Armsey, director of public relations, Illinois Institute of Technology, Chicago.

Publications—P. K. Hudson, assistant professor of electrical engineering, University of Illinois, Urbana.

Arrangements—James L. Murphy, supervisor of electrical engineering, Armour Research Foundation of Illinois Institute of Technology, Chicago.

Exhibits—N. Cohn, district manager of technical sales, Leeds Northrup Company, Chicago.

Housing—C. M. Brentlinger, division traffic superintendent, Western Union Telegraph Company, Chicago.

Sponsors are: Illinois Institute of Technology, University of Illinois, Northwestern University, American Institute of Electrical Engineers, and Institute of Radio Engineers.

Coming Events

March 7-10—IRE Annual Convention. Hotel Commodore and Grand Central Palace, New York, N. Y.

March 14-17—Illinois Seventh Chicago Production Show, sponsored by Chicago Technical Societies Council, Stevens Hotel, Chicago.

April 7-13 — National Association of Broadcasters, Annual Convention, Hotel Stevens, Chicago.

April 19-21 — American Institute of Electrical Engineers, South West District Meeting, Baker Hotel, Dallas, Texas.

April 25-27 — Fourth Annual Spring Meeting of IRE and RMA, Benjamin Franklin Hotel, Philadelphia, Pa.

May 2-4—International Scientific Radio Union and IRE, Joint Meeting, East Bldg. Lecture Room, National Bureau of Standards, Washington, D. C.

June 20-24 — American Institute of Electrical Engineers, Summer General Meeting, Swampscott, Mass.

NEW NAMES AND ADDRESSES

Television Equipment Corp., with laboratories and production facilities at 238 William Street, New York, is the newly-formed affiliate of International Television Corp., 745 Fifth Ave., N. Y. J. B. Milliken, president of both companies, revealed that the new concern will engage in the development and manufacture of television pick-up and transmission equipment.

* * *

Aeronautical Electronics Inc., Raleigh, N. C., is moving from the Raleigh Municipal Airport to new quarters at the Raleigh-Durham Airport. Building on the new location will provide the most modern sales and maintenance facilities yet offered by any organization devoted exclusively to aviation radio.

* * *

Vickers Electric Div., Vickers, Inc., a unit of the Sperry Corp., has expanded the Vickers line of electrical products and moved to larger quarters in St. Louis, Mo., at 1815 Locust St.

* * *

The Polytechnic Research & Development Co., Inc., formerly located at 66 Court St., Brooklyn, N. Y., has opened new and expanded research laboratories at 202 Tillary St., Brooklyn. The concern is headed by Dr. H. S. Rogers, president of the Polytechnic Institute of Brooklyn, and is under the technical direction of F. J. Gaffney.

* * *

Furst Electronics, manufacturers of specialized electronic laboratory instruments, has moved to larger quarters at 12 South Jefferson St., Chicago 6, Ill.

* * *

New offices of the FM Association are located at 526 Dupont Circle Bldg., Washington 6, D. C. The Association's former headquarters were in the Munsey Bldg.

Sylvania Buys New Plant

Sylvania Electric Products Inc. has purchased the plant formerly occupied by the Rumsey Pump Co., at Seneca Falls, N. Y., according to an announcement by J. C. Farley, general manager of the Radio Tube Division. Operations for television tube production have begun in the Seneca Falls plant, the third Sylvania television tube production center. Other plants are located at Emporium, Pa. and Ottawa, Ohio.

Tower Expert Appointed

Elizabeth Iron Works, Inc., Elizabeth, N. J., has announced the appointment of Emil Schaeffer as chief engineer of its tower division. He will be in charge of the design and construction of that part of the Elizabeth Iron Works structural steel fabrication activities.

Since graduating from the Technical University in Vienna in 1910, Mr. Schaeffer has specialized in structural engineering and tower design. Opening his own office in 1946 as consulting engineer, he was commissioned to design a number of radio towers for erection in various parts of the country. Among these were 420-ft. and 160-ft. steel towers for the Brookhaven National Laboratory; 350-ft. magnesium towers for the U. S. Army Air Corps' Watson Laboratories; 90-ft. aluminum towers for the Cruft Laboratory, Harvard University, and towers atop several skyscrapers in New York City for radio and television transmission.

URSI-IRE Meet

A joint meeting of the International Scientific Radio Union (URSI) and the IRE will be held in the East Bldg. Lecture Room, National Bureau of Standards on May 2-4. Papers on the following topics will be presented: radio standards, methods of measurement, terrestrial radio noise, communication theory, antennas, circuits, electron tubes, semi-conductors, and properties of matter.

Two-Way Radio Prevents Loss in Dam Project

Two-way radio has prevented loss of equipment which would have set back materially construction of the Medicine Creek Dam of the U. S. Bureau of Reclamation's Missouri Valley Authority on the Republican River in Nebraska.

Combatting the effect of a flash flood recently, radio was used to direct emergency crews to vulnerable points in the temporary cofferdams and to move equipment, according to George M. Stiers, general superintendent of the construction project. Water came to within 18 inches of the top of the cofferdams.

The system consists of eight G-E units located strategically in the main office, general superintendent's car, excavation superintendent's pick-up, the concrete superintendent's pick-up, in the field mechanic's truck, the service shop, at the quarry, and in the shift supervisor's pickups.

NAB Engineering Conference at Chicago in April

Television-station engineering, operation, and economics will be the principal topic before the Engineering Conference scheduled during the convention of the National Association of Broadcasters to be held at the Hotel Stevens, Chicago, April 7th to 13th. Remaining 25% of emphasis is expected to be placed on AM and FM engineering. At least 500 engineers are expected to attend, to listen to the two-day program of engineering papers and to inspect the exhibits. Television engineers are looking forward to this conference as being one of great importance to television.

Poppele Named TBA Head

J. R. Poppele, vice president, secretary and chief engineer of the Bamberger Broadcasting Service, was unanimously elected president of the Television Broadcasters Association, Inc., at a reorganization meeting held on December 8th at the Waldorf-Astoria Hotel, New York City. He is now serving his fifth term at the head of TBA.

G. Emerson Markham of GE was elected vice president; Will Baltin was re-elected secretary-treasurer for a sixth term and Paul Raibourn was re-elected assistant secretary-treasurer.

Chertok Joins Sprague

Appointment of Sidney L. Chertok to the application engineering staff of Sprague Electric Co., North Adams, Mass., has been announced by Julian K. Sprague, vice president. He will be the new sales promotion manager of the Sprague Products Co., jobbers' distributing organization for Sprague capacitors, resistors and other products.

Well known in the electronic and radio industry, Mr. Chertok was formerly sales promotion manager of Solar Manufacturing Corp., North Bergen, N. J.

REMOTE PICKUP TELEVISION TRANSMITTER TRUCK

Designed to carry equipment for relay of on-the-spot pickups to a television broadcasting station, this new mobile unit was delivered to WNAC-TV, Boston, Mass. by the Transmitter Division, General Electric Co. A feature of the TV truck is its low-bed (16 in. above the ground), facilitating easy loading and unloading and comfortable operation of the equipment by technicians. Height from the floor to ceiling is 78 in.

OSCILLATOR AND MIXER CIRCUITS

(Continued from page 31)

need to use either AFC or manual fine tuning in receivers. A good TV mixer should have: (1) low noise, (2) good conversion efficiency, (3) adequate bandwidth, (4) contribute to adequate overall selectivity, (5) shielding designed to minimize oscillator re-radiation.

It has become common practice to consider all of the electron fluctuation or shot noise generated within a given tube circuit as equivalent to the thermal noise which would be generated in a fictitious "equivalent noise resistance," R_{eq}, in the grid to cathode circuit of the tube. R_{eq} can be experimentally determined for an amplifier tube by shorting the grid-cathode circuit (for the frequency range of interest but maintaining correct DC bias potentials), measuring the noise power output, and then inserting into the grid-cathode connection a resistance just sufficient to double the output noise power. This will be valid of course only if the bandwidth of the following amplifier remains unchanged and the first tube gain is sufficient to make subsequent circuit or tube noise negligible. For a mixer, R_{eq} can be checked experimentally by measuring the equivalent noise with a saturated diode in the plate circuit, and then referring this to the grid circuit by using the conversion transconductance as measured separately.

It has been shown[1] that for triode mixers $R_{eq} = 4/g_c$ where g_c = conversion transconductance, and usually $g_c = g_m/3$ approximately, where g_m is the normal transconductance of the tube as an amplifier.

For pentode mixers:

$$R_{eq} = (I_b/I_b+I_{c2})(4/g_c+20\ I_{c2}/g_c^2)$$

where I_b = plate current and I_{c2} = screen grid current. For multigrid converters and mixers:

$$R_{eq} = 20\ I_b(I_a-I_b)/I_a g_c^2$$

where I_a = average cathode current.

