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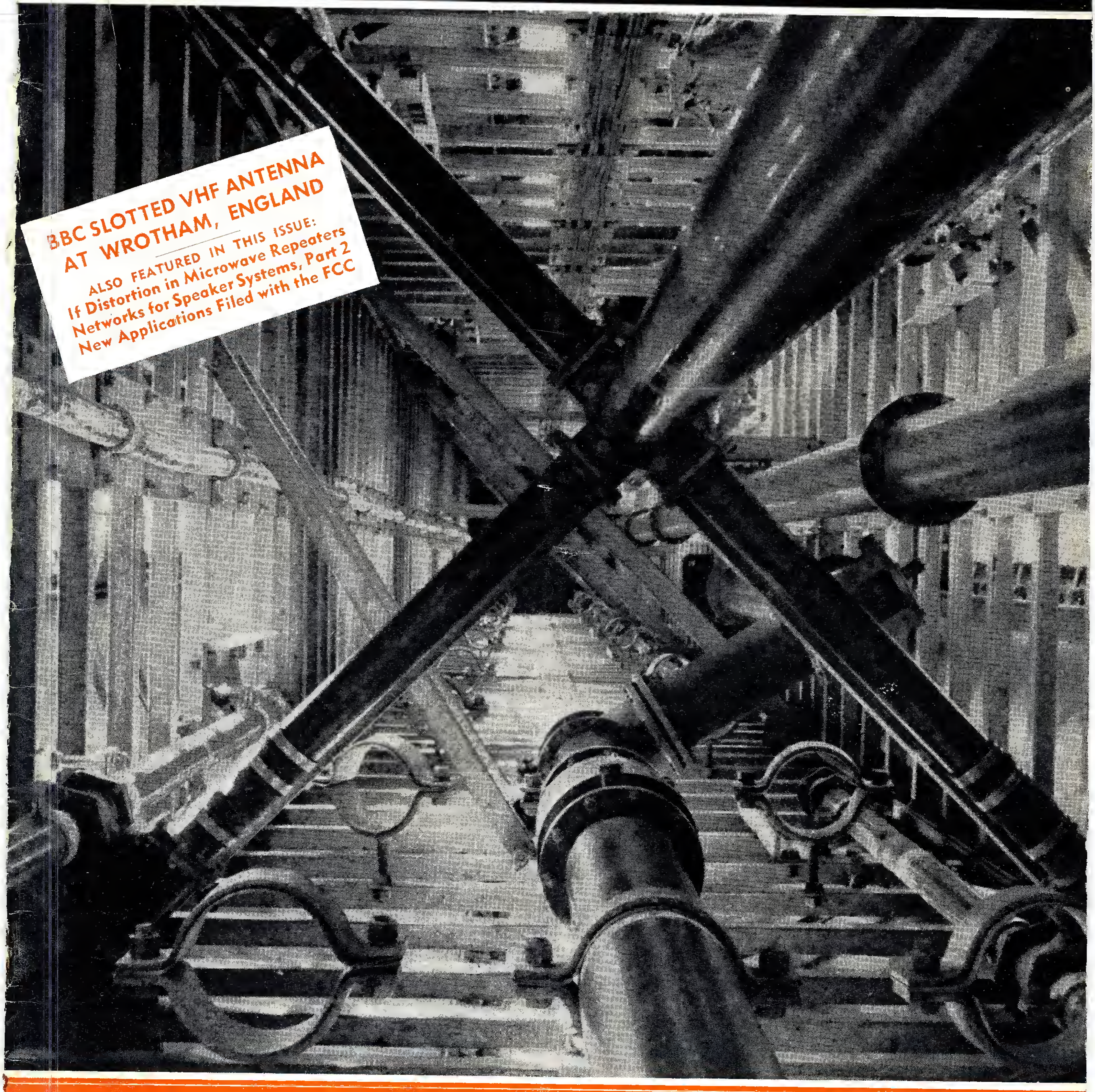
RADIO COMMUNICATION

★★Published by★★
Milton B. Sleeper



12th Year of Service to Management and Engineering

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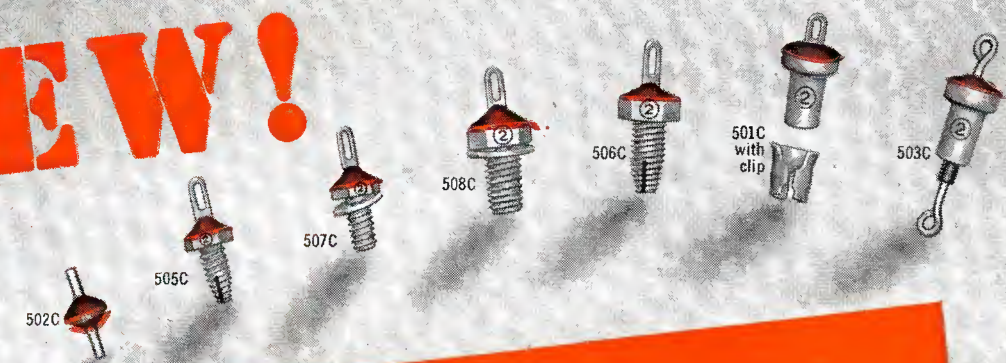


BUTTON CERAMIC CAPACITORS

...FOR TV AND U-H-F DESIGN

Design of electronic equipment and TV receivers for the higher frequencies is simplified by a new series of button ceramic capacitors developed by Sprague. A completely new construction using a disc capacitor element instead of the conventional dielectric tube results in higher self-resonant frequencies and improved circuit efficiency.

For bypass applications, Types 505C, 506C, 507C, and 508C are unique. The dielectric button is housed in a recess in the top of a hex-head machine screw and is sealed against moisture by a plastic resin. This shielded construction minimizes ground inductance and keeps it at a fixed value while providing a short bypass path to ground, which is radially uniform over the capacitor element. The lug terminals are essentially at tube socket terminal height to help maintain short, uniform lead lengths.

Type 501C is a ferrule shank bypass capacitor for push-clip mounting in TV receivers while type 503C is its feed-thru counterpart. The disc capacitor element is resin-sealed in a recess in the top of the metal shell.

Type 502C "shirt-stud" capacitors are ¼" diameter buttons intended for coupling in u-h-f TV set front ends.

All units are rated at 500 volts d-c and are available in both characteristic SL and GA general application bodies.

Engineering Bulletin 605 gives complete details on these new and different capacitors. Request it today on your company letterhead from Sprague Electric Company, North Adams, Mass.

PIONEERS IN ELECTRIC **SPRAGUE** AND ELECTRONIC DEVELOPMENT

NEW HIGH-VOLTAGE CERAMIC DISCS

Sprague Cera-mite Capacitors are now available in 1000 and 1500 volt ratings as well as in the usual 500 volt ratings. Write on letterhead for Bulletin 601C.

OPERATION SUCCESS!

with du mont telecasting equipment

The rich heritage of over 12 years' experience in the design, manufacture and use of telecasting equipment is reflected in every piece of Du Mont equipment today. This experience results in equipment without peer for performance, dependability and operating economies.

Du Mont-equipped stations were among the first to "break into the black" a few years ago. Today a roster of the most successful stations in the television world shows an impressive percentage of partial or 100% Du Mont-equipped operations.

It was Du Mont who first advocated the "Grow As You Earn" basis of station equipment. This has paid dividends to the many stations who recently increased their transmitting power through the Acorn-to-Oak Series Transmitters. Such power increases were achieved with no loss of "time on the air" or loss of former equipment.

Truly, a Du Mont-equipped TV station exemplifies OPERATION SUCCESS!

DU MONT Television Transmitter Division,

Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

No matter where your customer lives...

New 1952 ZENITH TV

REG. U. S. PAT. OFF.

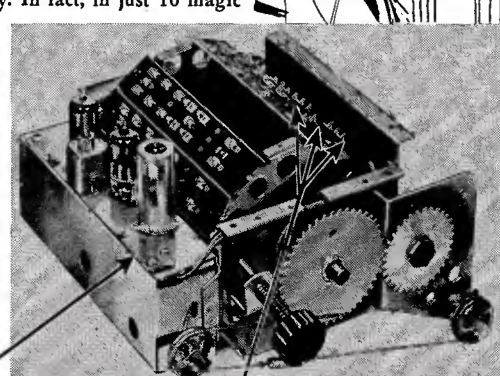
gives Customized Performance for his location on every station!

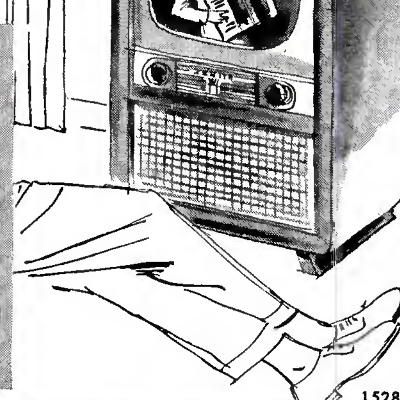
What a feature! New Zenith Customized Performance is sweeping the nation—building up store traffic and skyrocketing sales across the country! For here, at last, is the easy key to perfect TV reception. And—*of greatest importance to you*—here's the way to quicker sales and assured customer satisfaction. All with just 10 minutes installation time.

Yes—just 10 minutes! Customers want their sets tuned *exactly—precisely.* And you can do all that and more—quickly and easily. In fact, in just 10 magic minutes you'll tune the Fringe-Lock on your customer's Zenith to *his* distance from the station—and custom-compensate for *his* angle from the station.

Think of what Customized Performance means to a customer. Then better think of what it means to you in real profit-making potential.

All that for just 10 minutes installation time? RIGHT! It's Zenith Customized Performance—the Greatest Refinement in Television since Television began . . . and—**Only Zenith Has It!**





1528

The Miracle Zenith Turret Tuner with the 14 "Silver Fingers"

. . . a *Zenith Exclusive* on every 1952 model that really means something to television prospects. Thanks to a special "Bull's Eye Tuner Knob" built into Zenith's famous Turret Tuner—the tuner with the 14 "Silver Fingers"—every 1952 Zenith can be custom-tuned to the frequency of every individual station—for your customer's individual location.

And Customized Performance is permanent—yet it's simple! You can custom tune Zenith—any of your men can—with just a few minutes practice.

This profit-loaded feature ties in with Zenith's "Electronex" Tube, provision for UHF, Fringe Lock Circuit, and Dust-Proof Screen to give you the biggest selling combination in TV history.

ZENITH *LONG DISTANCE* RADIO and TELEVISION — THE ROYALTY OF RADIO AND TELEVISION

ZENITH RADIO CORPORATION • CHICAGO 39, ILLINOIS

FM-TV RADIO COMMUNICATION

Formerly *FM* MAGAZINE and *FM* RADIO-ELECTRONICS

VOL. 12 FEBRUARY, 1952 NO. 2

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CPA AUDIT

CIRCULATION AUDITED BY HENRY R. SYKES CERTIFIED PUBLIC ACCOUNTANT SYKES, GIDDINGS & JOHNSON PITTSFIELD, MASSACHUSETTS

IN December, AM set production, as shown by RTMA statistics, showed a substantial drop for the third consecutive month; TV sets gained 50,000 over November, and FM receivers inched up slightly. As the Barometer shows, AM home models actually went up, but that gain was offset by the small number of automobile models turned out.

Factory inventories of TV sets are dwindling steadily, as shipments continue to exceed the number produced. In December, shipments totaled 680,141, exceeding production for the month by a little more than 200,000. Thus, while the number of sets manufactured in December was substantially below that of the same month in '50, shipments were nearly equal. During '51, 20,000 or more TV sets were shipped into 32 states:

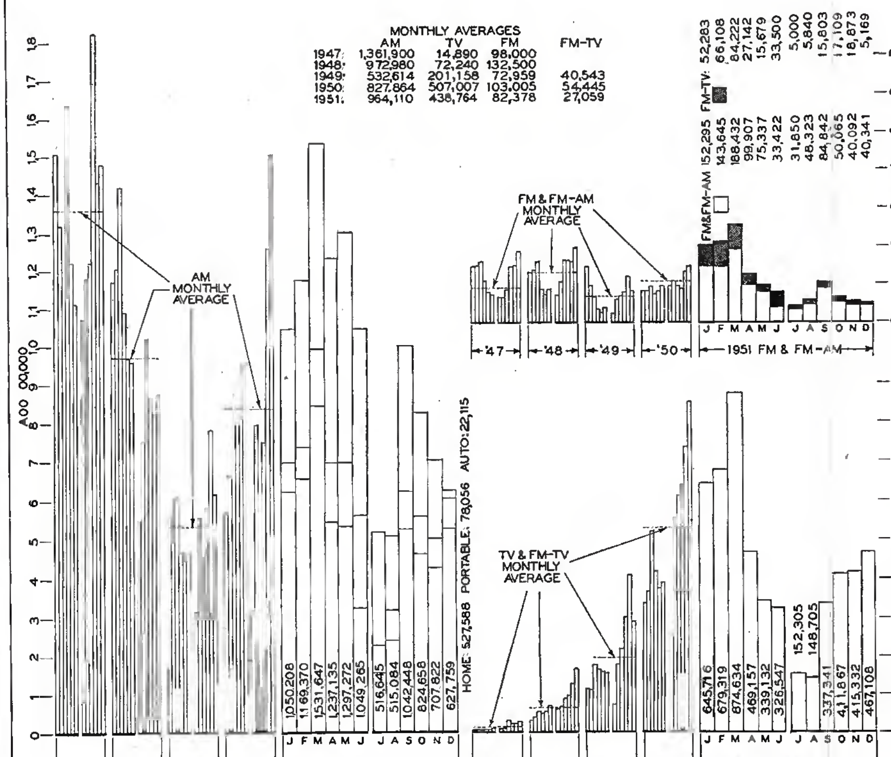
Ala.	41,938	Kans.	24,513
Calif.	437,172	Ky.	61,284
Conn.	122,815	La.	27,715
D. C.	59,561	Md.	95,492
Fla.	51,305	Mass.	231,755
Ga.	65,828	Mich.	281,515
Ill.	350,643	Minn.	78,094
Ind.	160,176	Mo.	151,188
Ia.	85,702	Neb.	45,301

N. J.	237,171	Tenn.	47,918
N. Y.	776,419	Texas	123,952
N. C.	80,158	Utah	22,673
Ohio	475,043	Va.	71,920
Okla.	45,717	Wash.	55,412
Penn.	540,489	W. Va.	30,331
R. I.	38,241	Wisc.	86,614

November sales of picture tubes to manufacturers amounted to 460,566 units, values at $9,696,247, compared to 455,636 tubes valued at $9,388,382 in October.

Receiving tube sales in November came to 32,710,369, compared to 34,137,-519 in October.

While RTMA statistics indicate a drop in factory-built FM sets, if FM tuners sold for custom installations were included, FM would probably show an actual gain. In fact, the volume of sales in FM tuners, together with amplifiers, expensive speakers, and other high-fidelity units has increased to the point where two of the major set manufacturers are now preparing to market complete lines of hi-fi equipment. These will not be sold through their set distributors, but directly to dealers who are specializing in this field.



TV, FM, and set Production Barometer, prepared from RTMA figures

STARTING NEXT MONTH:

PATTERN for TV PROFIT

BY ROY F. ALLISON

in collaboration with

A. B. CHAMBERLAIN
Chief Engineer, General Engineering Department
Columbia Broadcasting System

RODNEY D. CHIPP
Director of Engineering
DuMont Television Network

RAYMOND F. GUY
Manager, Radio & Allocation Engineering
National Broadcasting Company

THOMAS E. HOWARD
Chief Engineer
New York Daily News Station WPIX

FRANK L. MARX
Vice-President in Charge of Engineering
American Broadcasting Company

"Pattern for TV Profit" is a basic text for the information and guidance of those planning to operate VHF or UHF television broadcast stations, either independently or as network affiliates. This series, making available the experience of the leading television broadcast engineers in the U.S.A., will cover all the problems of organizing, equipping, and operating TV stations in large and small centers of population.

THIS MONTH'S COVER

This unusual photograph was taken *inside* a slotted-cylinder antenna developed for VHF aural broadcasting in England. The main feed line can be seen at the bottom of the picture. With a length of 105 ft. and a diameter of 6½ ft., adequate working space is provided inside so that feed lines and other equipment can be installed later for the addition of a TV antenna atop the cylinder.

Next month's issue will carry a detailed report on the BBC's comparative tests of FM and AM, for which this antenna was used.

SPOT NEWS NOTES

ITEMS AND COMMENTS, PERSONAL AND OTHERWISE, ABOUT PEOPLE AND COMPANIES CONCERNED WITH RADIO COMMUNICATION

Ultrasonics Vs. Seagulls:

Here is the story as we got it from Lieut. Sam Harmatuk and Nick Reinhardt of the New York City Fire Department: Some time ago, seagulls discovered a reservoir on Staten Island, and they swarmed over from the ocean in great numbers for a dip in fresh water. Because they fish in the waters of New York Harbor, authorities feared that the reservoir would become polluted. It was decided to use a shotgun to scare the gulls away. However, the gulls just moved farther out on the reservoir. Then, as they determined the range and trajectory of the gun, they flew and landed just far enough away to be safe and undisturbed. Finally, a few more venturesome gulls undertook to fly in from the land, and perch on the gun barrel. At that point, this means of scaring them away was abandoned in favor of an ultrasonic generator which, its proponents were sure, would so annoy the gulls that they would leave, and never return. But this proved to be a terrible mistake. The ultrasonic frequency chosen must have been that of the seagull's mating call, for when the device was turned on, gulls in great numbers flocked to the reservoir from all directions! So project Shoogull was dropped. It wasn't too important, anyway, as this water is held as a reserve supply, to be used only in case of an emergency.

IRE Convention:

Will be held at Grand Central Palace, New York City, March 3 to 6 inclusive. Four floors of exhibits will present an elaborate picture of radio and associated equipment, materials, and methods so complete that everyone connected with the industry should make a special effort to attend. Hours are from 9:30 AM to 9:00 PM except on Wednesday, when the doors close at 6:00 PM. You'll find staff members of Radio Communication and High-Fidelity Magazines in the Audio Section, third floor, space 325.

Radio Club of America:

Officers elected for 1952 are John Bose, president; Ralph R. Batcher, vice president; Frank H. Shepard, Jr., corresponding secretary; Frank A. Gunther, recording secretary; and Joseph Stanley, treasurer. Elected directors: Ernst V. Amy, Edwin H. Armstrong, George E. Burghard, Alan Hazeltine, Harry W. Houck, Jerry Minter, and Harry Sadenwater.

New Construction:

Clippard Instrument Laboratory, Inc., will move to a two-story building of 21,000 square feet, scheduled for completion on April 1. Address is 7350 Colerain Avenue, Cincinnati.

Avery Yudin:

Former staff member of NYU graduate division of the School of Education has joined Rek-O-Cut as director of audio education. Working with educators and school administrators, Mr. Yudin will explore means for more effective use of audio aides in education. As a part of this project, he will set up audio workshops in various cities where Rek-O-Cut equipment will be demonstrated to educators, with active participation by students.

Plant Expansion:

Half a million dollars will be spent by P. R. Mallory on an expansion program to add 35,000 square feet of space for production of electrolytic capacitors, and

(Continued on page 8)

SPOT NEWS NOTES

(Continued from page 6)

27,000 square feet for products of the company's metals and ceramics division.

Chicago Audio Show:

Will be held at the Conrad Hilton (Stevens) Hotel, Chicago, May 23 and 24. This show will follow immediately after the Parts Show, which runs from May 19 to 22. Staff members of both RADIO COMMUNICATION and HIGH-FIDELITY will be on hand in room 603. The first Audio Show in Chicago is long overdue, considering the great interest in hi-fi out there among parts jobbers, dealers, and the general public. Consequently, attendance should rival that at the New York show. Attendance may run even higher, since the exhibits will be open until 9:00 PM on Saturday evening. This show will be open to the general public.

Robert E. Bird:

Former sales manager of Bird Electronic Corporation has joined Magnecord, Inc., 360 N. Michigan Avenue, Chicago, as manager of contract sales, handling special magnetic recording equipment for industrial and military applications.

New Line of TV Sets:

Will be produced by the Lion Manufacturing Corporation, 2600 Belmont Avenue, Chicago, of which Raymond T. Maloney is president. Paul Eckstein will head the company's TV receiver division.

Phonevision, Pro & Con:

Our esteemed contemporary, *Broadcasting,* has editorialized strenuously against the promotion of phonevision and the seemingly selfish purposes of those who are doing the promoting. But where or how should the line be drawn against promotion and advertising? It is basic to our economy that new means and new methods, however great their merit, only materialize as public services to the extent that demand is created by paid advertising and promotion. Says *Broadcasting:* "And those who believe that dime, quarter or dollar-in-the-slot television is not in keeping with the traditional U. S. broadcasting system had better muster their arms if they don't want to lose the fight by default." Who, in the radio business, is going to lose if Phonevision is authorized? Not the public. They could still see free TV shows unless they prefer the pay-programs. Not the broadcasters. They would be paid for Phonevision time, and it may prove more profitable. Not the set manufacturers. They'd still sell sets. What is

(Continued on page 9)

SPOT NEWS NOTES

(Continued from page 8)

our opinion of Phonevision? We feel that as long as this Country is run by the people who live in it, they are the ones to decide whether they want Phonevision in addition to Freevision. So it seems to us that they should have the opportunity of expressing informed opinions on the subject. They'll pay if they want to, and no one can make them pay if they don't.

New Offices: Motorola's regional office at New York City, handling communications sales and field engineering in New York, New Jersey, and Pennsylvania, has been moved to 102 Linwood Plaza, Fort Lee, N. J. Phone number is Ft. Lee, 8-9100. Regional manager Lowell White explained: No parking space convenient to the New York office location, and too much traffic getting into and out of the City!

Airborne Electronics Conference: The next National Conference on Airborne Electronics, sponsored by the Dayton Section of the IRE, and the IRE Professional Group on Airborne Electronics, will be held at Hotel Biltmore, Dayton, Ohio, on May 12 to 14. Papers and exhibits will be related to both military and commercial equipment. Details can be obtained from David G. Clute, 2132 Meriline Avenue, Dayton 10.

That Trailer-Mounted Tower: Inadvertently, we omitted the address of the company which manufactures the 78-ft. telescoping tower, illustrated on page 29 of the November 1951 issue. We thought it an extremely useful means of checking communication and TV antennas, and antenna sites. Apparently our readers thought so, too, because we have had a great number of requests for the manufacturer's address. For the bene-

(Continued on page 35)

MEETINGS and EVENTS

MARCH 3-6, IRE CONVENTION & SHOW
Grand Central Palace, New York City

MARCH 20-21, CENTRAL STATES APCO CONFERENCE
Hotel Van Orman, Fort Wayne, Indiana

MARCH 31-APRIL 2, NARTB CONVENTION
Hotel Conrad Hilton, Chicago

MAY 5-7, QUALITY ELECTRONICS CONFERENCE
Bureau of Standards, Washington, D. C.

MAY 12-14, AIRBORNE ELECTRONICS CONFERENCE
Hotel Biltmore, Dayton, Ohio

MAY 16-17, SOUTHWESTERN IRE CONFERENCE & SHOW
Rice Hotel, Houston, Texas

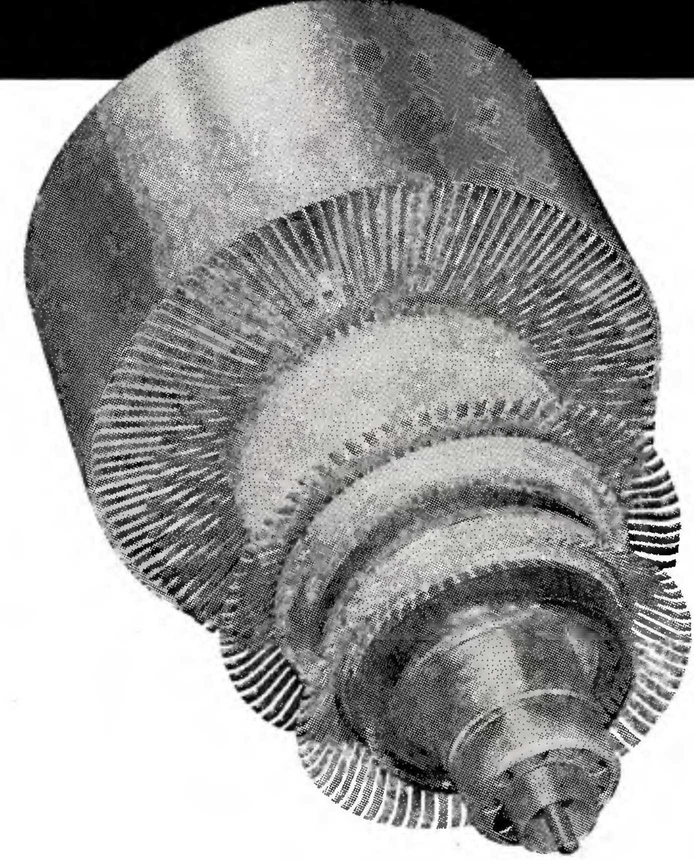
MAY 19-22, RADIO PARTS SHOW
Hotel Conrad Hilton, Chicago

MAY 23-24, AUDIO SHOW
Hotel Conrad Hilton, Chicago

AUGUST 27-29, WESTERN ELECTRONIC SHOW & CONVENTION
Municipal Auditorium, Long Beach, Calif.

OCTOBER 20-22, IRE-RTMA FALL MEETING
Syracuse, New York

NOW! AIR-COOLED FOR TV



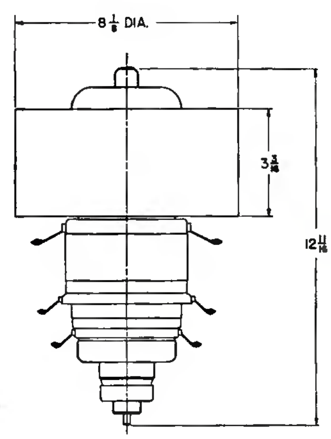
Eimac 4X20000A

★ **20 Kw Peak Sync. Output**

★ **5 Mc. Bandwidth**

★ **216 Mc. Operation**

★ **Ceramic Envelope**



Here's the companion tube to Eimac's sensational 4W20000A . . . the 4X20000A, the new powerful and practical air-cooled transmitting tetrode developed for TV on VHF. The 4X20000A incorporates all the special characteristics of the water-cooled tube including a ceramic envelope that gives greater mechanical strength and higher resistance to thermal shock. Integral contact fingers assure proper terminal contact and simplify circuit construction.

This tube's potentials are not limited to television.

- ***Write for Technical Data Sheet on the New 4X20000A***

TYPICAL OPERATION
Class-B Linear Amplifier — Television Visual Service
(Per tube, 5-Mc. Bandwidth, 216 Mc.)
Peak Synchronizing Level

Load Impedance	400 Ohms
D-C Plate Voltage	5500 Volts
D-C Screen Voltage	1200 Volts
D-C Control Grid Voltage . . .	−240 Volts
D-C Plate Current	7.1 Amp.
D-C Screen Current (approx.) . .	500 Ma.
Peak R-F Grid Input Voltage . .	430 Volts
Plate Power Input	39.1 Kw.
Plate Dissipation	16.5 Kw.
Useful Plate Power Output . . .	20.1 Kw.

Follow the Leaders to Eimac Tubes

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA
Export Agents: Frazar & Hansen, 301 Clay St., San Francisco, California

HIGH-POWER VHF SLOT ANTENNA

A DESCRIPTION OF THE SLOT ANTENNA DEVELOPED BY THE BBC RESEARCH BUREAU FOR VHF BROADCASTING IN GREAT BRITAIN — *By* G. D. MONTEATH*

WITH congestion in the long and medium wave bands becoming increasingly severe, the BBC recently prepared a plan for a domestic broadcasting service on VHF frequencies. High-power experimental transmissions have been broadcast from Wrotham in Kent since July, 1950, and aerials are being installed at each of the new high-power television stations in readiness for a sound broadcasting system on frequencies in the neighborhood of 90 mc.

At such frequencies, it is possible to employ either frequency or amplitude modulation, and to provide for a greater bandwidth than is practicable on long and medium wavelengths, thereby permitting the transmission of higher audio frequencies. Furthermore, the very short wavelength makes it possible to use a highly directive transmitting aerial to confine the greater part of the radiated energy to planes near the horizontal, thus increasing the field strength along the ground. This is important because the ground wave is more rapidly attenuated at VHF than at lower frequencies, and because hills and other large objects tend to cast shadows. These effects are, to some extent, offset by the fact that satisfactory reception is possible at a lower field strength than is necessary in the medium-wave band, provided interference from the ignition systems of automobiles and from other transmitters is not excessive.

The transmitting aerial described herein was developed by the BBC Research Department, and was designed mechanically and constructed by British Insulated Callender's Construction, Ltd. The feeder system, upon which the performance of the aerial depends, was designed, constructed, and installed by Marconi's Wireless Telegraph Company, Ltd.

Design Considerations:

The first consideration in the design of an aerial is the direction of polarization of the electric vector. It was decided to polarize the aerial horizontally since, while the propagation characteristics of horizontally and vertically polarized waves are not significantly different at 90 mc., impulse interference from motor vehicles and other sources was found to have more effect with vertical polarization.

The other requirements for the transmitting aerial will be summarized briefly. The directivity in the vertical plane was to be sufficient to give a power gain of about 8, equivalent to 9 db, over a half-wave dipole, with substantially uniform radiation in the horizontal plane. The aerial was to be capable of sharing the mast with a high-power television transmitting aerial which was to occupy the higher position. Finally, it was to be possible to radiate simultaneously up to three FM transmissions at frequencies spaced about 2 mc. apart, each signal having a power of 25 kw. and a peak frequency deviation of 75 kc. This last requirement did not imply that frequency modulation, rather than amplitude modulation, would necessarily be used; in fact, the first aerial, erected at the Wrotham transmitting station, is being used in an experimental comparison of the two systems of modulation.

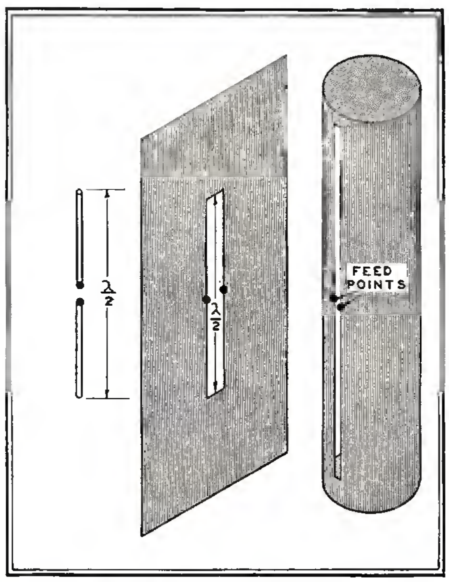


FIG. 1. DIPOLE AND ITS COMPLEMENTARY SLOTS

FM transmission requires that the aerial be matched closely to the feeder. If the aerial impedance departs from the characteristic impedance of the feeder, reflections occur; the reflected waves, after undergoing a second reflection at the transmitter, arrive again at the aerial after a certain time interval. The instantaneous frequency of the resultant of the original and delayed transmissions no longer follows the audio-frequency signal exactly, but exhibits non-linear distortion. A further result is the appearance of unwanted amplitude modulation of the carrier. Although this would be removed by the limiter in a good receiver, it might cause severe distortion if no limiter were employed.

The simplest way to obtain a highly-directive aerial is to combine a number of simple radiating elements into an array. The way in which the salient features of the aerial, considered as a whole, were determined by the required performance will be discussed first, and then the design of the individual elements composing it.