Now the actual noise contributed by a mixer will be slight if the RF stage gain is high, and while the mixer noise contribution is not simply proportional to R_{eq}, it does vary with it, and therefore it is desirable to keep R_{eq} low. For a pentagrid converter like the 6SA7, R_{eq} is about 200,000 ohms, for a 6AG5 pentode mixer R_{eq} is about 7600 ohms, and for a 6J6 triode mixer (1 section) about 2400 ohms.

Multigrid converter tubes are unsuited for use at TV frequencies because they have such a high noise level and low conversion gain and they usually fail altogether on the high channels. Many TV sets use a twin triode converter with one section as oscillator and the other as mixer. Others use separate tubes, often a triode oscillator and pentode mixer.

In triode mixer circuit design gain stability may be troublesome. The grid to plate capacitance may cause IF regeneration. The mixer plate circuit is parallel resonant at IF frequency and therefore presents a resistive impedance, but the grid circuit is inductive at the IF frequency since the grid input is parallel resonant at RF. Trouble of this sort may sometimes be most easily prevented by the use of a series L-C circuit from mixer grid to ground, resonant at IF, thus providing a low impedance at the intermediate frequency.

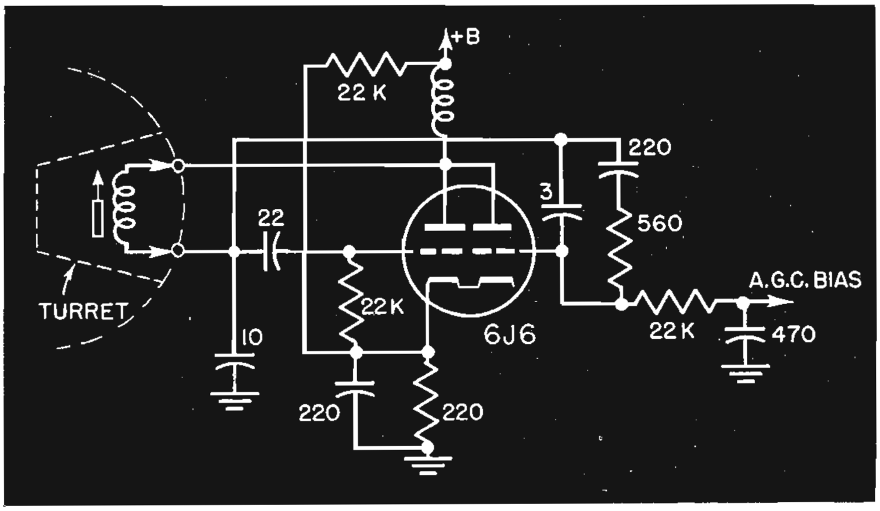
The grid to plate capacitance of the triode mixer also gives trouble at RF because the input impedance is dependent upon the plate circuit impedance. If the plate circuit reactance is made predominantly inductive at RF, the input circuit impedance for the triode has a negative conductance component. This negative conductance component can be used to neutralize the input circuit loading of the triode at the higher frequencies resulting from transit time and cathode lead inductance. Such neutralization is of interest in the case of an RF amplifier stage as well as in the triode mixer. The IF transformer primary tuning capacitance in the mixer plate would present a capacitative impedance under normal conditions, therefore a small series inductance should be added between the plate and the IF transformer. The proper inductance value can be best obtained by experiment for any given case. It may be only a plate lead of 1 or 2 inches length, or it may be a small inductor of perhaps three or four turns wound around a resistance of 1000 to 1500 ohms.

It is possible, and might seem desirable, to inject the signal voltage into one electrode, say the grid, and the oscillator voltage into another electrode such as the cathode, or in the case of a pentode mixer, the screen grid. Usually, however, it is found most desirable to ground the cathode of the mixer and inject both the oscillator and signal voltage into the grid. In some receivers the mixer and oscillator are magnetically coupled on the low channels and capacitatively coupled on the high channels, although either type of coupling could be used on all channels. In some receivers mixer bias is provided by the oscillator grid self-bias. Since the conversion gain is reasonably critical with mixer bias, oscillator activity may vary between high and low channels, and optimum bias should be determined for all channels. Mixer self-bias is generally used since it is simpler than using oscillator bias.

The tuning of the front end RF circuits may be by means of (1) a turret, which physically moves separate coils past a set of contacts, (2) by separate coils for each channel which are stationary but are switched into the circuit, (3) with sequential inductances mounted on a switch, (4) by permeability tuning where (a) the magnetic cores are moved within the coils, or (b) where a stationary magnetic core within

[1] Thompson, North, and Harris—"Fluctuations in Space-Charge-Limited Currents at Moderately High Frequencies." RCA Rev. April 1941

Fig. 2: Typical commercial circuit employs one tube as AFC controlled oscillator



the coil is either covered or uncovered by a moving non-magnetic sleeve, (5) the inductuner which consists of coils on a common shaft rotated to move the contacts along and so obtain a continuous tuning range, (6) plug-in coils, or (7) variable capacitors.

The turret type has the advantage of permitting nearly optimum design for each channel but may give contact trouble and requires component parts and adjustment for each channel, thus making it relatively expensive. The second type has about the same disadvantages plus longer leads, though it may be lower in cost than a turret. The third or sequential switch type solves the problem of long switch leads but is still subject to contact trouble and it is likely to be expensive and troublesome in manufacture to maintain necessary circuit tolerances. The permeability tuner may use a continuous tuning dial on each band (switching coils from high to low bands) or it may be provided with a detent mechanism operated like a switch, or by pushbuttons. This tuner has relatively low cost and good performance but still requires the band switch.

Regardless of the type of tuning chosen, the degree of freedom from service troubles will be more important to the purchaser and do more to give television a good or a bad name than the first cost of a receiver. It is likely that the simplest mechanical design which is integrated with good electrical design to achieve good performance will give both lowest cost and best service. No receiver is entirely free of servicing troubles and the design engineer should try to layout each unit so all component parts are readily available for test and replacement if necessary.

Automatic Electric Expands

An electronics department has been formed as a unit of the Automatic Electric Co. to meet the growing need for a comprehensive planning and equipment service devoted to electronic applications in the telephone field. K. W. Jarvis, who has headed his own electronic consulting firm for the past 14 years, is the manager of the new department.

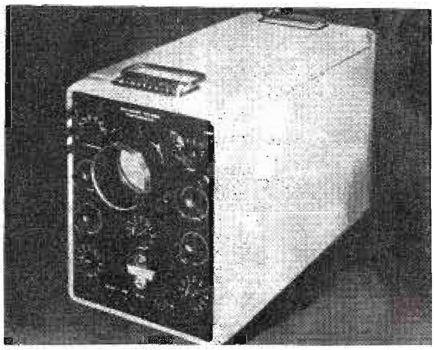
Magnetic Recording Standards

Adoption of standards for magnetic recording is foreseen by the NAB Recording and Reproducing Standards Committee which has formulated a final project group proposal of three recording speeds for magnetic tape: primary standard tape speed of 15 in. per second, a secondary standard of 7.5 in. per second and a supplemental standard of 30 in. per second.

New Lab and Test Equipment

DC Oscilloscope

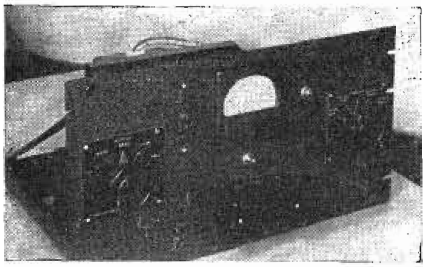
Type 1684N, the third of a new series of DC oscilloscopes made by Furzehill Laboratories (England) has been developed, incorporatng the same features as tbe 1684D.