The vertical radiation pattern of a vertical array of similar elements, energized in phase, consists of a main horizontal beam or lobe with a number of subsidiary beams or side lobes above and below it. The width of the main lobe is determined almost entirely by the overall vertical aperture or length of the aerial, while the number and strength of the side lobes are also dependent upon the characteristics of the individual elements and the spacing between them. Thus, if the vertical aperture is fixed, the potential gain is limited, and is realized fully when the power radiated in the side lobes is reduced to negligible proportions. The side-lobe power can be reduced either by increasing the number of elements, so that they are closer together, or by making each element more directive in its own right.

For an aerial omnidirectional in the horizontal plane, having a gain of 8 over a half-wave dipole, the vertical aperture cannot be much less than 8 wavelengths. Therefore, the aerial to be described had to be about 85 ft. long. Its transverse dimensions had to be substantial, in the order of 5 ft., so that the lower aerial could support a television aerial and its high-power feeders, and so that this aerial could be assembled and adjusted in position.

The radiation pattern of a single element is disturbed by the presence of a thick supporting mast. To achieve uniformity in the horizontal plane, it is necessary to surround the mast by rings of elements, the minimum number of elements necessary in each ring increasing with the ring radius. Unfortunately, the vertical radiation pattern of a ring of elements energized in phase is less sharp than that of a single element, with high-angle radiation being accentuated. This effect becomes more pronounced as the radius is increased. For this reason, and also to minimize the number of elements

*Research Department, Engineering Division, The British Broadcasting Corporation, Broadcasting House, London, W1, England. This article appeared originally in the *BBC Quarterly* under the title "An Aerial for VHF Broadcasting."

required in each ring, the radius should be small; in other words, each element should be mounted as close to the mast as possible.

Up to this point the general form of the aerial has been discussed without regard to the nature of the radiating elements composing it. The following characteristics were required of each element:

1. The radiation had to be horizontally polarized.

2. The radiation pattern had to be as directive as possible in the vertical plane.

3. The impedance had to be suitable for drive by coaxial feeder, and substantially constant over the band of approximately 4 mc. occupied by the three transmissions.

4. The element had to be suitable for mounting close to the supporting mast.

5. The mechanical form had to be such as to discourage the accretion of ice.

Apart from the third, each requirement is satisfied by a vertical slot aerial cut in a hollow cylindrical mast. Although the impedance characteristics of simple slot aerials are not quite satisfactory, it was found possible to correct for this by the method of feed.

Slot Aerials:

The general properties of slot aerials were first studied during the late war. Progress has been so rapid that they are now used extensively for VHF broadcasting in the USA. Their development has been facilitated greatly by the work of H. G. Booker,[1] who established a general relationship between slot and wire aerials, thus permitting the body of existing knowledge on wire aerials to be brought to bear on slots. He showed that to every aerial consisting of wires or strips arranged in a plane there corresponds a complementary slot aerial, in which the places of the wires are taken by slots cut in a conducting sheet. While the wire aerial is energized by breaking it and connecting a generator across the break, the generator is connected between the edges of the complementary slot. This principle is illustrated in Fig. 1, which shows the familiar half-wave dipole and the complementary slot.

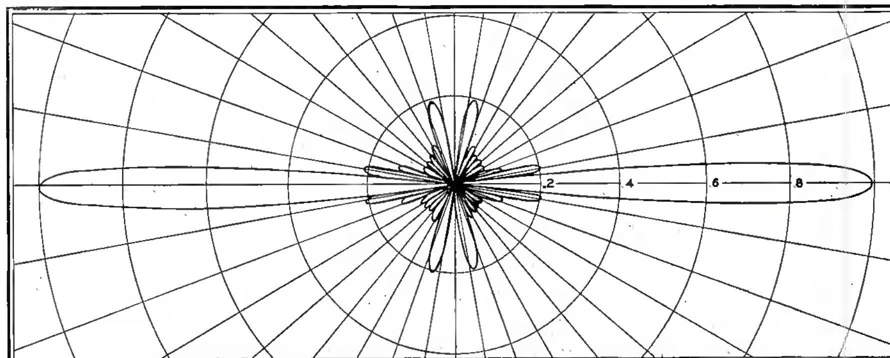


FIG. 3. VERTICAL RADIATION PATTERN OF THE ANTENNA. THE HORIZONTAL PATTERN IS CIRCULAR

Ideally, the sheet in which the slot is cut should be flat and infinite in extent, and the wire aerial should take the form of a flat strip that would just fit into the slot. Under these conditions, the electric field set up by either of the complementary aerials is identical in form to the magnetic field of the other. Thus, a slot aerial can be regarded as a magnetic dipole, or a magnet of alternating polarity. The two aerials shown in Fig. 1 at the left and center have similar radiation patterns but, unlike the vertical dipole, the slot radiates horizontally-polarized waves. A further consequence of the general relationship is that the complementary aerials behave as inverse networks, the impedance of one being proportional to the admittance of the other. More precisely, the geometric mean of the impedances of the two aerials is a resistance of 188 ohms. It follows that the bandwidths are equal.

In practice, it is rarely convenient to cut a slot aerial in a flat metal sheet that is so large as to be effectively infinite. Also, it is usual to box the slot in on one side, so that it radiates only from the other. For these reasons, the relationship between slot aerials and the complementary wire aerials does not hold exactly in practice, though it does provide a useful qualitative guide. When a slot is boxed in at the rear as, for example, when it is cut in a hollow cylinder as shown at the right in Fig. 1, the principal effect is to raise the resonant frequency. If this effect is counteracted by lengthening the slot, a more directive radiation pattern is obtained.

In the light of the foregoing discussion, it is evident that vertical slots, cut in a hollow cylindrical mast, are well suited to meet the requirements listed above. They combine directivity in the vertical plane with horizontal polarization, and are certainly as close to the mast as possible, since they are parts of it. Further, by fitting insulating windows into the slots, the smooth continuity of the surface of the mast can be preserved to discourage ice formation.

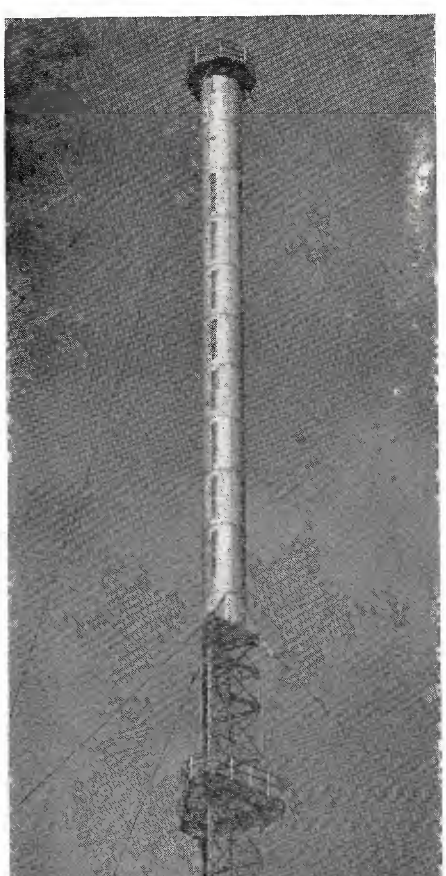


FIG. 2. THE 105-FT. SLOT ANTENNA AT WROTHAM

Description of the Aerial:

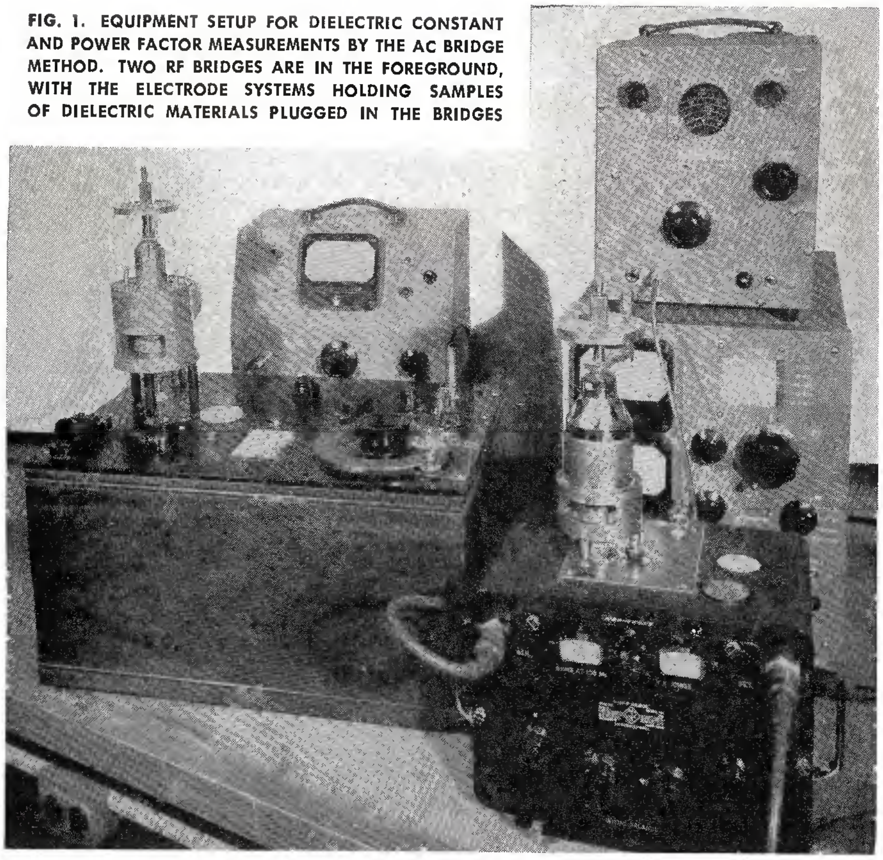
The Wrotham aerial, shown in Fig. 2, is a hollow galvanized-steel cylinder, 105 ft. high and 6½ ft. in diameter, supported on a triangular lattice mast of conventional design. A platform is provided at the top for mounting a topmast carrying a television aerial, should this be required. The upper 21 ft. of the cylinder are left clear for associated equipment. The remainder of the cylinder, 84 ft. high, is an aerial with 32 vertical slots arranged in 8 tiers, each of 4 slots. The vertical spacing between the centers of the tiers is 10 ft. 6 ins., or about one wavelength. Each slot is 8 ft. high and 1 ft. wide, and is provided with a plastic window. All 32 slots are energized in phase. The use of 4 slots at each level results in a substantially uniform distribution of energy in the horizontal plane, the greatest departure from the mean being 0.5 db.

The interior of the cylinder is shown in the photograph reproduced on the front cover of this magazine. A central space of square cross-section is screened from the fields of the slots by horizontal bars spaced 1 ft. apart. One object of the screening is to permit the installation of coaxial feeders, both for the slot aerial and for the television aerial if required, without disturbing the performance of

(Continued on page 36)

[1] "Slot Aerials and their Relation to Complementary Wire Aerials (Babinet's Principle)," by H. G. Booker, *J.I.E.E.*, 1946, Vol. 93, p. 620f

FIG. 1. EQUIPMENT SETUP FOR DIELECTRIC CONSTANT AND POWER FACTOR MEASUREMENTS BY THE AC BRIDGE METHOD. TWO RF BRIDGES ARE IN THE FOREGROUND, WITH THE ELECTRODE SYSTEMS HOLDING SAMPLES OF DIELECTRIC MATERIALS PLUGGED IN THE BRIDGES



Measurement Techniques for

DIELECTRICS AT RF

NATIONAL BUREAU OF STANDARDS PROMULGATES RF STANDARDS FOR DIELECTRIC MEASUREMENTS

INFORMATION on the properties of dielectric materials has become increasingly important in recent years, not only to designers and manufacturers of radio equipment, but also to scientists studying molecular structure.

To facilitate determination of the properties of various dielectrics, and their dependence on frequency, temperature, and humidity, the National Bureau of Standards has established radio-frequency standards for dielectric measurements. For solid dielectric specimens, dielectric constant and power factor calibration services are now available in the frequency range from 10 kc. to approximately 600 mc. Somewhat more limited calibration services can be obtained also for gases and liquids. The new standards and services provided by the Bureau are expected to be of material assistance in these fields.

In NBS techniques for evaluating dielectric properties, a disc-shaped capacitor made from the material to be investigated is utilized. The complex dielectric constant of this capacitor is measured conveniently by bridge resonance methods. Special micrometer electrode systems are used, which consist essentially of pairs of plates that form variable capacitors. They are precision instruments, constructed so that the circular electrodes are plane-parallel, and of nearly optical flatness. One electrode is insulated by a quartz disk, while the movable or grounded electrode is attached to a holder by metal bellows arranged in such a way that no sliding contacts are required. The position of the movable electrode is controlled accurately by a micrometer, and the capacitance of the entire system is calibrated against an incremental precison capacitor. The structure supporting the movable electrode forms an effective shield for the electrode system.

Measurement Methods:

The micrometer electrode system is used in conjunction with conventional bridges or resonance-indicating devices. The dielectric specimen is inserted between the electrodes, and the bridge is then balanced or the circuit resonated. When the specimen is removed, the spacing between the electrodes is reduced until the bridge is balanced again or the circuit is reresonated. The dielectric constant is determined from the difference between the capacitance corresponding to this reading on the micrometer dial and the capacitance corresponding to the micrometer dial reading with the specimen in place.

This technique for determining the dielectric constant, known as the susceptance variation method, circumvents fringing errors. It is valid with commercially available bridges for frequencies up to approximately 300 mc. Errors caused by series inductance variations are reduced, becoming functions only ot the changes in length of the movable electrode. These are negligible for most values of capacitance.

Fig. 1 shows equipment for measuring dielectric constant and power factor by the bridge method. The electrode sys-

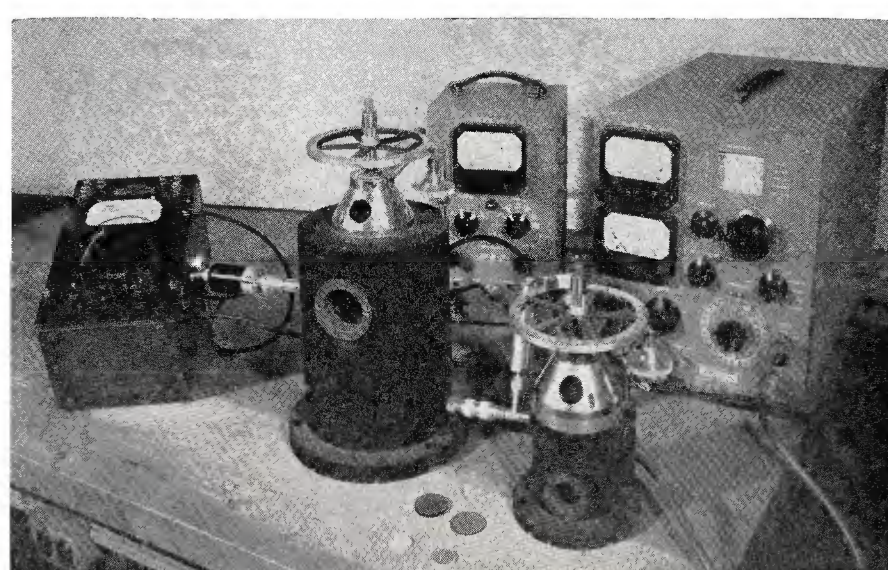


FIG. 2. DETERMINING DIELECTRIC CONSTANT AND POWER FACTOR BY THE RESONANT-CAVITY METHOD

tems are designed so that they can be plugged conveniently into most commercial bridges. In the foreground are two bridges of different frequency ranges, with the electrode systems plugged into position. Typical disk specimens are on top of each bridge, and associated monitoring and frequency-generating equipments are in the background.

Resonance Techniques:

At frequencies above 500 kc., power factor and dielectric constant are usually determined most accurately by a resonance method. In this procedure, the circuit including the electrode system and the specimen is resonated, and the voltage across the unknown is recorded. The specimen is then removed, the circuit reresonated, and the voltage across the air capacitor is recorded. From these voltages, and the known Q of the electrode system, the loss properties of the specimen are calculated. Again, the dielectric constant is determined simply from the dial reading of the micrometer at the second point of resonance and the corresponding calibrated capacitance.

Resonant-cavity measuring apparatus for determining dielectric constant and power factor are shown in Fig. 2. The specimen, in the shape of a circular disc, is inserted in a cavity, and forms part of the resonant circuit. Both instruments at the left are voltmeters, aud the unit at the extreme right is a signal generator. The cavity at the left operates in thc frequency range from 150 mc. to 300 mc. The smaller cavity in the right foreground operates in the range from 400 mc. to 600 mc.

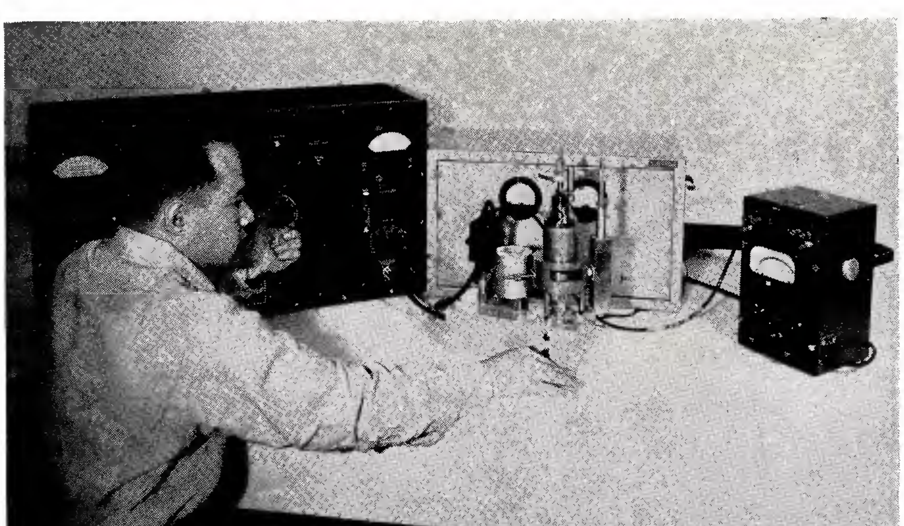


FIG. 3. NEGATIVE-RESISTANCE APPARATUS FOR LOW-FREQUENCY RESONANT MEASURING TECHNIQUE

This resonance technique is useful over a wide frequency range. It is particularly applicable without modifications at frequencies above 100 mc. At these frequencies, the inductor becomes a single turn. Therefore, a doubly-reentrant resonant cavity of either fixed or variable length can be utilized. This device consists essentially of a coaxial structure shorted at both ends, with a variable gap in the center conductor. The test specimen occupies the gap between the reentrant posts. The frequency of operation of the fixed-length cavity is governed by the constants of the specimen inserted between the reentrant posts as well as by the geometry of the cavity. Consequently, the operating frequency cannot be determined in advance. The variable electrode, similar in structure to the movable electrode of the micrometer-electrode system described previously, is also micrometer-controlled. It is calibrated at the lower frequency in terms of the capacitance between the reentrant posts. This permits measurements without appreciable corrections for lead inductance. Resonant cavities are advantageous because Q's in the order of 1,000 to 3,000 are readily obtainable, thus providing convenient voltage ratios even for very low-loss specimens.

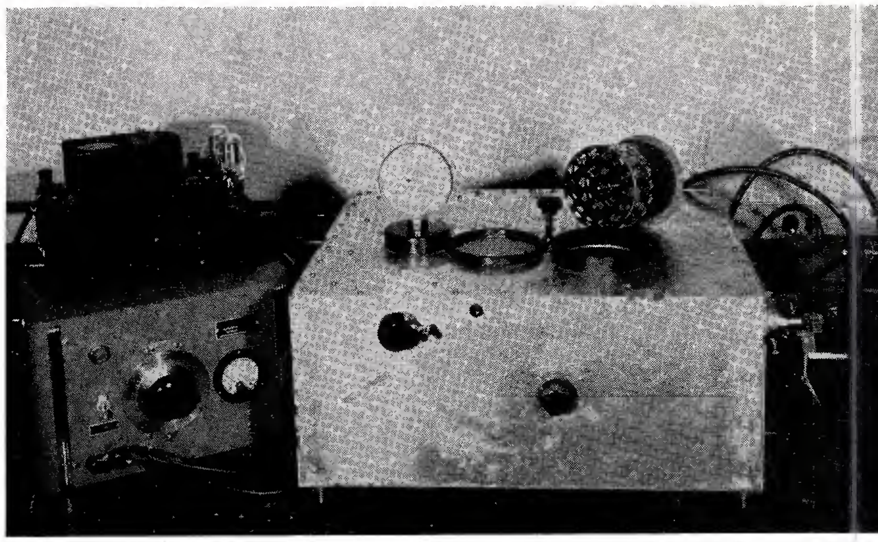


FIG. 4. EQUIPMENT FOR DIELECTRIC TESTS AT VARIOUS DEGREES OF TEMPERATURE AND HUMIDITY

Resonant circuits with Q's of this magnitude are not common at frequencies below 50 mc. Therefore, it is necessary to resort to special circuitry in order to obtain low-loss measurements at these frequencies. A suitable circuit can be designed employing a linear, stable negative resistance. When this resistance is connected in series with an inductor and a conventional micrometer electrode, it can be adjusted to cancel almost completely the resistance of the rest of the system, thus producing a resonant measuring system of extremely high *Q*. As a result, the losses in the system are caused primarily by the specimen, which facilitates an accurate evaluation of its dielectric properties.

The circuit employed is, in effect, a cathode follower with a capacitive load and increased grid-to-cathod capacitance. Under these conditions, the real component of the input impedance has a large negativc value which can be adjusted by varying one of the circuit parameters. The great amount of negative feedback makes the circuit extremely stable and provides excellent linearity, because only signals of very low amplitude need be applied. *Q*'s of 100,000 have been obtained with an instability of only a few per cent over a pcriod of 10 minutes, with no detectable deviation from the normal resonance curve resulting from non-linearity. These conditions make it possible to measure dissipation factors in the order of .00001 to an accuracy of about 10%. Of course, losses of less than .00001 are measured with less accuracy.

Fig. 3 shows this apparatus in detail. The negative-resistance measuring unit, which yields *Q* values of 100,000 at frequencies near 1 mc., is in the center foreground. The sample material is inserted in the electrode system, which can be seen just above the operator's hand. A voltmeter, at the right, measures the voltage across this capacitor-electrode

(Concluded on page 26)

Relationship of RF-IF to Baseband Amplitude Distortion in

MICROWAVE REPEATER SYSTEMS

HOW SPURIOUS FM CAUSED BY AMPLITUDE DISTORTION IN RF-IF AMPLIFIERS CAN BE DETECTED AND CORRECTED — *By* J. P. SCHAFER AND L. E. HUNT*

IT was found, when making measurements on AT&T's TD-2 transcontinental FM repeater system, that the video frequency response characteristic was not as flat with increasing frequency as might have been expected from the known amplitude-frequency characteristics of the video amplifiers in the terminal equipments. Instead, variations of as much as 8 or 10 db over the band of 0 to 8 mc. were sometimes observed, with a loop of some 60 stations.

By referring to the vector diagram in Fig. 1, it can be seen that such baseband distortion can be caused by distortion in the IF or RF amplitude vs. frequency characteristic. The diagram, limited to first-order sidebands, shows that any change in the amplitudes of the sidebands relative to the carrier produces a corresponding change in the modulation angle, and only a second-order change in resultant amplitude. Accordingly, amplitude limiters can effect only second-order correction to the distortion, which then finally appears at the discriminator as spurious angular modulation. This vector picture can, of course, be confirmed by a more formal mathematical representation of what takes place.[1]

This paper describes laboratory studies made of a frequency-modulated wave passing through circuits having unequal transmission efficiency over the frequency band, these inequalities being concealed from direct observation by components which cause compression or limiting. This set-up gives a qualitative laboratory representation of what takes place in an actual FM repeater radio circuit. The main difference between the two lies in the number of such components. In the latter there are over a hundred repeaters, each containing slight irregularities in attenuation across the transmission band. These irregularities are interspersed with compressions which, in the aggregate, may be hundreds of decibels. The primary purpose of the work was to devise means for observing and annulling the effects of the concealed attenuation distortions to which the FM carrier was subjected.

IF and Baseband Distortion:

It can be shown that distortion in the baseband characteristic is in exact correspondence with that in either half of the IF amplitude characteristic, provided that the latter has even-function symmetry about the carrier frequency, and that the deviation ratio over the baseband frequency range is small compared with unity. This limits the effect to low-order sidebands. Curves of amplitude vs. frequency having odd-order symmetry about a point corresponding to the carrier frequency will not produce baseband distortion, provided that the carrier is at the point of symmetry, and that the resultant is not caused at any moment to depart greatly from the carrier amplitude. This is evident if the curves, such as an unbroken straight line, are plotted on a linear scale.

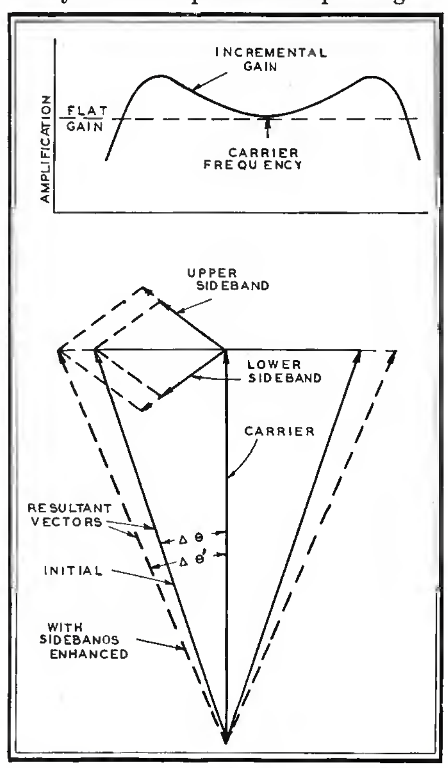


FIG. 1. EFFECT OF IF AMPLITUDE DISTORTION

The large rise in the baseband response curve at the higher frequencies found in a particular section of the repeater system was attributed at that time to the slightly saddle-shaped IF amplifier characteristic in each repeater, accentuated by a similar amplitude characteristic of the delay-distortion equalizers. Apparently these departures from flatness, while in themselves only fractions of a decibel, added cumulatively through the many repeaters and account readily for variations of several db in the final video response curve. These same characteristics are not obtained in all sections of the system, indicating that components other than the IF amplifiers are contributing to the variations.

W. J. Albersheim of Bell Telephone Laboratories has shown mathematically that, in principle, an IF amplitude-frequency distorting or correcting characteristic can be constructed from data obtained by observing the baseband response while taking baseband characteristics about several fixed carrier frequencies. As a practical matter, amplitude correction of this type has not so far been at all important, but it might well become important in the future if the baseband frequency range should be extended to accommodate increased numbers of multiplex telephone channels, for example, or television pictures with enhanced definition. It may be necessary at that time to amplitude-equalize the RF and IF transmission circuits to meet even stricter requirements than those already successfully met by the TD-2 circuits. Alternatively, or possibly in addition, the use of "clean-up" amplitude equalizers might be called for to correct long sections of repeater circuits rather than to do it in each individual repeater.

Experimental Investigations:

It seemed desirable to conduct some experimental investigations in order to check the predictions of theory and to find some useful and practical method of observing and correcting baseband distortions.

Since an experiment designed to determine the IF amplitude-frequency characteristic from the baseband response is exceedingly difficult, a more direct and convenient laboratory procedure is to observe the distortion appearing in the baseband response and to take steps to equalize the system until the observed distortion disappears.

A dynamic sweep method of observation was devised, in which the baseband amplitude characteristic over a 0 to 10-mc. frequency range is displayed on the

*Bell Telephone Laboratories, Inc., Deal, New Jersey.

[1]Phase distortion will have some effect on the amplitude characteristic, but can be neglected in a first approximation. See Appendix.

screen of an oscilloscope, for a number of IF frequencies. As will be shown, if these various sweep-frequency response lines are separated appreciably, IF distortion is present; if the lines are essentially superimposed and flat, distortion is not present. In case amplitude distortion *is* present, a method for correction utilizes an adjustable IF amplitude

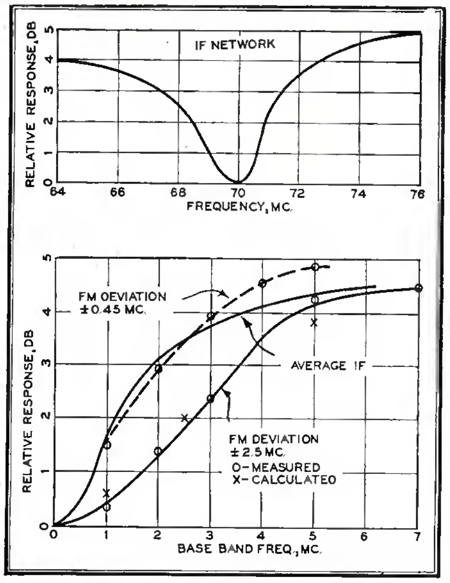


FIG. 2. BASEBAND RESPONSE VS. IF CHARACTERISTIC FOR VARIOUS VALUES OF FM DEVIATION

equalizer inserted at the input to the FM terminal receiver. By a cut-and-try manipulation of the equalizer controls, the various sweep lines are adjusted for optimum flatness and superposition. Tests over a system can be made on either a straight-through or loop basis.

The equipment as planned was set up in the laboratory. As a first step, some point-by-point data was obtained after introducing a known IF distorting network into a 60 to 80-mc. FM circuit. The results of this experiment are shown in Fig. 2. The IF network amplitude characteristic and corresponding baseband characteristics are given for two values of FM deviation. It will be observed that the actual IF characteristic is not quite symmetrical about 70 mc. A new IF curve, which is the average of the two halves on either side of 70 mc., was redrawn for purposes of comparison with the baseband response curve. This is shown in the lower half of Fig. 2. It can be seen that the basband response curve for a small value of FM deviation is in very good agreement with the *average* IF characteristic, whereas the response curve for a large deviation is considerably different. That this departure is according to theory is shown by the several calculated points for this condition. These curves illustrate the fact that small deviations must be used in any experiments in which it is desired to get an exact correspondence between baseband response and IF characteristics.

As the correspondence between baseband and IF characteristics occurs only when the carrier frequency is set exactly at the midpoint of a symmetrical response curve, it is apparent that in general the IF response cannot be deduced from a single baseband characteristic curve. Moreover, it appears to be impossible to measure directly the actual IF characteristic in a circuit such as a repeater chain, where compression or limiting occurs. The cumulative effect is the complicated resultant of a large number of attenuation curvatures interspersed with equally numerous compressions.

Correction of Distortion:

In order to correct the unwanted curvature in the baseband characteristic, it is necessary to observe rapidly the baseband response, and then provide means to correct it. A given baseband response can be equalized with a baseband equalizer if the baseband modulating signal contains no DC component, since the carrier frequency is then fixed. On the other hand, if a television signal which has a DC component is to be transmitted, the baseband characteristic is a function of carrier frequency as well as of the baseband frequency. In general, this changes the baseband response, and requires a varying equalization. That requirement is removed, however, if the equalization can be made at the IF frequency.

Since the spurious effect is observable only at the baseband output, the equalization is most readily accomplished at the system's FM terminals preceding the limiters, and must be such as to introduce a counteracting phase modulation. A simple way of doing this is to insert in the IF circuit a network having the proper corrective amplitude characteristics. Such a network, when properly adjusted, alters the sideband-carrier relationship in the correct way to counteract the spurious phase modulation introduced by the system. The equalizer can consist of either a series of fixed networks or a number of adjustable networks.