Range is from zero to 50 KC with negligible phase distortion up to 30 KC. The vertical amplifier is direct-coupled, symmetrical and is designed for balanced or single-ended input. Horizontal amplifier is for single-ended input. Time base range from 5 cps to 10 KC is automatically synchronized and has sweep expansion up to five screen diameters. Unit is portable and weighs 35 lbs.—**American British Technology Inc., 57 Park Ave., New York 16, N. Y.**

Electric Operation Checker

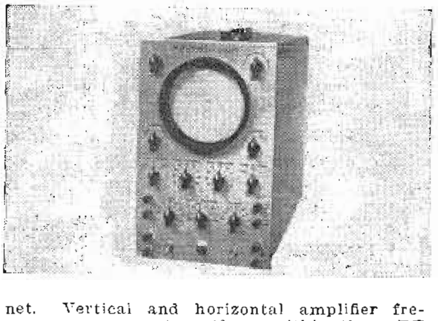
Operation of electric components at rated, under, and over voltage may be checked rapidly with a recently-developed test instrument which can be powered by a 220 volt,



60 cycle, 3 phase line. Two controls are provided. One adjusts the output to the nominal voltage required for test. The second control adjusts the output to the required under or over voltage. Nominal output voltages are: 110, 208, 220, 380, 440, and 550 volts. These voltages may be varied 10 or 20% above or below the nominal voltage.—**Eastern Transformer Co., Inc., 147 West 22nd St., New York 11, N. Y.**

Oscilloscope

Model 450A is a new, low-priced five-in. wideband oscilloscope with components mounted on resistor boards and all wiring laced and encased in a hammertone gray cabi-



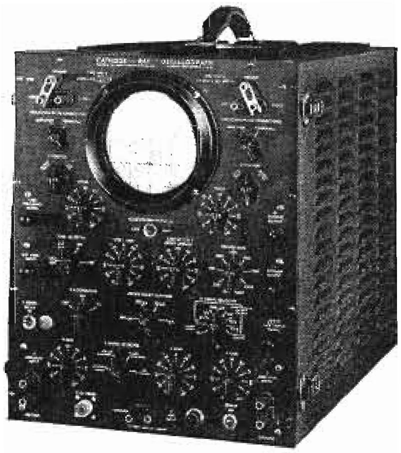
net. Vertical and horizontal amplifier frequency response is uniform within three DB from 8 cycles to 450 KC at any attenuator or gain control setting. CR tube is type 5BP1 with an accelerating potential of 1150 volts. Frequency range is 6 cps to 50 KC.—**Telemark Electronics Corp., 325 Troy Ave., Brooklyn 13, N. Y.**

Capacitor Analyzer

A small, light-weight capacitor analyzer (Model CBC) measures capacitances from 10 μμf to 800 μf, using a "Magic Eye" indicator for capacitance bridge balancing. Power factor measurements on electrolytic capacitors are made by the bridge method. Simplified neon lamp test circuits are incorporated for visual checks of the insulation resistance of paper and mica capacitors and of the leakage current of electrolytic capacitors.—**Solar Manufacturing Corp., 1445 Hudson Blvd., North Bergen, N. J.**

High-Voltage Oscillograph

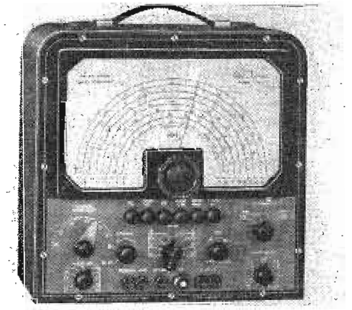
Addition of a suitable external power supply to the 248-A oscillograph facilitates operation at accelerating potentials up to 14,000 volts. Incorporation of the 5RP-A



high-voltage cathode-ray tube is the basis for this increased versatility. The only change in characteristics of the 248-A at the higher accelerating potential is in deflection sensitivities. Deflection factor at 14,000 volts (using DuMont 263-B external power supply) is 0.15 rms volt per in.; whereas at 4,000-volts accelerating potential, this factor is 0.10 rms volt per in. Photographic writing rates of 69 in. per microsecond can be recorded when using the increased accelerating potential. Where less light output is required or where the writing speed is not so great, the 248-A can be operated at the normal accelerating potential of 4,000 volts.—**Allen B. DuMont Laboratories, Inc., 1000 Main Ave., Clifton, N. J.**

TV Sweep Generator

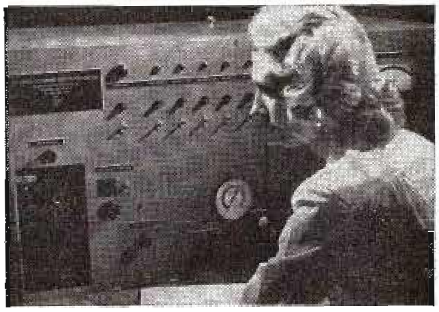
Equipped with a built-in variable marker from 19 to 40 MC on fundamentals, Ferret model 720 FM-TV sweep generator has a frequency coverage from 0 to 260 MC on 8 bands



and a sweep range from 50 KC to 20 MC on all bands. A combination of push buttons operates the B+ circuits only and permits individual or simultaneous use of the crystal oscillator, internal audio oscillator, RF generator, marker oscillator or sweep FM-TV generator. The sixth button is used for stand-by, cutting off the B+ from various oscillators but keeping the filament voltage circuit in operation.—**Coastwise Electronics Co., Inc., 130 N. Beaudry Ave., Los Angeles 12, Calif.**

Spectroradiometer

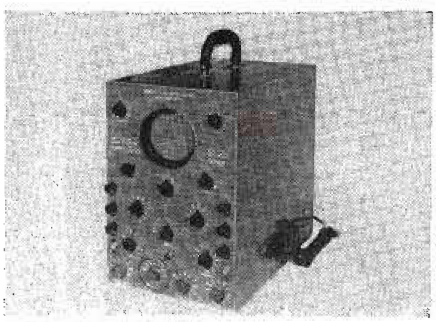
An accurate plot of the full range of visible light produced on a television viewing tube screen is provided by a recently-de-



veloped recording spectroradiometer. The instrument analyzes the components of the light produced by the tube screens by measuring and recording the degree of output of all visible light wavelengths progressively. Only 48 seconds are required for a complete and automatic tube analysis, involving a continuous charting of light at all wavelengths. Operator in photo is shown inspecting photomultiplier section.—**Sylvania Electric Products, Inc., Emporium, Pa.**

Oscilloscope—Sweep Generator

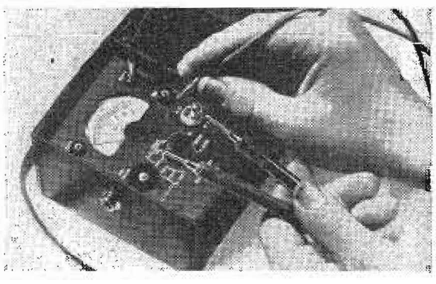
An oscilloscope and a sweep generator have been built into a single cabinet, measuring 14 x 18 x 12½ in. Either instrument can be used independently. Oscilloscope synchroni-



zation is provided for internal positive or line frequency and there are terminals for connection to an external source. Sweep generator has continuously variable bandwidth from 50 KC to 6 MC with a range from 4.5 to 30 MC. Traveling detector probe is included for observing signal at any point of the RF circuit under test.—**Radio City Products Co., Inc., 152 West 25 St., New York 1, N. Y.**

Volt-Ohmmeter

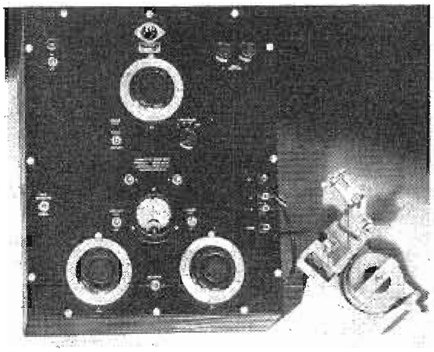
Measuring only 4¼ x 3 x 1½-in., this new miniature multitester measures ac and dc up to 300 volts and reads ohms up to two



megohms in four ranges; 0 to 2,000, 0 to 20,000, 0 to 200,000, 0 to two million. All values are indicated on a single, two-scale dial, clearly set off in the front of the case. The instrument is furnished with two Koiled Kord test leads terminating in pin plugs and clip leads.—**International Instruments, Inc., 311 East St., New Haven 11, Conn.**

Magnetic Test Set

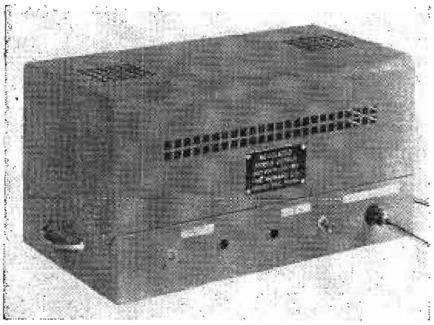
Measurements of permeability and core loss may be made at 60 cycles and at low levels (like those encountered in inductors and transformers used in communication systems) with



a new type of magnetic test set. Test sample may be a single lamination or a few duplicate strips in parallel. The sinusoidal magnetizing force applied to the test sample is adjustable from one millioersted to six oersteds. Permeability range is 25,000 full scale for a specimen cross section of 10 sq. mm.—**General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.**