A technique for checking rapidly the degree of equalization has been devised. This is a dynamic method, in which the FM transmitter is modulated by a baseband signal which is swept at a low rate over the desired frequency range. A low index of modulation is used, thus confining the energy to low-order sidebands, a condition which facilitates the observation of curvatures. As the baseband frequency sweeps from zero to a maximum, the sidebands correspondingly sweep over the IF characteristic on both sides of the carrier. Any variations in the sideband amplitudes are translated into spurious phase variations, which reappear as amplitude variations in the baseband output.[2]

The baseband frequency characteristic is displayed on the screen of an oscilloscope whose horizontal sweep is synchronized with the baseband sweep. A flat pattern indicates that the amplitude characteristic throughout the RF and IF sections is either flat or has odd-order symmetry. In order to correct for various curvatures in different parts of the IF band, the equalization should be checked with the carrier at several different frequencies in the band. This was accomplished by modulating the beating oscillator of the transmitter with a multiple step voltage. The result is a family of curves, each one representing a different IF carrier, swept out on the oscilloscope screen. Correction is accomplished by a cut-and-try adjustment of the IF equalizer until all the curves are as flat as possible and nearly super-

[2]See Appendix.

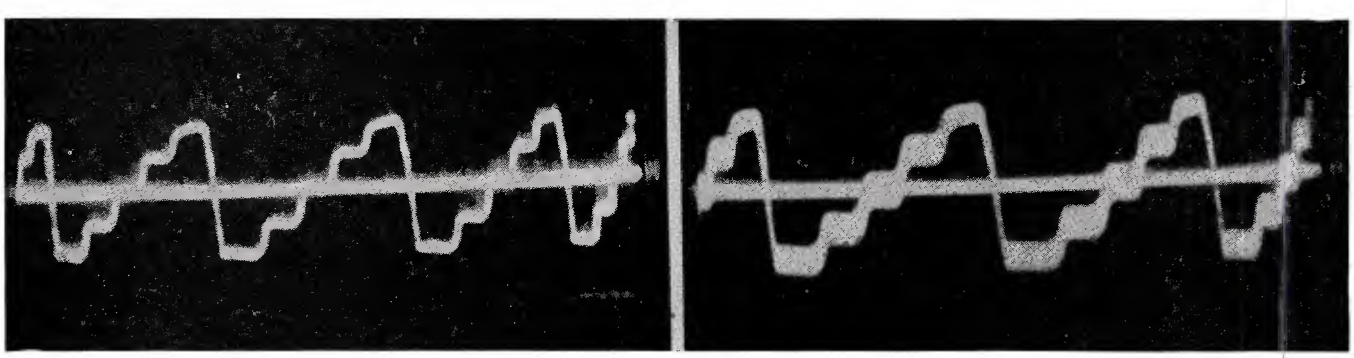


FIG 3. STEP VOLTAGE FOR MAKING BASEBAND RESPONSE TESTS WITH VARIOUS IF CENTER FREQUENCIES. MODULATION IS SUPERIMPOSED AT RIGHT

imposed. These flat response curves were observed using a low index of modulation, but they remain flat, of course, for higher indices as well. It has been shown experimentally, and it can be seen from the discussion in the Appendix, that a straight sloping amplitude characteristic does not affect the baseband response. It follows that even though the baseband curves are made flat, it is still possible (and likely) that such a sloping amplitude characteristic might be introduced by the IF equalizer and still go unnoticed. If a slope is undesirable from the viewpoint of noise, it is necessary to measure the IF amplitude characteristic of the variable equalizer after it has been adjusted to obtain flat baseband response. An additional slope equalizer can then be added and adjusted to remove any undesired slope.

Shifting the IF Carrier:

The multiple step voltage was generated in alternate ways. In the first method, a six-pole motor-driven commutator was connected to a DC voltage-divider. In the second, a series of crystal diodes was used, biased in progressive steps as in a quantizer. The resultant DC step voltage, obtained by either method, provides rapid switching from one carrier frequency to another when applied to the repeller of the microwave beating oscillator. The frequency of the switching is preferably non-commensurate with the oscilloscope sweep frequency. A broken-line presentation of baseband response is obtained for the various carrier frequencies. The continuity of each swept line depends upon the frequency of switching, the sharpness of the breaks in the step voltages, the disturbance caused by switching transients, and the oscilloscope screen persistence.

Of the two methods, the crystal quantizer arrangement seems to be the more satisfactory, since the switching rate is controlled easily and the number of steps can be changed as desired. The switching rate used was about 5,000 per second, which is many times faster than could be obtained readily with the motor-driven commutator arrangement, and results in a fine-structure line display on the screen of the scope. The switching transients cause a blurred background on the screen. However, the response curves are clear enough for observation purposes, as is shown by the reproduced photographs.

Oscillograms of the step voltage appear in Fig. 3. The unmodulated step wave-form appears at the left. Steps are at 66, 68, 70, 72, and 74 mc. In the waveform at the right, 0 to 10-mc. baseband modulation has been superimposed on the step voltage.

Experimental Results:

Fig. 4 is a block schematic of the test setup. The video output of the receiver is filtered to provide 1) a sweep synchronizing voltage, and 2) the rectified voltage representing baseband amplitudes corresponding to the degree of distortion. Fig 5 shows a typical baseband scope pattern for the IF distorting network whose characteristic is given in Fig. 2. Five carrier steps were used with the center one at 70 mc., which is the point of symmetry for the network.

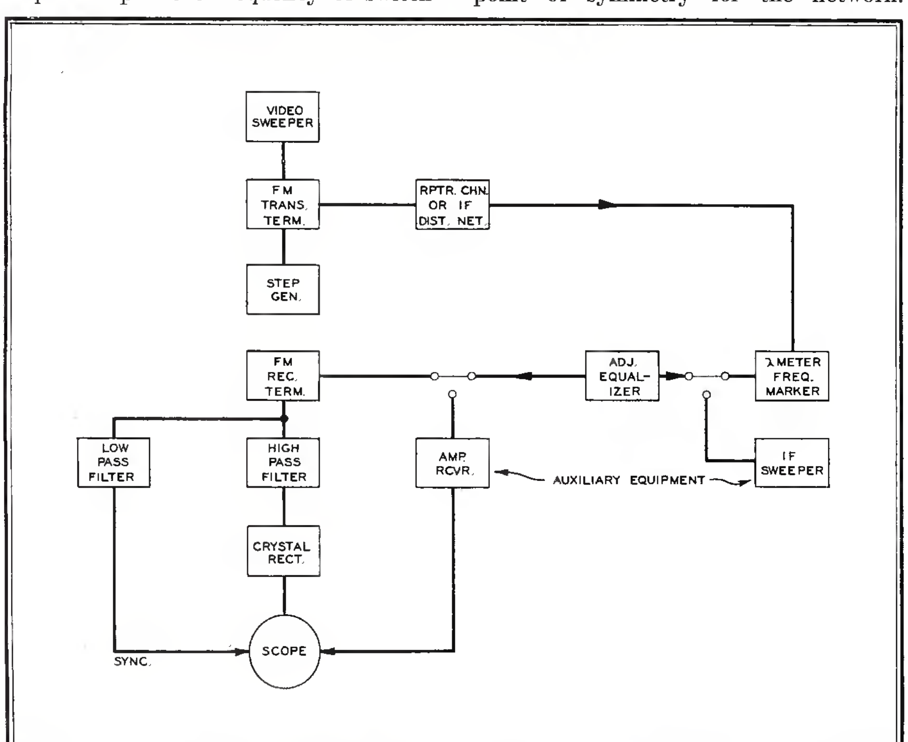
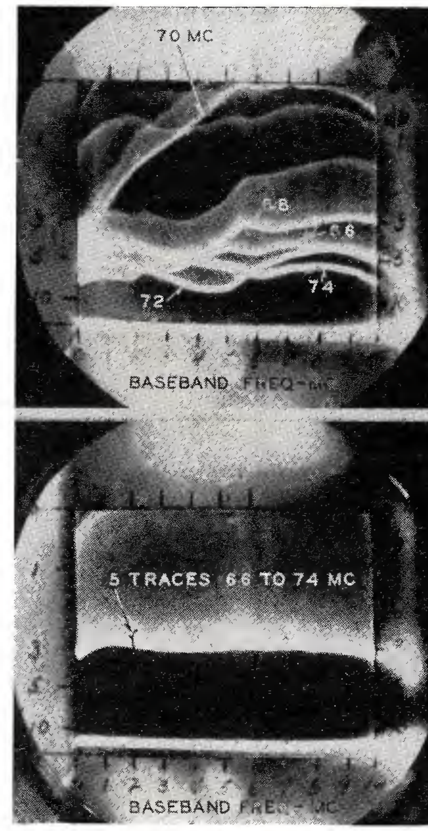


FIG. 4. DIAGRAM OF THE EQUIPMENT EMPLOYED IN MAKING THE LABORATORY TESTS DESCRIBED



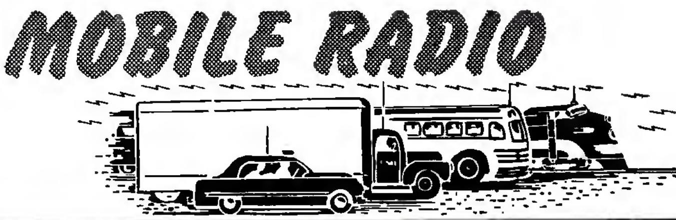
FIGS. 5 AND 6. BASEBAND RESPONSE WAVEFORMS

Fig. 6 shows the curves for the same five carrier steps, but with the distorting network removed. It will be noticed that the five curves in Fig. 6 are all essentially flat and superimposed, indicating that the residual IF distortion in the FM terminal equipment is negligible. For purposes of frequency identification, a calibrated wavemeter circuit is coupled into the IF circuit, Fig. 4, to form marking pips. These frequency markers are useful to identify the various carrier steps and to measure the frequency sweep of the baseband signal. A pip indicates that the wavemeter is tuned to one of the two sidebands produced by that particular combination of carrier and baseband frequencies. For example, a pip could be produced on the 70-mc. curve at the 5-mc. abscissa by tuning the wavemeter to 65 or to 75 mc.

In order to demonstrate the feasibility of using the equipment described to observe the effect of IF amplitude distortion, and then to correct it by IF equalization circuits, this test was made:

An IF distortion network was inserted in the circuit, with the resultant baseband sweep display as shown in Fig. 7. This circuit has the parabolic characteristic illustrated in Fig. 8, with rises of 3 or 4 db at 60 and 80 mc. The baseband display was not altered appreciably when a heavily-overloaded amplifier was connected in the circuit following the distorting network. This simulates compression in the RF amplifiers of the

(Continued on page 24)



NEWS AND FORECASTS

New FCC Applications:

Going over the listings for our monthly report on applications filed with the FCC for new communication facilities, it appeared to us that we should also publish some kind of a tabulation to show the extent of activity in each type of service. Before we had come to any conclusion, we received a letter from R. L. McLaughlin at General Electric, in which he said: "We would like to suggest that, along with the list of applicants, you summarize the information in tabular and graphic form. It would be very interesting to know how many base stations and mobile units are applied for each month in the various 2-way categories."

Thus prompted, we went to work on such a plan, and decided to publish a detailed summary of applications every three months. Thus, the first such summary will appear in the April issue, covering applications filed in January, February, and March. It will be arranged in such a way as to show the relative activity in each type of service.

Not Rural Subscriber Service:

An interesting and significant point was raised recently when AT & T applied for construction permits to establish a rural subscriber radiotelephone system in Alabama and Mississippi for the exclusive use of the Gulf Refining Company. After consideration of the application, the Commission *en banc,* with all the Commissioners participating, advised AT & T as follows on January 9:

"The Commission has carefully considered the information set forth in the applications, and is of the opinion that the furnishing of a private radio communication system of the type involved herein does not come within the scope of a 'rural subscriber' service as contemplated by footnote 1 to Section 6.401 of our Rules and our statement of policy on rural subscriber service in our Public Notice of October 16, 1946. Therefore, your application is dismissed.

"Provision of the type of service you propose in the instant applications will, however, be considered when Rules for the rural subscriber service are promulgated.

"If a hearing with respect to the above matter is desired, a request therefor should be filed within twenty days from the date of this letter."

This brings up an interesting question as to whether or not common carriers will be permitted to supply private radio communication service to a company which could, under the Rules for the industrial services, operate its own radio system.

Radio for Fire Departments:

During a discussion with Deputy Chief Thomas P. O'Brien, in command of New York City's Bureau of Fire Alarm Telegraph, we learned some of the reasons why so many fire departments are now putting radio equipment on their sedans and apparatus. He told of one instance when a fire on Staten Island was reported by telephone at night. When the apparatus arrived at the address given, there was no fire. Meanwhile, another report was received, giving the exact location of the fire — about two miles from the place to which the apparatus had been sent. The first person who called had simply misjudged the location, a mistake which, according to Chief O'Brien, is not uncommon at night.

On this particular occasion, the battalion chief had some difficulty getting to a phone, so that he could report that he found no fire. Then, of course, he was given the correct address, but by the time the apparatus reached the scene, three people had been trapped in the fire, and were burned to death. A sailor who had seen the fire as he walked past the house did rescue one person. Presumably, the others could have been saved if firemen had been sent to the correct address in the first place.

Mistakes in judging the location of a fire occur mostly at night. Someone sees a glow in the sky, rushes to the phone, and gives the operator at fire headquarters what he thinks is the right address. It is probably right as to direction, but it may be so wrong as to distance that a company from far beyond the actual location is sent out.

Chief O'Brien explained another kind of situation where radio can play an important part. Without radio, the firemen are cut off from communication when they leave the scene of a fire until they return to the fire house. This means driving back as fast as possible, against the chance that, en route, another alarm might be sounded. And, in crowded streets, the greater the speed the greater the possibility of accidents. With radio, the apparatus can return without haste, since the driver can be reached with new instructions at any time. Expressed in the cold terms of expense to taxpayers, without regard to the safety of firemen and the general public, the expense of claims resulting from accidents and repairs to apparatus may run much higher than the cost of a fire department radio system.

As to the use of separate systems for police and fire, Chief O'Brien expressed the opinion that, in the larger cities, this is very necessary. Each department has so much traffic, and of such a distinctly different nature, that it cannot be handled over the same system. Also, there is too much likelihood that separate emergencies might arise simultaneously, putting the operator in the position of having to make decisions as to priority.

These matters came up during a discussion with Chief O'Brien about plans to publish in Radio Communication a very complete account of the new 5-boro radio system now being completed for the New York City Fire Department. This system, comprised of 6 control offices and 660 mobile units on sedans and fire apparatus, was planned in accordance with the exacting standards of fire protection practices. Some two years were spent on surveys, system planning, and preparation of specifications. Thus, the information to be presented may well serve as a basic code for fire department radio practice in other cities, both large and small.

Communication Equipment:

During the fall and winter months, Motorola has been moving its entire communication division from the main plant to a building just next door, formerly occupied by Tropic Aire and the Greyhound Bus Company. This property, purchased at a price of $1.25 million, contains 200,000 square feet of space. The address is 4501 Augusta Boulevard, Chicago.

The building has been completely renovated. Office, laboratory, and manufacturing facilities have been provided for communication equipment sales, engineering, and production. About 1,000 people are already at work in the new plant. Comment from one of the executives: It looked as if we would have twice as much space as we'd ever use, but we began to be crowded even before we finished moving in.

RTMA statistics on Government contracts received by member companies in the third quarter of 1951 for radio communication equipment show a total of $142,259,000. This compares with $324,-

493,000 in the second quarter. Of the second-quarter total, $71,856,000 were for transmitters and receivers, $53,000,000 for search and fire-control radar, $9,850,000 for sonar, $1,135,000 for laboratory and test equipment, and $430,000 for quartz crystals.

This does not represent the total of contracts placed, for many large contracts are going to non-member companies, of which the majority specialize in Government work. In the case of laboratory and test equipment, the larger manufacturers have relatively few prime contracts. Thus, although they are producing such equipment in great volume, it is being delivered to prime contractors, and does not appear as Government business in their records.

Quarterly Review:

Because of the activity in radio communication, the demands of clients, and the many new Rules and modifications coming from the FCC, our good friend Jeremiah Courtney has not had the time to provide material each month for this Department. However, we have persuaded him to prepare a quarterly review of progress and changes at Washington as a means of keeping our readers informed on actions which may affect them now, or in the future. The first of these quarterly reviews will appear in our April issue.

Proposed Maritime Frequencies:

The FCC proposes to amend the Rules relating to maritime radiotelephone services, in order to relieve operational problems in the Great Lakes area, and to simplify VHF radio equipment used on the Great Lakes and connecting waterways, by setting up uniform frequency assignments. This problem was recognized by the FCC when overall revisions were made in June, 1951 of the coastal and marine relay services and former ship service Rules. However, the situation could not be remedied without rule-making procedure.

In the June revision, the Commission provided, for public correspondence purposes, two pairs of ship-to-shore channels in the 152 to 162-mc. band for various port areas, with the exception of Chicago, where only one such channel was provided since the excluded frequency of 161.90 mc. had, in effect, been authorized at 161.91 mc. since 1945 to the railroad radio service in the Chicago area. However, since the latter frequency has not been utilized by the railroads, the Commission looks toward deleting it from the railroad service, and making it available for public coast stations in that area, subject to the condition that no harmful interference is caused to the railroad radio service on 161.85 mc. Thus, two ship-shore channels (162 mc. coast paired with 157.3 mc. ship, and 161.90 mc. coast paired with 157.4 mc. ship) would be common to all areas.

The FCC also proposed to shift the Government assignment of 157.3 mc. to 157.1, so that 157.3 can be assigned for ship-to-shore use. Then that service would have 157.3 and 157.4 as adjacent channels. If the maritime mobile service finds, in the future, that it can operate with 50 kc. separation instead of 100 kc. separation as now provided, it will be possible to add a pair of frequencies for public correspondence or operational service, whichever the Commission may find to be more in the public interest.

In addition, the FCC proposed to change the present sharing of the block of maritime mobile frequencies by public safety services on a secondary basis, so that existing highway maintenance stations now on 157.05 and 157.11 mc. may continue on a non-interfering basis to the maritime mobile service, but no new public safety stations would be authorized. To compensate for this change, 157.29 and 157.35 mc. would be made available to public safety service, provided interference is not caused to the marine mobile service.

Reducing Co-Channel Interference:

Some time ago, engineering consultant Raymond Wilmotte gave a demonstration of reception under co-channel interference conditions at his laboratory, 1469 Church Street, N. W., Washington. During subsequent development work, he has been able to pick out either the weaker or the stronger of two signals on the same frequency, when the signals differed in strength by as little as 1 or 2 db. So far, this work has been treated only as a scientific curiosity, and no attempt has been made to apply it in any commercial form. It seems very probable, however, that it could contribute to further improvement in the performance of communication receivers. Mr. Wilmotte would probably be willing to supply the basic information to anyone interested in what he has accomplished.

25th Anniversary:

February 23 marks the 25th year since the establishment of the Federal Radio Commission. The Dill-White Radio Act was signed on that date. The first law for the domestic control of wireless telegraphy was the Radio Act of 1912. However, when radio broadcasting started, and stations began to jump frequencies and increase their power as a means of meeting competition, the courts found that the Act of 1912 did not give the Secretary of Commerce the power to deal with such situations. This led to the enactment of legislation which set up the five-member Radio Commission, of which W. H. G. Bullard was the first Chairman. It was empowered to allocate bands to radio services, assign specific frequencies to stations, and to issue licenses. As a result of the new regulation, 50 broadcast stations went off the air, leaving 682 on July 1, 1927. During the next five years, 83 more quit.

Subsequently, to eliminate divided and overlapping authority, Congress decided that all radio, wire, and ocean cable communication services should be regulated by a single body, and the Communications Act of 1934, signed on July 19 of that year, provided for the creation of the present Federal Communications Commission. The seven Commissioners are appointed by the President and confirmed by the Senate. The President designates the Chairman. Not more than four Commissioners may be members of the same political party. The normal term of each Commissioner is 7 years, with the termination dates staggered so that one new member is appointed each year.

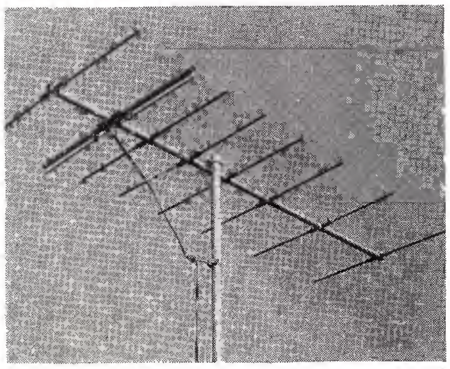
The first Chairman was E. O. Sykes, who served from July 11, 1934 to April 5, 1939. Other members, and their terms of office are listed below:

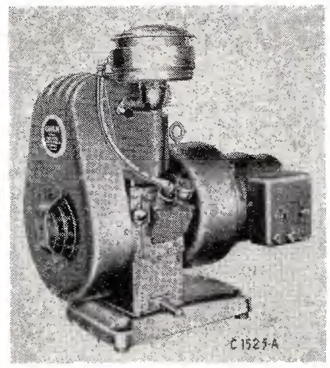
T. H. Brown, July 11, '34—June 30, '40
Paul A. Walker, July 11, '34—
N. S. Case, July 11, '34—June 30, '45
Geo. H. Payne, July 11, '34—June 30, '43
Irvin Stewart, July 11, '34—June 30, '37
H. Gary, July 11, '34—Dec. 24, '34
A. S. Prall, Jan. 17, '35—July 23, '37
T. A. M. Craven, Aug. 25, '37—June 30, '44
F. R. McNinch, Oct. 1, '37—Sept. 1, '39
F. I. Thompson, Apr. 13, '39—June 30, '41
James L. Fly, Sept. 1, '39—Nov. 13, '44
Ray C. Wakefield, Mar. 22, '41—June 30, '47
C. J. Durr, Nov. 1, '41—June 30, '48
E. K. Jett, Feb. 15, '44—Dec. 31, '47
P. A. Porter, Dec. 21, '44—Feb. 25, '46
C. R. Denny, Mar. 30, '45—Oct. 31, '47
W. H. Wills, July 23, '45—Mar. 6, '46
Rosel H. Hyde, Apr. 17, '46—
E. M. Webster, Apr. 10, '47—
Robert F. Jones, Sept. 5, '47—
Wayne Coy, Dec. 29, '47—
G. E. Sterling, Jan. 2, '48—
Frieda B. Hennock, July 6, '48—

Messrs. Sykes, Prall, McNinch, Fly, Porter, Denny, and Coy served as Chairmen, in that order.

Looking back over the past 25 years, and the multiplication of the functions and responsibilities of the Commission, it is hard to imagine that communication services will continue to expand at the present rate. The fact is, however, that the current rate of progress has been accelerating steadily from year to year during this period.

NEW EQUIPMENT AND COMPONENTS





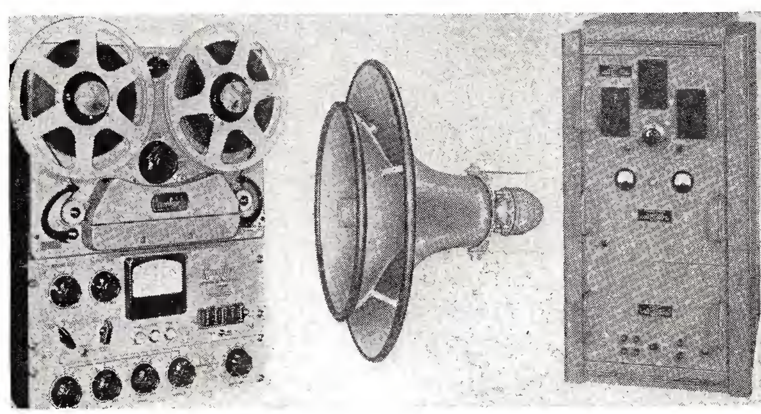
FAR LEFT: Single-channel, 8-element Yagi antenna, designed for long-distance TV reception, and to reduce co-channel interference. Gain is rated as equal to stacked 5-element Yagis. Required channel must be specified. *La Pointe Plascomold Corp., Windsor Locks, Conn.*

LEFT: Diesel-electric emergency unit supplies 3 kw. at 115 or 230 volts, 60 cycles for communication transmitters. Push-button starter can be connected to relay control to start the engine automatically when outside power fails. Fuel oil consumption is rated at .155 gallon per kilowatt-hour output at full load. Electrically-heated glow plug assures cold weather starting. Also available for 32-volt battery charging. *D. W. Onan & Sons, Inc., Minneapolis 14.*

RIGHT: Tape recorder intended for use in broadcast and recording studios and industrial installations can be fitted with 1 to 5 magnetic heads. Controls can be operated from remote push-buttons. The two units illustrated are furnished in portable cases, or for rack mounting. *Berlant Associates, 4917 W. Jefferson Blvd., Los Angeles 16.*

CENTER: Radial re-entrant sound projector can be mounted for 360° distribution if required. Model RC-8 has a 5-ft. air column, bell diameter of 28¼ ins., cuts off at 110 cycles. Model RC-6 has 4-ft. air column, bell diameter of 24¾ ins., cuts off at 140 cycles. *Atlas Sound Corp. 1449 39th St., Brooklyn 18.*

FAR RIGHT: Frequency marker produces calibration signals at intervals of 1 mc. from 950 to 2,040 mc. Particular markers can be selected, and all others rejected. Accuracy is rated at 1 part in 100 million. Interpolation oscillator determines frequency of unknown signal within 10 kc. *Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11.*



BELOW: Dielectric sample holder of the Hartshorn type for measurement of dielectric constant and dissipation factor at .1 to 100 mc. This type of holder is recognized in ASTM Specification D-150. *General Radio Co., Cambridge 39, Mass.*

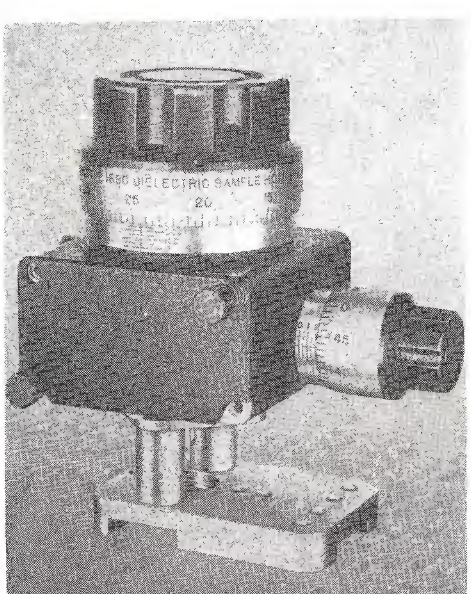
TOP LEFT: Miniature low-power pulse transformer weighing less than .1 oz. can be mounted by the leads. Built for pulse widths of .2 to 5 microseconds when used as a blocking oscillator. Frequency response 100 kc. to 30 mc. *PCA Electronics, Inc., Hollywood 28, Calif.*

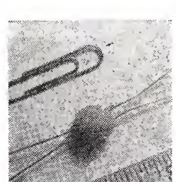
TOP RIGHT: One-piece tube-cap connector has ½-watt resistor of any required resistance molded in place. Available for ¼ and 23/64-in. tube caps, in polyethylene, polyvinyl, or Kel-F. *Alden Products Co., Brockton, Mass.*

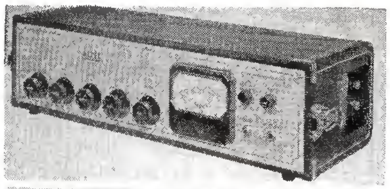
CENTER: Molded powdered-iron toroids of .8 to 3 ⅜ ins. outside diameter. Core material can be selected for high *Q*, high inductance, low harmonic distortion products, high magnetic and temperature stability, or small size and cost, according to requirements. *Lenkurt Electric Co., San Carlos, Calif.*

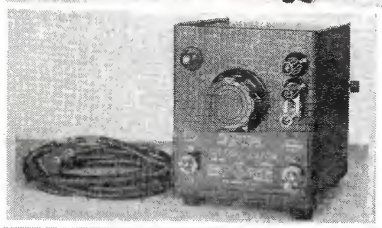
BELOW LEFT: Miniaturized indicator light is ¾ in. over all, fits in .348-in. hole. Can be mounted .4 in. between centers. Lens unscrews to replace bulb. *Alden Products Co., Brockton, Mass.*

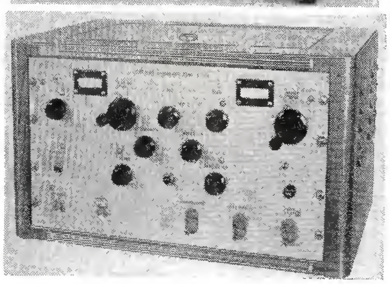
BELOW RIGHT: Shirt-stud type miniature capacitor employs ceramic disc ¼ in. in diameter; overall length is ½ in. Capacity up to 22 mmf. Rated at 500 volts DC; test voltage, 1,000. *Sprague Electric Co., North Adams, Mass.*



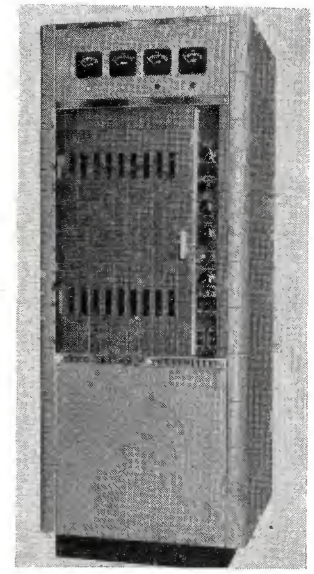








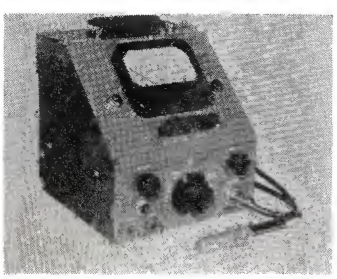
LEFT TOP: Model 220A portable mixer has two dual amplifiers with volume controls for 4 mike inputs, line amplifiers, master volume control, power supply, and VU meter. Characteristics are suited to use for high-quality broadcast and public address service. *Altec Lansing Corp., Beverly Hills, Calif.*
LEFT CENTER: Oscillator with built-in power supply provides 400 and 1000 cycles for modulating HF oscillators. Output of .2 watt, with less than 3% distortion, for bridge measurement use. *General Radio Co., Cambridge 39, Mass.*
LEFT BOTTOM: Sweep oscillator with built-in marker oscillator and crystal calibrator for development of tuners, filters, and amplifiers to be used on the 470 to 890-mc. TV band. *Radio Corp. of America, Harrison, N. J.*
RIGHT: AM broadcast transmitter of small, simplified design has 1,100 watts output. New design features single tuning control, use of only 15 tubes of 4 common types, and power-change kit to cut output to 500 or 250 watts. *Radio Corp. of America, Camden, N. J.*

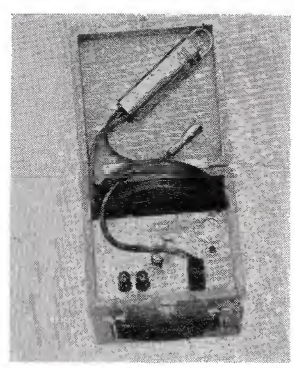


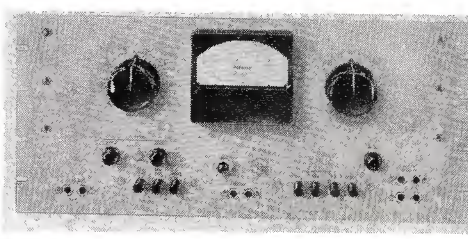
BELOW: VT voltmeter covers 1, 3, 10, 30, 100, and 300 volts AC and DC, plus 1,000 volts DC. Power level scale calibrated from −10 to +10db. Overall accuracy is rated 3%. *Electronic Measurements Co., Red Bank, N. J.*

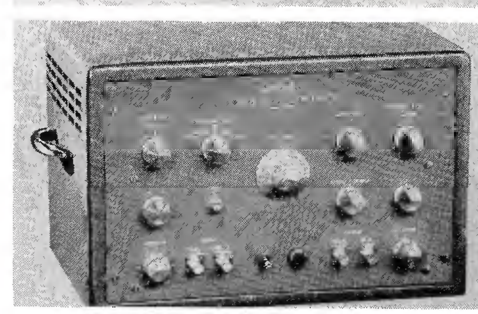
BELOW: Cathode follower for use between phono pickups and other high-impedance devices into standard equipment. Input impedance 60 megohms; response 1 cycle to 200 kc. *Gulton Mfg. Corp., Metuchen, N. J.*

BELOW: Rack-mounted gain set has 1,000-cycle, low-distorting, feed-back type RC oscillator, buffer, and power supply, with a high-gain, wide-range amplifier, variable from +20 to −60 db full scale. *Daven Company, Newark 4, N. J.*









ABOVE LEFT: Combination voltohmmeter has 7 DC ranges from 1.5 to 1,200 volts; 7 rms AC ranges from 1.5 to 1,200 volts; 7 peak-to-peak AC ranges from 4 to 3,200 volts; and 7 resistance ranges from 10 ohms to 10 megohms. *Hickok Electrical Inst. Co., Cleveland 8.*
ABOVE CENTER: Portable volume-level indicator requires no batteries or external power supply. Copper-oxide type meter indicates 99% normal deflection at zero VU in about .3 second. *Daven Co., 191 Central Ave., Newark 4, N. J.*
ABOVE RIGHT: Pulse generator produces single or double pulses for laboratory work on wide-band amplifiers, gating circuits, and scalers. Negative pulses are continuously variable from 200 volts maximum into 1,000 ohms to 10 volts maximum into 50 ohms. *Berkeley Scientific Corp., Richmond, Calif.*
RIGHT: High-*Q* trap to eliminate high-band or low-band TV interference, or FM broadcast interference. A fourth model is built to order for other frequencies. *Jerrold Electronics Corp., Philadelphia 46.*

DISGUISED 2-WAY RADIO ANTENNA

SECRET ANTENNA FOR POLICE CARS APPEARS TO BE BROADCAST RECEIVING AERIAL, AND IS MOUNTED IN THE SAME WAY — *By* MILTON R. FRIEDBERG*

THE long whip antenna used extensively on 2-way radio-equipped cars of detectives and other law-enforcement officers has long been considered a necessary evil, since it reveals at a glance the true nature of the vehicle. Standard broadcast antennas cannot be employed for transmitting, since heavy RF current causes arcing and eventual failure at the antenna section joints.