Regulated Power Supply

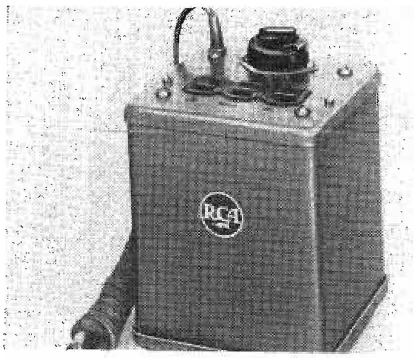
Output voltage of the model A regulated power supply is held to less than 1 volt variation from 0 to full load and when line voltage



changes occur between 105 and 125 volts. Ripple is less than 10 millivolts at full load with 115 volts input; less than 25 millivolts between 0 and full load with line voltage variations from 105 to 125 volts. Unit is light and compact and can be supplied in cabinet (Illustr.) or panel mounting for rack installations.—**The Howard Co., 934 Argyle Road, Drexel Hill, Pa.**

Isolation Transformer

An adjustable voltage-tapped primary and secondary enable the WP-24A isolation transformer to provide a choice of three voltages: 117-volt normal supply, 105-volt low supply,

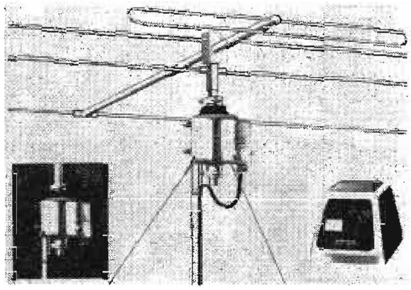


and a 130-volt high supply. The 105-volt tap permits a quick check for oscillator stability and the 130-volt high supply makes possible a breakdown test to expose parts on the verge of failure. When the instrument is placed between the power supply and the radio receiver being tested or the test equipment being used, shorts are eliminated between chassis and ground, and between separate chassis.—**RCA Victor Div., Radio Corporation of America, Camden, New Jersey.**

Communications Components

Antenna Rotator

Selection of the exact point on the compass for optimum TV-FM reception is provided by an electric antenna rotator designed



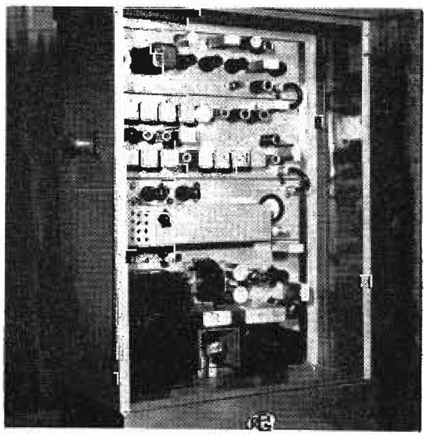
to rotate the beam antenna in FM, television and other high frequency radio applications. Rotator mechanism is an electrically driven rotating hollow shaft into which the antenna center post is clamped. Gear train which drives shaft is motivated by an intermittent duty, reversible, capacitor type motor. Antenna with the Tenna-Rotor attached will rotate clockwise or counter-clockwise through 365° at approximately 1 rpm. Control box plugs into 110-volt, 60 cycle line and is connected by a 4-conductor cable to the rotator. —**Alliance Mfg. Co., Alliance, Ohio.**

Conical Antenna

Driven elements on the 4X-TV conical antenna are shaped to present a "V" to the incoming wave, preventing a change in the receiving lobe as the frequency increases. The reflectors have a front to back ratio of better than 4 to 1 on all frequencies. Nominal center impedance is 150 ohms which is prevented from varying by the conical elements. When stations are within a 5 to 15 degree sector (depending on distance from the transmitter) the 4X-TV, used for maximum efficiency at low frequencies, becomes a much more efficient antenna than a separate half-wave dipole and reflector could be at the high frequencies. This antenna is stacked to present a ¼ wave spacing on channel 2 which increases to full wave length spacing on channel 13; the angle of inception is lowered tremendously and high angle response lobes directly above and below the antenna are eliminated.—**Telrex, Inc., 26 Neptune Highway, Asbury Park, N. J.**

FM Broadcast Transmitter

Designed for schools, universities, and other non-commercial educational institutions, model 706 10-watt FM broadcast transmitter has a maximum coverage of approximately 5 miles. The Serrasoid Modulator is used and



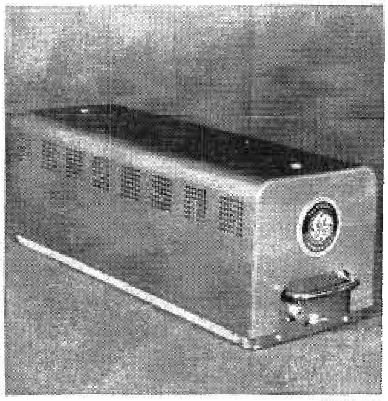
the entire transmitter utilizes only 18 standard tubes. Cabinet is made of aluminum and measures 39 x 29 x 14½ in. Maximum distortion is less than ½% from 50 to 15,000 cycles at 100 modulation, facilitating perfect reception on any conventional FM receiver in the 88 to 108 MC band.—**Radio Engineering Laboratories, 35-34 36th St., Long Island City, New York.**

TV Antenna

A strong signal pickup is facilitated by the stacked array arrangement of the TV S-6 television receiving antenna. The two antennas have been stacked one above the other with correct ½-wave spacing, still permitting complete adjustability for orientation. Pre-assembly of component parts saves installation time and expense.—**Ward Products, Inc., 1523 E. 45th St., Cleveland 3, Ohio.**

FM Transmitter-Receiver

High selectivity is a feature of a new single-unit FM transmitter-receiver, designed for the 152-162 MC band. Transmitter (ES-



1-B) has a carrier frequency stability from —30° C. to +60° C. of better than ±.002%, using a temperature-controlled crystal. Receiver selectivity is 60 KC. 50 db down for an adjacent channel and 120 KC. better than 85 db down, for an alternate channel. Metering jacks and adjustments for squelch and receiver volume are located on the instrument's front end. Unit measures 8 x 8 x 26 in. and weighs 46 lbs.—**General Electric, Transmitter Div., Syracuse, N. Y.**

Firemen's Receiver

A special receiver has been developed which will operate in the 152-162 mc band to provide the means for alerting reserve or volunteer firemen. Tied in with the regular fire department radio system, the unit remains on silent standby 24 hours a day. When a message is transmitted, the receiver turns on and the message is heard. At the conclusion of the alarm, squelch noise is heard continuously until the receiver is turned off manually. The dispatcher at the central control point may activate all receivers simultaneously or call any single receiver. The home receiver unit utilizes a 17-in. wire antenna installed on the roof and operates on ac.—**Motorola, Inc., 4545 Augusta Blvd., Chicago, Ill.**

TV-FM Antenna

Horizontal directivity pattern of the 710 Di-Fan broadband receiving antenna (broadside to the major axis of the antenna) is a

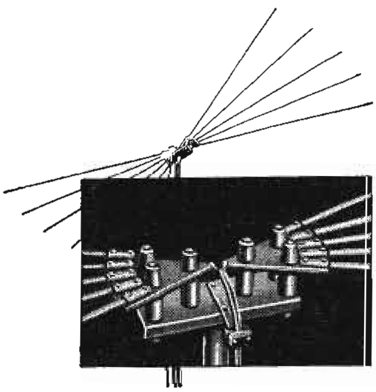
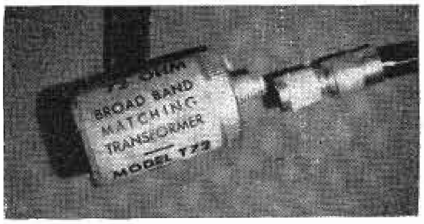


figure eight on the entire FM band and on television channels 2 to 6. In high frequency television channels, the forward gain is decreased somewhat and the angle of acceptance is enlarged. It maintains a 300-ohm standard impedance over the television spectrum and shows little mis-match loss over a wide range of frequencies. The fan elements are supported by glazed steatite insulators.—**Andrew Corp., 421 Seventh Ave., New York 1, N. Y.**

Parts for Designers

Matching Transformer

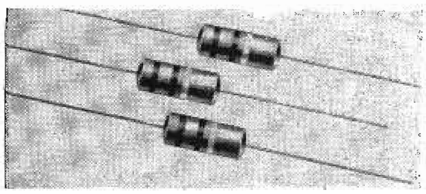
An RF transformer and a specially-designed polyiron core, mounted in a small aluminum container are the basic components of a new broad band impedance matching transformer



for use at frequencies between 50 and 225 MC. A standard miniature connector is mounted at one end for connection to 72 ohm nnbalanced coaxial line and a 6-in. piece of 300 ohm balanced line is connected to the transformer through the side of the container.—**Workshop Associates, Inc., 66 Needham St., Newton Highlands, Mass.**

High Voltage Resistor

Capable of withstanding voltage surges up to 6,000 volts, the new BTAV resistor is a variation of the Advanced BT with features that enable it to operate continuously at much



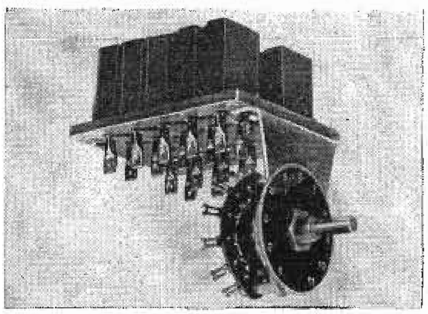
higher voltages than the maximum rated voltage of the standard BT resistor. The internal part of the lead wires is short, leaving a wide air gap between the lead ends. This reduces power handling capacity somewhat below that of the standard unit, but permits it to operate continuously at potentials up to 2,000 volts.—**International Resistance Co., 401 North Broad St., Philadelphia 8, Pa.**

DC-AC Chopper

Type 222 dc-ac chopper is a single-pole, double-throw electro-mechanical chopper, rectifier or square-wave generator. Because it operates well below the point of mechanical resonance, uniform performance is obtained over the entire range of 10 to 500 cps. When used as a chopper, it will convert pure dc into pulsating dc or ac so that the output of thermocouples, strain gages or other low-level dc sources may be amplified by means of an ac rather than a dc amplifier.—**Stevens-Arnold, Inc., 22 Elkins St., South Boston 27, Mass.**

Crystal Selector

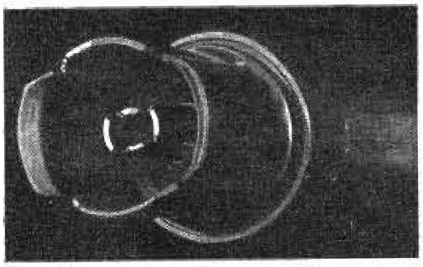
Instant selection of ten frequencies is provided by the new Johnson crystal selector with no danger of getting out of the band,



removing excitation, switching off plate current, or detuning transmitter stages. Unit accommodates all crystals with ½-in. spacing. A special bracket permits vertical or horizontal mounting of crystals.—**E. F. Johnson Co., Waseca, Minn.**

Coaxial Connector

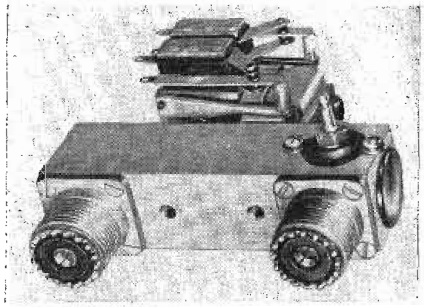
Unique design feature of the type 874 coaxial connectors is that identical units can plug smoothly into each other without any



intermediate elements, and the complication of male and female assemblies is completely avoided. A strong, friction grip is made by the multiple, spring-loaded contacts. Inner and outer conductors are similar in principle; each is essentially a tube with 4 longitudinal slots in the end and with 2 opposite quadrants displaced inward. To make a joint, 2 connectors are plugged together so that the undisplaced quadrants of one connector overlap the displaced quadrants of the other. The characteristic impedance is 50 ohms throughout the connector and standing-wave ratio is less than 0.3 DB at all frequencies below 4500 MC.—**General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.**

Coaxial Relays

Though only 2-15/16 in. long, the new Advance relays have been designed to maintain a VSWR from 1.04:1.00 at 80 MC to 1.40:1.00 at 300 MC, with a maximum rating of 250



watts. Terminal positions on the relays can be varied to meet special requirements and they may be obtained with "N" type connectors and DPDT auxiliary contacts. They are built for applications where 50 ohm RG cable is used.—**Advance Electric & Relay Co., 1260 West Second St., Los Angeles 26, Calif.**

Transformer Core Structure

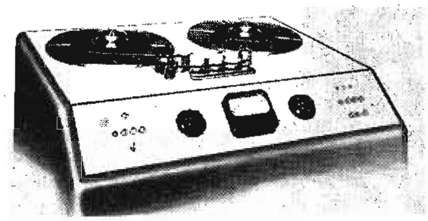
A watt-loss 25% less than for an equivalent sheared or laminated core is claimed for the new Elcor wound transformer core structure. Reduction in watt-loss is credited to atmos-

phere-controlled annealing and to orientation or preference which the magnetic flux has for the direction of rolling effected in manufacturing. The single cut in the core structure saves assembly time and permits use of any manufacturer's coil. It is particularly adaptable to specially built transformers where limited production does not warrant the cost of dies to produce the small lot stampings.—**Elcor, Inc., 4525 N. 124th St., Butler, Wis.**

Sound Equipment

Tape Recorder

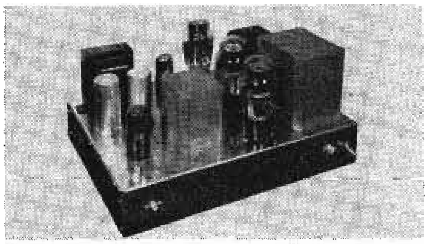
The same high fidelity performance formerly thought possible only at a tape speed of 30 in. per second has been achieved at



15 in. per second tape speed in this new recorder. Recording time has been doubled for any specific amount of tape and operating speed has been cut in half, thus improving starting, spotting, stopping and editing operations. Tests have shown better than a 60 db signal-to-noise ratio with a maximum total harmonic distortion of two per cent. A specially-designed synchronous motor drive provides an overall time accuracy of better than ½ second in 30 minutes' playing time.—**Fairchild Recording Equipment Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.**

Audio Amplifier

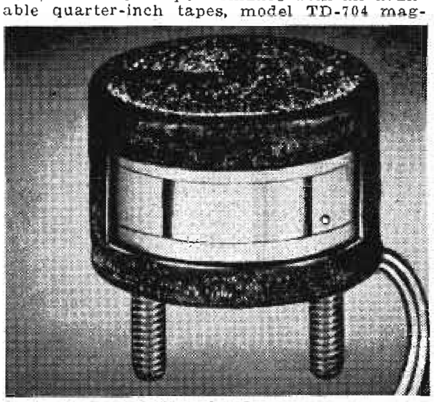
A high-fidelity, medium power, all triode amplifier, the model AA-20, is recommended as a companion unit to the recently-released RJ-20 FM-AM tuner. All triode voltage gain



and power stages have a response within 1 DB from 10 to 17,000 cycles with less than 1¼% harmonic distortion at 14 of the rated 15 watts output. Hum level is 65 DB below maximum rated output. Push-pull input and output transformers are used and voice coils from 1.2 to 30 ohms can be matched by tap selection. The output stage consists of push-pull 6B4B's driven by two triode sections of a 6SN7 in cascade with separate bias rectifier.—**Browning Laboratories, Inc., 750 Main St., Winchester, Mass.**

Magnetic Tape Recording Head

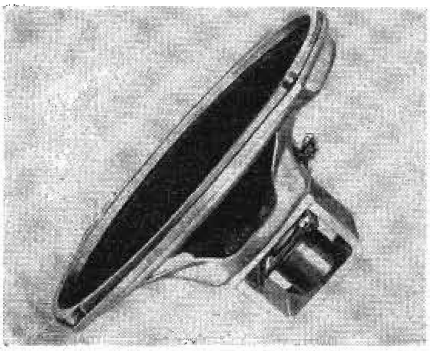
Featuring high output, maximum frequency response, extremely low hum level, compactness, and efficient performance with all available quarter-inch tapes, model TD-704 mag-



netic tape recording head may be used for recording and playback. It gives optimum results with a track .200 in. wide. Using tape with a coercive force of 300 oersteds at a speed of 7½ in. per second, the operating bias level at 40 kc is 1.7 milliamps. and the audio signal current for standard recording level is 0.15 milliamps. Impedance at 1000 cps is 1000 ohms.—**Indiana Steel Products Co., Dept. A26, 6 N. Michigan, Chicago 2, Ill.**

Permanent Magnet Speaker

Permanent-magnet type speakers (308S2 and 408S2) are useful in applications which require high sensitivity at medium power



levels. Each speaker will handle 6 watts of audio power; they differ only in size of magnet employed. Both have a one-piece stamped, steel frame and are rust-resistant and dust proof. Cones, voice coils, and suspensions are moisture-resistant. The magnet clamping spring holds the Alnico V magnet accurately in place without use of cement. —**Radio Corporation of America, Tube Dept., Harrison, N. J.**

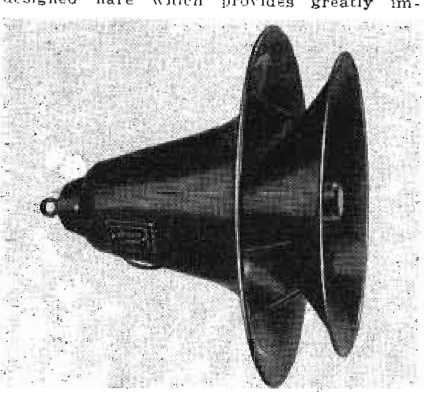
Rotary Converter

Wherever dc to ac conversion is necessary for the operation of wire and tape recorders, the Carter Super Converter will deliver a

pure ac output that requires no filtering. It is the smallest and lightest of any converter now in use. This equipment which has been specifically designed for recorders and sound projectors has power factor matched to the load to assure proper playback.—**Carter Motor Co., 2644 N. Maplewood Ave., Chicago, Ill.**