Now, however, complete disguise of police cars can be achieved with the Ward SPPB71 antenna, which is constructed so that it has the appearance of an ordinary broadcast receiving antenna, and can be mounted in the same place. However, permanent electrical connections are made at the telescopic joints of the tube assembly. This simple change not only makes the antenna capable of withstanding transmitting currents, but fixes the length of the rod so that it cannot become detuned.

How effective this disguise is can be seen in Fig. 1. The ball-joint base, together with the thin brass step-tapered rod, make up an assembly that cannot be identified as a transmitting antenna.

In order to make the deception still more complete, radio control heads and microphones were installed in the glove compartments of St. Paul Police System detective's cars, as Fig. 2 shows, and the transmitter-receiver chassis in the luggage compartments.

Installation:

The 55½-in. whip is operated as a ¾-wave antenna in the 152 to 174-mc. band. Loading devices are not required. However, it is advantageous to mount the antenna as close as possible to the corner post of the windshield, which then serves as the ¼-wave grounded leg of a J-match assembly. Normally, good loading of commercial transmitters can be obtained without difficulty.

For service at 25 to 50 mc., the antenna is physically shorter than a quarter wavelength, and it is necessary to employ a simple stub arrangement to obtain minimum standing-wave ratio. The most convenient loading method, shown in Fig. 3, consists of a shorted stub bridged across the feed line at a point where the resistive component of the impedance, seen looking toward the antenna, is equal to the characteristic impedance of the line. The stub is of such a length that its inductive reactance is sufficient to cancel the capacitive component of the impedance seen at that point on the line.

Length of A and B, Fig. 3, are given in the table for various frequencies. When a stub is connected to the feed line according to directions, the antenna will load the output circuits of commercial transmitters satisfactorily.

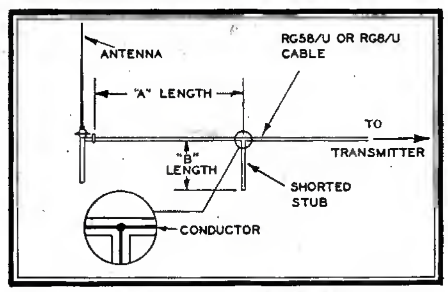


FIG. 3. HOW A LOADING STUB CAN BE ATTACHED

The tube assembly can be removed easily for replacement in case of damage. Also, if the transmitter is removed from the car, a standard broadcast antenna will plug the hole left by the SPPB71. Thus, if the car is to be sold, the body does not require repairs and repainting, as it does when conventional mobile antennas are removed.

The antenna, without deteriorating radio performance in any way, permits complete disguise of the vehicle and increases its trade-in value.

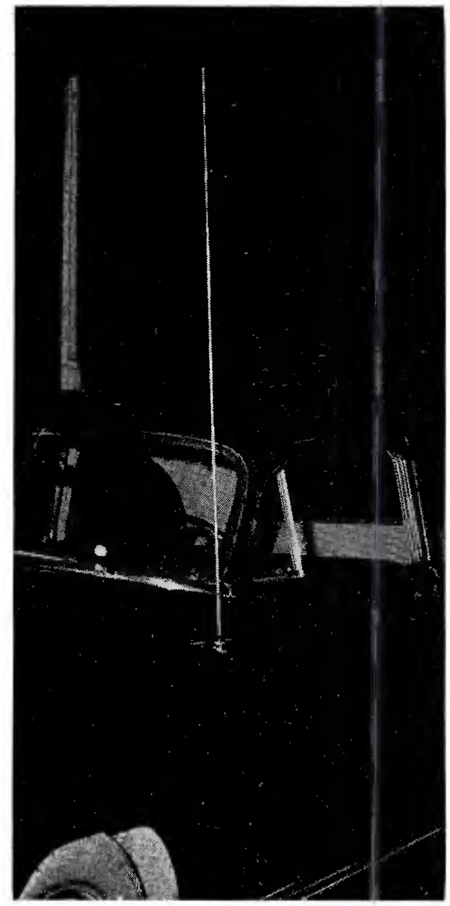


FIG. 1. THE ANTENNA, INSTALLED ON A POLICE CAR, CANNOT BE IDENTIFIED AS A 2-WAY WHIP

LOADING STUB CHART

FREQ. MC.	A, INS.	B, INS.	FREQ. MC.	A, INS.	B, INS.
24	60	3	38	25	4⅜
25	56¼	3	39	23	4¾
26	53⅛	3	40	21¼	5
27	50½	3⅛	41	19½	5½
28	47¾	3⅛	42	17½	5¾
29	45	3⅛	43	15	6¼
30	42½	3¼	44	14	6¾
31	40	3¼	45	12½	7⅜
32	37¾	3⅜	46	10½	8
33	35½	3⅜	47	8½	8¾
34	33¼	3½	48	6¼	9¾
35	31¼	3¾	49	3¾	10¾
36	29	3⅞	50	1	12
37	27	4⅛			

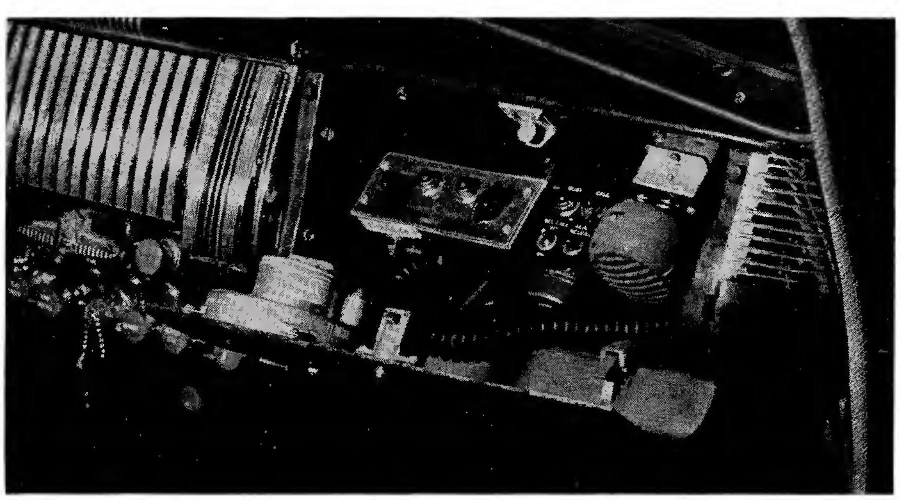


FIG. 2. INSTALLING RADIO CONTROLS IN THE GLOVE COMPARTMENT COMPLETES THE DECEPTION

*Director, Communications Department, Ward Products Corporation Division of The Gabriel Company, 1523 E. 45 Street, Cleveland 3, Ohio.

A MICROPHONE CIRCUIT TESTER

DETAILS OF A SIMPLY-CONSTRUCTED MICROPHONE AND HANGUP-BOX TESTER THAT PROVIDES FOR CHECKING ALL THESE CIRCUITS QUICKLY AND EASILY

ONE of the most common and irritating troubles experienced with mobile radio equipment is a faulty microphone cable or hangup box. In most cases, the trouble is intermittent, so that detection is difficult.

In order to facilitate maintenance of these components, a simple microphone and hangup box tester was devised by Clare Watson, communication engineer for the Erie Cab Company of Erie, Pa.

The diagram of the tester is given in Fig. 1. All three circuits can be tested simultaneously, simply by plugging the microphone cord into the tester, Fig. 2, and flexing the cord.

For testing the hangup box and the relay-operating contact circuits, 6-volt batteries in series with 6-volt indicator lamps are used, since these circuits are completely closed. Indication of faulty cord or contacts is an unsteady light as the cord is flexed, or no light at all if the corresponding circuit is open completely.

Because of the voltage drop across the carbon microphone cartridge, a battery voltage higher than the rated indicator lamp voltage must be employed for tests of the mike cartridge. A 16½-volt C battery and a No. 40 pilot light are recommended. If the cartridge is functioning properly, the brightness of the lamp varies as the microphone is shaken or is spoken into.

Another useful application of this device is the adjustment of the contacts of the press-to-talk switch. When the lights go on simultaneously, the relay-operating contacts and the microphone contacts are closing at the same time.

Since the tester is operated by lightweight dry batteries, it can be constructed either as a portable instrument or built into a test panel. By testing each microphone and cord assembly before installation, and making routine tests on units already in service, the insignificant time and expense involved in building the tester will be repaid many times over in reduced outages due to microphone-cord troubles.

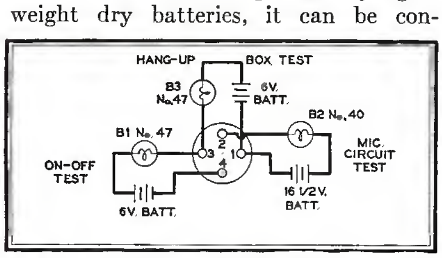


FIG. 1. DIAGRAM OF THE SIMPLE TEST UNIT

FIG. 2. TO CHECK THE MICROPHONE CIRCUITS, CORD IS PLUGGED INTO THE TESTER AND FLEXED

DUPLEX SELECTIVE DISPATCHING SYSTEM

A General Electric development in selective calling should increase privacy and reduce interference in 2-way radio communication systems. The new system is called Duplex Selective Dispatching.

The Duplex method of operation permits mobile radio operators to select either of 2 headquarters dispatchers for mobile-to-headquarters communication. Each receiver at the dispatching headquarters is receptive to calls preceded by one particular tone signal. Mobile transmitters in the system are provided with signaling equipment which generates a tone of the proper frequency to unlock the desired headquarters receiver. There is no delay associated with the transmission of the tone signal, since it is triggered automatically when the press-to-talk button is operated, and the duration of the signal is only .5 second.

In municipal systems where 2 services, such as fire and police, are operated on the same frequency, or where 2 taxi companies share the same frequency, 2 dispatchers using separate headquarters receivers can be employed.

Two types of equipment are available for Duplex Dispatching. One type transmits a single tone which opens one of two headquarters receivers in a predetermined plan. The other type employs a toggle switch, permitting the mobile operator to select one of 2 tones, each of which opens one of the 2 receivers.

With this equipment, not only the mobile units but the headquarters receivers can be made non-receptive to interference, receiving only the system calls preceded by the proper tones.

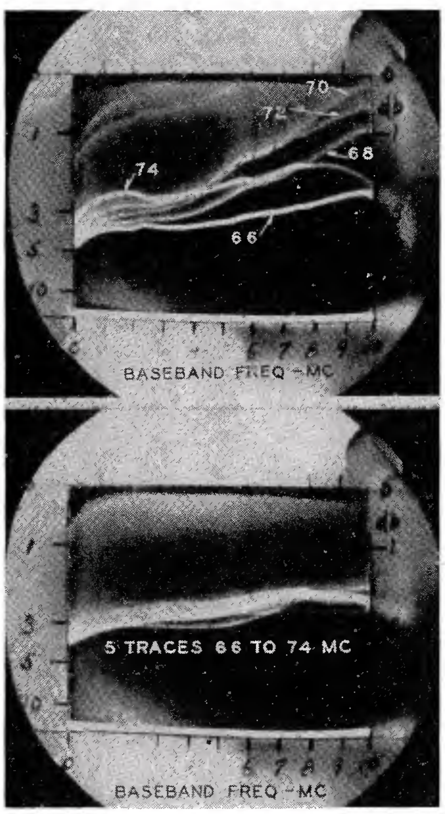
REPEATER DISTORTION

(Continued from page 17)

repeaters, and wipes out any actual amplitude variations at this point. An equalizing network was then inserted at the input circuit of the receiver between two cathode-follower amplifiers, so as to keep the input and output impedances reasonably constant. This network consisted of several adjustable tuned circuits whose reactive and resistive components could be varied continuously. It was not designed specifically for the purpose, but served to demonstrate that equalization can be obtained in this manner. This is shown in Fig. 9, where the sweep curves have been made fairly flat, and approach superposition.

Networks with more variable elements could be designed to do a better equalization job or, perhaps, a number of networks in cascade, some fixed and some variable, would be easier to manipulate.

As has been stated previously, a straight sloping IF amplitude characteristic can be obtained without being revealed by the baseband response curves. This was tried experimentally and found to be true. It is apparent that if a slope were introduced during equalization, it would not be known unless a measurement of response were made.



FIGS. 7 AND 9. EFFECT OF EQUALIZER NETWORK

One would expect the equalizer characteristic to have a shape which is the inverse of the parabolic shape of the distorting network. This condition was being closely approached by the networks used in our experiments, as shown by

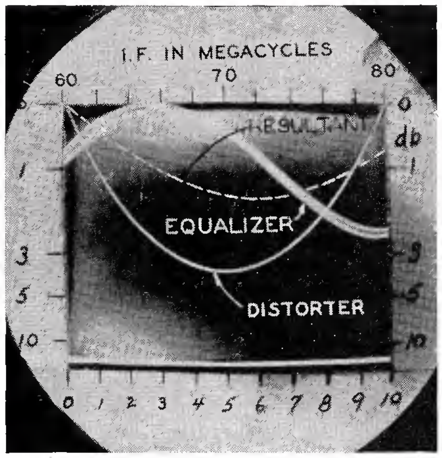


FIG. 8. IF AND EQUALIZER CHARACTERISTICS

Fig. 8. The actual difference is small but significant, as can be demonstrated by adding the two characteristic curves together. This discrepancy probably accounts for the incomplete equalization indicated in Fig. 9.

Conclusion:

It can be shown theoretically that amplitude distortion due to curvatures in the gain-frequency characteristics of the RF and IF sections of an FM system will appear in the baseband response curve, and the relationship can be demonstrated experimentally. An exception occurs in the case of odd-order symmetry about the carrier, which does not produce baseband distortion. For the case of even-order symmetry, the baseband response is in exact correspondence with the RF or IF amplitude characteristic, provided that the deviation ratio is small.