Radial Projection Speaker

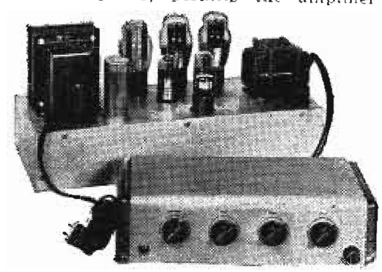
Sound can be distributed over a complete circular area by the VR-241 ST-789 Hypex projector, a new speaker with a specially designed flare which provides greatly im-



proved acoustical performance, particularly at the lower frequencies. Developed acoustic path length is 54 in. and usual frequency response ranges from 140 to 6000 cps. Voice coil impedance is 16 ohms. Power rating is 25 watts maximum speech and music signal input. The driver unit, an integral part of the assembly, has a phenolic diaphragm and Alnico V magnet and is completely enclosed yet can be removed and replaced if ever necessary.—**Jensen Mfg. Co., 6601 South Laramie Ave., Chicago 39, Ill.**

Amplifier

The "transient peak" circuit, a new development on the latest model of the Brook 10-watt amplifier, permits the amplifier to



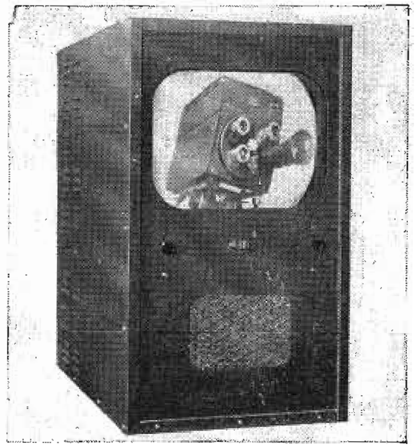
handle power peaks considerably higher than its ten-watt rating. At the same time, it holds distortion within the limits applying to constant power output specified by the manufacturer. Intermodulation and harmonic distortion are negligible and frequency response is virtually flat from 20 to 20,000 cycles. Within the range of its power rating, the new model 12A series equals the performance of Brook 30-watt models in every respect.—**Brook Electronics, Inc., 34 DeHart Place, Elizabeth 2, N. J.**

Tape Noise Eraser

All signals and background noise may be eliminated from entire reels of magnetic tape in a few seconds by the Goodell Magnetic Noiseraser. The instrument consists of a carefully engineered-tuned magnetic circuit which provides optimum erasing flux densities. Oil-filled paper capacitors and coils wound with varnish and glass insulated wire are used. Power supply requirements are 110 to 120 volts, 60 cycles ac.—**Minnesota Electronics Corp., 6th and Minnesota Sts., St. Paul 1, Minn.**

TV Picture Monitor

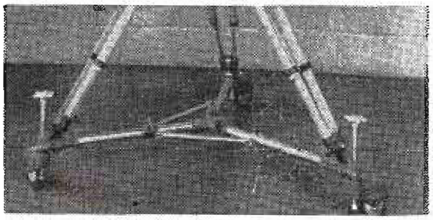
The full light output from the 20-in. picture tube of model 2116 large-screen picture monitor is such that brilliant images can be en-



joyed in fully lighted rooms. DuMont deflection system provides better-than-usual focus and results in approximately a 450 line resolution. Unit operates from a composite signal on a 75-ohm line with a level between 0.5 and 2.5 peak-to-peak voltage.—**Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.**

TV Tripod Dolly

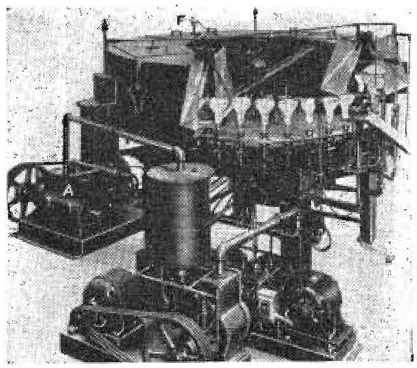
A new portable tripod dolly (Type MI-26042) may be locked to the base of a field-type television camera tripod, facilitating



movement of the unit during location pickup. It is sturdy, compact, chrome-finished and can be locked in position with spring-loaded stop-feet. For convenience in transporting, the dolly folds into an 8 x 14 x 29 in. package.—**RCA Victor Div., Radio Corporation of America, Camden, N. J.**

Automatic Exhaust Machine

A 36-head automatic exhaust machine able to evacuate all types of bulbs up to 5½ in. in diameter has been specially designed for



exhausting carbon lamps. The machine is powered by a ¾ hp, 1720 rpm electric motor with variable speed pulley. Mounted on a steel table structure, the turret is indexed by a large barrel-cam driving mechanism and carries a water-cooled circular manifold equipped with 26 compression chucks. The electrically-heated high-temperature oven is supplied with automatic bulb entry and exit doors which open and close simultaneously at each indexing. From 350 to 600 units can be processed every hour by the machine, depending upon the size of the bulbs.—**Eisler Engineering Co., Inc., 750 South 13th St., Newark 3, N. J.**

PERSONNEL

Frank Lester has assumed the post of chief engineer of the Insuline Corporation of America. Prior to joining insuline, he was chief engineer for Electronic Corp. of America and Radio Wire & Television Inc.

Robert M. Hanson has been named chief engineer of the Audio Development Company, Minneapolis, Minn. He comes from the Thordarson Electric Co., Chicago.

Paul Heteny has been appointed consulting engineer for the Aerovox Corporation, New Bedford, Mass.

John N. Fricker has become director of engineering services of Airborne Instruments Laboratory, Mineola, N. Y. **Robert B. Beetham** has been elevated to post of executive assistant to the vice president in charge of research and engineering.

Dr. W. W. Wetzel, former assistant director of central research laboratories, Minnesota Mining & Manufacturing Co., St. Paul, Minn., has been appointed technical director for the recording tape unit. Assistant research director will be **Dr. Lew W. Cornell. Melvin C. Hegdal** has been promoted from products supervisor to the post of operations manager in the production of sound tape.

Robert Bigwood has been appointed facilities engineer of the DuMont television network. His chief responsibilities will be planning, design and installation supervision of all network facilities, including studios and transmitting plants.

Two Motorola appointments have been announced: **Walter H. Stellner**, vice president of merchandising; and **Elmer H. Wavering**, vice president of product design. Mr. Stellner was formerly vice president in charge of home radio and television set design and Mr. Wavering was vice president in charge of automotive product design.

Commodore Jennings B. Dow, USN (Ret.) has been elected executive vice president of Hazeltine Electronics Corporation. He specialized in electronic engineering during his years in the U. S. Navy, and in the war served as Chief of the Electronics Section of the Bureau of Ships in Washington, D. C.

Charles E. Rynd has resigned as vice-president of the American Broadcasting Company, to become president and general manager of Audio and Video Products Corporation, 681 Fifth Avenue, New York, which specializes in the sale of technical equipment for broadcasting and television stations. One of the principal products represented is the Ampex magnetic tape recorder, for which Audio-Video has exclusive rights East of the Rocky Mountains.

LETTERS . . .

Some Television Essentials

Editors Tele-Tech:

The recent holding up of further action on television permits shows an unusual degree of fearlessness on the part of the Federal Communications Commission. For an administration to be capable of admitting the possibility of an error in judgment is a manifestation of a rare quality that gives great confidence in the present organization.

In a note of this kind I should no doubt use broad, general terms that I could construe later in many different ways, but since my neck is still unsevered after having been put out a number of times, I will put it out again with the following prediction:

1. The Commission will be able to give a green (commercial) light to VHF television operators in a relatively short time, and the rush for permits will be in full swing shortly after the Commission acts.
2. It will be possible to produce an economic service in the UHF band and in the higher part of the VHF band which will be at least equal to and probably better than in the lower VHF band.
3. The polycasting system, a system now under study, may well prove the means of achieving this result.
4. Equipment will be available in a short time after the F.C.C. shows that a market is available in UHF.

I would like and hope to see the Commission in this television allocation follow a course radically different from that in other broadcast bands by applying at least part, but preferably all the following principles:

1. That the American systems engineer be given freedom to use his skill and imagination, telling him what performance is required as to service and interference, but not how to achieve it.
2. That rules be based on reliable experimental results to include the effects of a variety of atmospheric conditions, of hills, of buildings, reception in apartment houses, etc.
3. That geographic and market areas be not defined in millivolt per meter contours, leaving it to the engineer to fit his millivolts per meter to an area and not vice versa.
4. That laws of nature and propagation be accepted as fundamental without compromise. We should adapt ourselves to them and never them to us. And in this connection, that tabus be placed on all industrial, legal and administrative wishful thinking.
5. That experimentation with new systems be stimulated by giving their sponsors special consideration and privileges and by simplifying the process of obtaining permits to try them out.

Raymond M. Wilmotte
Consulting Engineer.
1469 Church St., NW.,
Washington 5, D. C.

Designing TV Sets for Easier Servicing

Editors Tele-Tech:

In your editorial of October, 1948, under the heading of "Time For New Methods," I notice your remarks on construction and assembly methods of AM, FM or television receivers.

We at Magnavox are very much in accord with your thinking and I believe we have attempted in our television receivers to provide for ease of service to a greater degree than usual. The Magnaxox television receiver chassis is cleaner in construction and wiring than is normally found for mass-produced television receivers. We use cabling instead of point-to-point wiring, which is somewhat more expensive, but we do find the assembly problem on our lines easier, and our trouble-shooters tell us that our circuits are very much better to trace.

Most components which might be subject to failure in the field are assembled to the chassis with screws, lock-washers and nuts, rather than the cheaper form of riveting. Our field service people feel that this is a definite advantage. We pay particular attention to our sockets, and where possible we use the moulded-type unit which is easier to repair, since the defective tube contact can be removed and replaced without the need of removing the complete tube socket.

In our smaller table models it is only necessary to tilt the cabinet on its side, remove four screws which hold the bottom panel in place and the service engineer can readily gain access to all of the wiring under the chassis. To gain access to the high voltage components located within the protective chamber, it is only necessary to remove two self-tapping screws and the back cover of the high voltage compartment slips off. When this cover is removed an ingenious interlock arrangement removes the power from the chassis and thus protects the service operator from undue shock hazard.

I believe we have gone a long way at Magnavox to help the field service engineer and judging from the comments we have had from our service organizations, it would appear we are justified in whatever additional expense has been entailed in providing these advantages.

Antony Wright
Chief Television Engineer
Magnavox Co.
Fort Wayne, Ind.

Selling to Air Force

(Continued from page 23)

phase of selling to the Air Force should be addressed to the respective Procurement Field Office or to the Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, marked to the attention of the proper office or department.

All of the foregoing Air Force buying procedure is comparatively new. A thorough reorganization of the Procurement Division has brought about the present "Streamlined Procurement" program which closely parallels modern industrial purchasing methods. The new system makes it much easier to sell to the Air Force and is proving to be a decided step forward not only in efficiency of purchasing but in its alignment to the constantly changing requirements for an up-to-the-minute air defense of the nation.

East Mid-West Coaxial

(Continued from page 20)

tem will not give out a quotable figure, but it certainly runs to many millions. This is probably the reason for the gradual shift to radio relay, which is cheaper and easier to install and more flexible in operation.

The coax and the relay links are, of course, only the connecting medium for the TV networks. The terminal and intermediate equipments fill large bays and require the services of many engineers. Currently, there are about 250 amplifier units in the television terminals in telephone buildings along the nets, and about 540 repeater-amplifiers strung along the circuits to maintain the TV signals at the correct level. During 1948 alone, 551 plant employees were given special training to prepare them for the job of handling network television programs.

The engineering of the coaxial cable dates back to May 23, 1929, when the original Espenschied-Affel patent application was filed. The work was carried out by engineers of the Bell Telephone Laboratories, the research branch of the parent American Telephone and Telegraph Company. The actual responsibility for the operation of the present networks rests with the Long Lines Department of the A.T.&T. Co., with headquarters at 32 Sixth Avenue, New York.

OVERALL SYSTEMS PLANNING

(*Continued from page 38*)

equalizer so that the overall frequency characteristics of the system are substantially flat for the prevailing average weather and temperature conditions. However, if the transmission characteristics of the line changes, the level of the pilot increases or decreases accordingly. This change, which is measure of departure of the slope and line loss from the initial prevailing condition, causes a corresponding variation in the magnitude of the current applied to the negative coefficient resistors in the feedback circuit of the carrier amplifier, and in turn these vary in resistance in such a way that an increased pilot level results in a decreased carrier amplifier gain and a less steep frequency characteristic slope. The net result is that the overall frequency response characteristic of the line and common receiving amplifier is maintained substantially flat, and the circuit net loss of the channel is kept relatively constant. A 1 DB change of line attenuation on either side of the average value for which the system has been initially lined up causes a change of only 0.1 DB in the output level of the receiving carrier amplifier.

A meter and an optional alarm are inserted in the circuit to indicate transmitting or receiving levels and give audible indication when the pilot fails for any reason. In addition when the line change exceeds 12 DB, or when the pilot channel fails, a relay releases and keeps the gain of the amplifier 2 DB below normal level.

Within each repeater there is the equivalent of two such pilot receiving units, one for the E-W direction and the other for the W-E direction. The remainder of the repeater is similar to that of the 9-A-1, with the exception that the transmitting amplifier has sufficient bandwidth to amplify three channels.

Short Haul System

The equipments described heretofore were designed for long line communications, with long lines being defined as those lines giving over 18 DB of attenuation at the carrier frequency. Where the distances involved do not dictate the need for such long line equipment, the FTR 9-H-1 Short Haul Carrier Telephone System may be employed.

The equipment consists of three separate single channel units, each of which may be operated and installed collectively or individually in accordance with the demand. The three channels operate at different frequencies, chosen so as to coordinate with other commercial carrier telephone systems. The first channel, operating on 4.2 to 10.2 KC, coordinates with the 9-A-1 or its equivalent; the second channel, operating on 13.5 to 19.5 KC, coordinates with the 9-F-1 and 9-B-1 or their equivalents; and the third channel, operating on 27.4 to 33.4 KC, coordinates with the 9-B-1 or its equivalent.

There are a number of economies in design that have been incorporated in the 9-H-1 equipment due to the fact that it is used for short haul. Since the maximum difference between receiving and transmitting levels is only 18 DB, a lower-cost directional filter can be employed. On long line equipment, where the level difference was 36 DB, the directional filter was required to have a very sharp cut-off characteristic. In the 9-A-1, for example, the low frequency portion of the directional filter had to pass, virtually unattenuated, the 3.5 to 5.9 KC band, but attenuate a 7.5 KC signal more than 60 DB. due to the 36 DB level difference.

Also in the 9-H-1, by employing opposite sidebands of a single carrier frequency for the transmitting and receiving, respectively, the same oscillator and rectifier bridge can be used for both modulation and demodulation.

Fig. 7 shows a block diagram of the first channel East Terminal of the 9-H-1 which is typical of all the others. It is obvious that, by taking full advantage of the lower levels required, the system can use considerably fewer components with no degrading of quality.

The distance over which each channel can be employed varies in accordance with its frequency band. The first channel, being in the lowest band, has a range of 100 to 150 miles over open wire lines; the second channel has a 75 to 100 mile range: while the third channel ranges from 50 to 75 miles. Where a number of towns or centers are to be served by these carriers, the distances between towns can be coordinated with the range of the channel.

In some communications systems it is desirable to add telegraph facilities to existing voice channels. Where a 2700 cycle voice band is employed, it is possible, through the use of the FTR 9-C-1 equipment to provide a telegraph circuit, without loss of the speech channel,, for each existing voice circuit. Thus, if a three channel system such as the 9-B-1 were used, 4 to 7 telegraph circuits could be added, 3 to 6 on the carrier telephone channels and one on the voice channel.

Speech plus duplex is accomplished by removing from the speech path all frequencies above 2200 cycles and using the 2200 to 2700 cycle band for telegraph transmission. The two telegraph channels, one for receiving and the other for transmission, are centered at approximately 2375 and 2575 cycles. The FTR 9-C-1 equipment is normally placed between switchboard and telephone line and/or carrier, and contains a filter for removing the 2200 to 2700 cycles speech frequencies, as well as the oscillator, modulator and demodulator.

In the discussion thus far the existence of wire lines has been assumed and the means of increasing the capacity of these lines considered. There is also the condition where lines do not exist or all existing lines are fully exploited so that additional transmission facilities must be provided.

Microwave radio links offer the advantages of being able to easily span difficult terrain such as presented by rivers and mountains, simplify maintenance and repair since all equipment is confined to two known locations, provide virtually 100% reliability under all adverse weather conditions (when switchover units are used), and are capable of wide modulation bands making them suitable for transmitting a large number of channels simultaneously. Their major disadvantage lies in that their range is limited to "line of sight" distances without repeaters, and the need for a source of power at each terminal.

Radio links, in their application to wire transmission, fall into two general categories, namely

(1) As part of long line telephone systems, in which the link is used only to span difficult terrain.

(*Please turn to next page*)

OVERALL SYSTEMS PLANNING

(*Continued from preceding page*)

(2) As point-to-point links initiating and terminating directly in telephone instruments and switchboards, or other subordinate telephone equipment such as a carrier system. This is illustrated in Fig. 9.

In either of these systems radio links can be integrated with any of the aforementioned carrier systems. However, two important radio link characteristics should be considered in its application with carrier telephone. One is that the link comprises a circuit of zero attenuation loss — the input level is equal to the output level — and secondly the link is equivalent to an ideal four wire system, that is, the receiving path is completely independent of the transmitting path.

Where the radio link is part of an overall wire system, the type of carrier used will be dictated mainly by the requirements of the wire portion of the system. However, where there is an option, such as in point-to-point links, the more economical short haul 9-H-1 equipment would normally be used since there is no attenuation across the link. Furthermore, since the E-W path is completely independent of the W-E path, separate carrier frequencies for W-E and E-W are not necessary. Hence all six frequency bands in the three channel 9-H-1 system can be employed in both directions, providing six channels. With the voice frequency channel, a 7 channel system can thus be realized.

In the design of the radio circuit, the accepted standards of Wire Transmission Systems must be observed. Channel output stability, distortion and noise, among others, must be such as to give satisfactory overall operation of the composite wire-radio link. In addition adequate precautions must be taken to assure correct radio operation at all times through sufficient receiver selectivity, low spurious response and high carrier frequency stability.

These requirements are met in the FTL-13A equipment which operates in the frequency range of 900 to 940 MC. Each radio link, comprising one radio transmitter and one radio receiver terminal requiring a single assigned radio carrier frequency, constitutes a one-way broad-band communications circuit. Two such links, operating in opposite directions over the same path on two separate radio carrier frequencies, provide a two-way circuit adaptable to 4-wire signal transmission.

This equipment is capable of transmission of signals in the 200 cycle to 60 KC range. Since the 9-H-1 employs carriers only up to 30 KC, this means that more than 7 channels can be transmitted simultaneously in this link through the use of the 30 to 60 KC band. The transmission quality obtained is sufficient to permit the incorporation of these links in line circuits utilizing carrier telephone, telegraph, program and facsimile equipment. Use of more than one link in tandem, where radio circuits of extended length are required, may be accomplished with some reduction in transmission quality. Frequency modulation is employed with adequate transmitted power and antenna gain to assure uninterrupted service on a continuous basis. The high degree of directivity of the parabolic antennas used, in addition to providing a high power gain and assuring privacy, also permits the operation of several radio channels on adjacent frequencies for maximum utilization of the RF band.

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BULLETINS

FM & TV Antennas

"FM & Television Antennas with Flexibility" is the title of loose leaf catalog No. 1304, released by L. S. Brach Mfg. Corp., 200 Central Ave., Newark 4, N. J. Antenna accessories, police, fire alarm, and telephone accessories are described. (Mention T-T)

Audio Transformers

A detailed description of the Standard line of high-fidelity transformers is featured in the new catalog released by Standard Transformer Corp., Elston, Kedzie and Addison Streets, Chicago 18, Ill. Each of the 10 new models has been designed for a specific circuit application. (Mention T-T)

FM Antenna

A new, low-cost FM antenna for transmitters rated up to 10 KW is the subject of bulletin 86, published by Andrew Corp., 363 East 75th St., Chicago 19, Ill. The Multi-V is easy to install and has a mnimum power gain of 1.6 (at 88 and 108 MC). (Mention T-T)

Tube Classification Chart

A tube classification chart with detailed specifications of Sylvania's converters, power amplifiers, RF pentodes, rectifiers, triodes, and diode detectors has been released by Sylvania Electric Products Inc., Emporium, Pa. (Mention T-T)

Precision Potentiometer

Specifications, prices and diagrams of the RV2 high precision potentiometer, manufactured by Technology Instrument Corp., Waltham, Mass., are presented in a new 8-page booklet. Rated rotational life is one million complete cycles. (Mention T-T)

Flat Press Subminiatures

Subminiature tube sockets and other methods of connecting circuits to the tube are discussed in "Socket and Mounting Notes for Raytheon Flat Press Subminiature Tubes", a booklet by Raytheon Mfg. Co., Inc., 60 East 42nd St., New York 17, N. Y. (Menton T-T)

Resistors

International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa., has just published comprehensive data on characteristics and specifications of new, advanced type BT insulated fixed composition resistors. Advanced performance standards are given for 1/3, 1/2, 1 and 2 watt types. (Mention T-T).

Magnetic Tape Recorders

"Ninety-nine Questions Most Often Asked About Twin-Trax Magnetape Recorders" is the title of a 12-page booklet released recently by the Engineering Dept., Amplifier Corp. of America, 398-26 Broadway, New York 13, N. Y. This booklet provides information which is not normally covered in sales literature but which has proven valuable to those interested in magnetic tape recording. (Mention T-T)

Hardware and Finishing Materials

Walter L. Schott Co., 9306 Santa Monica Blvd., Beverly Hills, Calif., has published its 1948 catalog listing the complete Walsco line of hardware, chemicals, tools, finishing materials and service items for the electronic trade. (Mention T-T)

Transmitting Tubes

More than a score of power and transmitting tube characteristics are tabulated in a booklet available on request from Sylvania Electric Products Inc., Emporium, Pa. Rated plate dissipations range from 20 to 175 watts. (Mention T-T)

Welding Alloys

Eutectic Welding Alloys Corp., 40 Worth St., New York 13, N. Y., has released a new eight-page bulletin which explains in simple non-technical language how Eutectic low temperature welding alloys compare with welding and brazening processes. (Mention T-T)

TELE-TECH

Advertisers February 1949

HERE'S THE FIRST
BIG FM NEWS
FROM REL FOR 1949!

THE REL MODEL 707 FM RELAY LINK

A complete 890 to 960 mc system for $3950

F.O.B. FACTORY—LONG ISLAND CITY, N. Y.

EQUIPMENT INCLUDES:

1. CRYSTAL CONTROLLED 5 WATT TRANSMITTER MOUNTED IN RELAY RACK CABINET
2. 15 db PARABOLIC TRANSMITTING ANTENNA
3. CRYSTAL CONTROLLED RECEIVER MOUNTED IN RELAY RACK CABINET
4. 15 db PARABOLIC RECEIVING ANTENNA
5. ONE COMPLETE SET OF TUBES AND CRYSTALS

..offering wide application for FM STL, all other aural broadcast STL requirements, point-to-point communication, multi-channel voice relay systems.

The Model 707 FM Relay Link is a high quality equipment that meets or betters FCC and RMA requirements for FM studio-to-transmitter link in the 940 to 952 mc band or a one-way voice communication relay system within the 890 to 960 mc band. It is also recommended for inexpensive but highly reliable relay service where multiple voice frequency channels are desired. With suitable terminal equipment five such channels can be handled.

Salient features of this equipment include low first cost, low maintenance (all tubes are standard low cost types) and exceptional performance characteristics resulting from the application of the REL SERRASOID MODULATOR to the system. Complete details including field performance of the basic design covering many months will be supplied promptly on request on company letterhead.

ELECTRICAL PERFORMANCE

- FREQUENCY: 890 to 960 megacycles.
- FM SIGNAL TO NOISE RATIO: 70 db. below 100% modulation.
- AUDIO RESPONSE: 0.5 db., 50 to 15,000 cycles.
- DISTORTION: Harmonic distortion is .50% at 100% modulation.
- CENTER FREQUENCY TOLERANCE: .003%.
- PRIMARY POWER: 115 volts, 60 cycles, single phase.
- TRANSMITTER AUDIO INPUT: Impedance—600/150 ohms Level—+10 dbm, balanced or unbalanced.
- RECEIVER AUDIO INPUT: Impedance—600/150 ohms Level — +18 dbm maximum, balanced or unbalanced.
- TRANSMITTER POWER OUTPUT: 5 watts.
- MODULATION BAND WIDTH: 50-20,000 cycles.
- SPACE ATTENUATION: For signal to noise ratio of 70 db. with 75 microseconds de-emphasis, 105 db. max.

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35-54 — 36th STREET, LONG ISLAND CITY 1, N. Y.

The RCA List of Preferred Type Receiving Tubes fulfills the major engineering requirements for future receiver designs.

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These RCA receiving types are especially recommended because their wide-spread application permits production to be concentrated on fewer types. Longer manufacturing runs reduce costs—lead to improved quality and greater uniformity. These benefits are shared by you and your customers.

RCA Application Engineers are ready to suggest the best preferred types for your receiver design requirements. Just contact our nearest regional office—or write RCA, Commercial Engineering, Section 57BR, Harrison, New Jersey.

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RADIO CORPORATION of AMERICA

HARRISON, N. J.