When a frequency-swept baseband modulating signal is applied to an FM system, the oscilloscopic baseband response is, in general, not a flat line, the departure from flatness being an indication of the degree of amplitude distortion in the RF and IF circuits. The response can be made flat by inserting a properly-adjusted amplitude-correcting network at the receiver, ahead of the limiter. In order to equalize over the entire RF and IF bands, the sweeping should be done with the carrier set at several different frequencies. In the method described, this is done automatically, resulting in a family of oscilloscopic traces. When the correcting network is adjusted until all traces are flat and superimposed, equalization is perfect.

The authors wish to acknowledge the many helpful suggestions made by Mr. J. C. Schelleng of these Laboratories during discussions relating to the progress of the work, and in the preparation of the paper.

Appendix:

If the frequency-modulated wave at the input of the distorting network is expressed in terms of the usual Bessel functions representing sideband amplitudes, the wave at the output becomes:

$$(1) \quad I_t = I_m \begin{bmatrix} J_0(\beta)\sin \Omega t \\ + J_1(\beta)[K_{1U}\sin(\Omega+w)t \\ -K_{1L}\sin(\Omega-w)t] \\ + J_2(\beta)[K_{2U}\sin(\Omega+2w)t \\ +K_{2L}\sin(\Omega-2w)t] \\ + - - - \text{etc.} \end{bmatrix}$$

where $\beta \doteq \frac{\Delta F}{f} \doteq \Delta\Theta$, the modulation index, and the factors K indicate the sideband response of the IF and/or RF circuits relative to the carrier frequency Ω. The subscripts U and L refer to upper and lower sidebands respectively.

In our experiments, the frequency deviation ΔF was held constant, but the baseband frequency f was continually varied, resulting in a constantly-changing carrier and sideband structure.

Calculations were made on a network whose observed response is shown in Fig. 2. For each baseband frequency, the sideband structure was calculated, and the individual amplitudes altered according to the network characteristic. The resultant of the modified sidebands was combined with the modified carrier to obtain the maximum phase deviation, as indicated in Fig. 1. The final modified frequency deviation was determined by multiplying the modified phase angle by the baseband frequency. This angular relationship is given by:

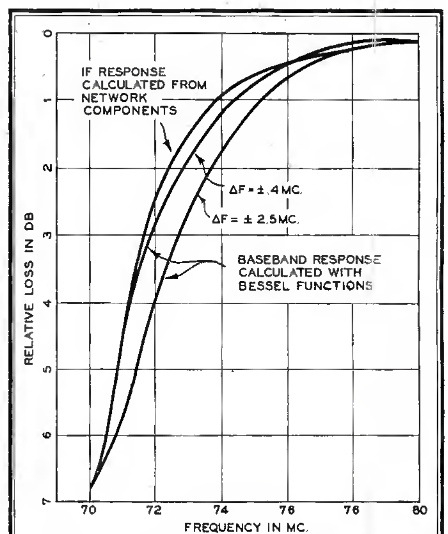


FIG. 10. RESPONSE AT THE POINT OF SYMMETRY

$$(2) \quad \tan \Delta\Theta' = \frac{J_1(\beta)[K_{1U}+K_{1L}] - J_3(\beta)[K_{3U}+K_{3L}] + - -}{J_0(\beta) - J_2(\beta)[K_{2U}+K_{2L}] + J_4(\beta)[K_{4U}+K_{4L}] + - -}$$

and the modified frequency deviation is $\Delta F' = f\Delta\Theta'$, proportional to the video response.

The calculated response for the carrier

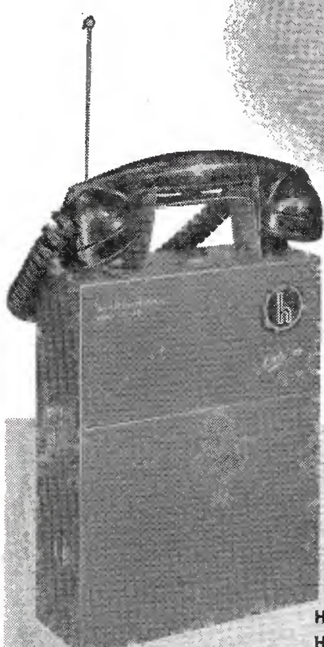
(Concluded on page 26)

hallicrafters

new communications "TOOL" for industry!

the littlefone®

2-WAY FM RADIO-TELEPHONE



10 lb. lower powered models also available

HAND CARRY

HT-21 (25-50 Mc.)
HT-22 (150-174 Mc.)

- FULL TWO-WATT ANTENNA OUTPUT*
- Weighs only 14 pounds!
- Complete, self-contained 2-way radio-telephone station!
- Powered by Dry, or Wet Rechargeable Batteries (can be recharged from car battery or 117 Volts AC)
- Rugged, weatherproof
- 22 sub-miniature tubes!

*On 25-50 Mc. • One-Watt output on 150-174 Mc.

CENTRAL STATION

HT-23 (25-50 Mc.) HT-24 (150-174 Mc.)

Same performance and specifications as the "Littlefone" Hand Carry.

- AC-operated Central Station
- Audio-amplifier, providing one watt of audio for loudspeaker
- Power consumption is 35 watts
- Plugs in any AC outlet (117 Volts)

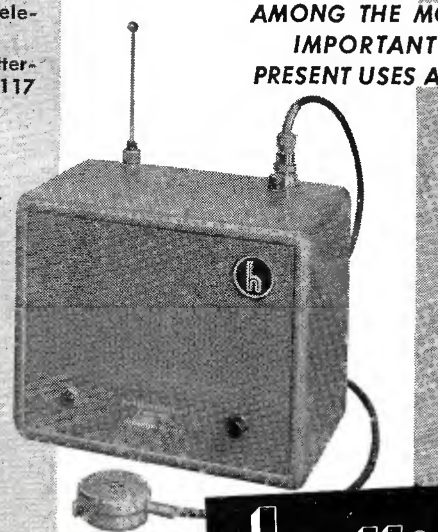
Where one or more extra stationary receiving stations are desired, Hallicrafters economical S-81 receivers may be added.

A new Hallicrafters product—the "*littlefone*"—is now ready for thousands of important uses in hundreds of industries.

This light, rugged, dependable radio-phone will be offered through Hallicrafters distribution organization—by the men who know communications best.

USES OF "LITTLEFONE" CHALLENGE YOUR IMAGINATION!

There are literally thousands of industrial uses for the "*littlefone*" radio—anywhere where powerful, dependable, "on the move" contact is required.



AMONG THE MORE IMPORTANT PRESENT USES ARE:

- RAILROADING
- FREIGHT HANDLING
- WAREHOUSE OPERATIONS
- RANCHING & LARGE FARMS
- MINING (Above & Below Ground)
- PIPE LINE INSPECTION
- ROAD BUILDING
- SHIPPING (Dock Operations)
- CONSTRUCTION
- LUMBERING

hallicrafters
"The Radio Man's Radio"

World's Leading Manufacturer of *Precision* Radio and Television — Chicago 24

RF DIELECTRICS

(Continued from page 14)

system. At the left is a high-frequency generator, and in the center is a DC power supply.

Fig. 4 shows equipment used for dielectric measurements under controlled conditions over a wide range of temperature and humidity. The measuring unit at the center is designed so that 10 specimens can be conditioned simultaneously, and measurements made individually on all specimens without opening the test chamber. This system is used at frequencies up to 30 mc. Auxiliary appratus shown is for controlling humidity.

REPEATER DISTORTION

(Continued from page 24)

at the point of symmetry appears in Fig. 10, which illustrates again the fact that the frequency deviation must be kept small if the video response is to represent the transmission amplitude characteristic accurately. This was confirmed experimentally, as shown in Fig. 2.

New FCC Applications

This list includes applications for mobile, point-to-point, control, and relay communication facilities filed with the FCC during January, 1952.

This listing, planned as a regular monthly feature, is made possible by the cooperation of the Federal Communications Commission. Each listing shows the name and address of the applicant. If the transmitter is to be located in a different city, the name of the city appears on the second, indented line. The number and type of facilities are shown, with the respective frequencies and the make of equipment for which applications have been filed. These may, of course, be changed before licenses are issued. Explanation of the code letters used in this listing appears below.

WEEKLY REPORTS

For the benefit of those who want to receive this data in advance, RADIO COMMUNICATION can furnish weekly reports. Requests for information on this service, and questions concerning these listings should be addressed to the Registry Editor.

CODE LETTERS

The following letters indicate the type of facilities for which applications have been filed. Unless indicated otherwise, FM operation is to be employed:

a AM operation	q Control station
b Base station	r Repeater or relay
m Mobile unit	s Fixed
mm Marine Mobile	t Temporary
p Portable unit	u Operational

Make of equipment is indicated by one of these letters:

AA Aircraft Radio	M Motorola
A Hallicrafters	N Gen. Railway Signal
B Belmont-Raytheon	NN Ntl. Aero. Corp.
C Comco	O Farnsworth
D Doolittle	P Philco
E W. Coast Electronics	Q Collins
F Federal Tel. & Radio	R RCA
G General Electric	S Railway R. & S.
H Harvey	T Bendix
J Comm. Equipment	U Western Electric
K Kaar	W Westinghouse
L Link	X Miscellaneous

AERONAUTICAL & FIXED

Caribbean Atlantic Airlines Inc Box 3214
San Juan P R 2b 72.30, 159.51 L
Maravillas P R 2r 75.70, 161.79 L
Mayaguez P R 2b 72.30, 159.51 L
Santa Isabel P R 2b 72.30, 159.51 L
St Croix Virgin Islands 2b 72.30, 159.51 L
St Thomas Virgin Islands 2b 72.30, 159.51 L

AIRDROME CONTROL

Garner Aviation Serv Corp Bartow Airbase Bartow Fla 4m 140.31, 140.40, 141.30 C
Serv-Air Aviation Corp Kinston Air Base Kinston N C 1b .236, 121.5, 126.18, 140.40, 141.30 C; 4m 121.5, 126.18, 140.40, 141.30 T

FLIGHT TEST

Youngstown Airways Inc Mun Airport Youngstown 1 Ohio 1b 136.08 AA

AERO MOBILE UTILITY

Port of N Y Authority 111 8th Ave New York 11 N Y 30m 121.90 X
New Castle County Airport Commission Court House Wilmington Del 1m 121.90 C

AIRLINES

Commercial Airport Tulsa Okla 1b 122.80 NN
Palo Alto Airport Inc Palo Alto Calif 1b 122.80 T
Ringel Flying Service Decatur Ill 1b 122.80 NN
Amart Farm & Airport Lake Grove Ore 1b 122.80 NN
Plantation Airlines Inc Everglades Fla 1b 122.80 NN
County of Otsego Gaylord Mich 1b 122.80 NN
Miami Vly Flying Serv Dayton Ohio 1b 122.80 NN
Longmont Fly'g Ser Inc Longmont Colo 1b 122.80 NN
Saline Air Serv Harrisburg Ill 1b 122.80 NN
Board of County Commissioners Ft Lauderdale Fla Broward City Fla 1b 122.80 NN
George Hunter Ritnour Lancaster Pa 1b 122.80 NN

CIVIL AIR PATROL

CAP Nevada Wing Ely Flight Ely Nevada
3b 2.374, 4.507, 4.585, 5.500, 148.14 MT
16m, 2.374, 4.507, 4.585, 5.500, 148.14 MT
CAP New Iberia Sqdn La Wing New Iberia La
2b 2.374, 4.585, 5.500, 148.14 GM
8m 2.374, 4.585, 5.500, 148.14 GM
CAP Wash Wing No Seattle Sqdn Bothell Wash 1lb 4.585 G
CAP Shelton Flight Shelton Wash 1b 2.374, 4.585 X
CAP Wash Wing Puyallup Flight Route 1 Spanaway Wash Puyallup Wash 1b 2.374; 5m 4.585, 5.500 X
CAP Sacramento Signal Flight #80 Sacramento Calif 1b 2.374, 4.585 A
CAP Vermont Wing 107th Sqdn Springfield Vt 1b 2.374, 4.585 X
CAP Temple Sqdn Temple Tex 1b 2.374, 4.585 Q
CAP Ogden Flight Utah Wing Roy Utah 1b 148.14 T
CAP Tallahassee Sqdn Grp VII Fla Wing Tallahassee Fla 1b 4.585, 4.325 G

POLICE

Livermore, City of, Calif 1b 155.13, 155.67; 12m 155.13 L
Avon, Town of, Conn 4m 45.78, 45.90 M
McDowell County Sheriff Welch W Va 1b 154.65 M
Caretta Mtn W Va 1b 159.15; 60m 154.65 M
Oakwood, Village of, Turnsburg Rd Bedford Ohio
Oakwood Ohio 2p 39.42 M
Johnston City Ill Police Dept 1b 39.51 M
Box Butte County Sheriff Court House Alliance Neb 3m 39.90 M
Santa Barbara County Sheriff Santa Barbara Calif 1b —X
Calhoun County Sheriff Blountstown Fla Chipley Fla 2m 45.06 M
State of Calif State Capitol Bldg Sacramento Madera Calif 1b 42.34 G
Barber County Sheriff Medicine Lodge Kans 1b 39.58; 5m 39.58 M
Loris, Town of, S C 1b 45.10; 4m 45.10 M
Rockford, City of, Mich, City Hall 1m — M
Cherokee, City of, Iowa 1b 37.10; 11m 37.10 G
Alaska Hwy Patrol 111 E 5th Anchorage Alaska Kenia Alaska 1b 2.442 K
Ripley County Sheriff Versailles Ind 1b 155.13, 155.37; 3m 155.13, 155.37 M
Halifax, City of, Virginia 1b 39.50; 15m 39.50 G
Palmyra Ambulance Assoc Palmyra N J 1m 155.49 R
Fanquier County Sheriff Warrenton Va 3m 42.70 M
Mitchell Cty Sheriff Colorado City Tex 7m 37.18 L
Moore Cty Sheriff Dumas Tex 1b 37.18; 8m 37.18 Gm
Dumas, City of, Tex, Box 296 15m 37.18 M
Cumberland, City of, Wisc, City Hall 1m 39.42 M
Wash State Patrol, Nr Ephrata Wash, 1b 42.54 M
905 Dexter Ave Seattle Wash 4tb 1.985, 1.945 R
McLeod County Sheriff Court House Glencoe Minn 1b 155.31; 12m 155.31
River Hills, Village of, Wis 1b 46.02; 6m 46.02 K
Greenbrugh, Town of (Police Dept) N Y
388 Tarrytown Rd White Plains N Y 1tb 2.450 X
Austintown, Twp of, Ohio, 5340 Mahoning Av Youngstown 9 O 1b 155.61; 16m 155.61 155.85 M
Fox Pt, Village of, Wis, 7300 N Richard St Milwaukee 11 Wis 1b 46.02; 8m 46.02 K
Ohio State Hiway Patrol 1117 E Broad st Columbus O Greenville Ohio 1b 39.10 M
Sidney, City of, Neb 1b 155.25; 3m 155.25 G
Fanwood, Boro of, Watson Rd Fanwell, N J 1b 158.73, 2m 158.73 L
Minn State Hiways Patrol Div 1279 Univ Ave St Paul Minn 3tb 42.82 M
Auburn, Town of, Ky c/o Mayor H D Scott 1m 39.50 M

Walton Hills, Village of, Ohio, Village Hall, Bedford P O Ohio 1m 39.42 M
Warren Cty Sheriff McMinneville Tenn 5m 37.26 M
Kenilworth, Boro of, N J
1b 152mc band; 10m 152 mc band
Sherman County Sheriff Goodland Kans
1b 39.58; 10m 39.58 G
Bailey County Sheriff Muleshoe Tex
1b 37.18; 5m 37.18 M
Kenova, City of, W Va 1b 155.13; 6m 155.13 M
Aransas County Sheriff Rockport Tex
3m 37.26, 37.18 M
Lyon County Sheriff Yerington Nev
1b 1.634 H; 1m 39.38 G
Smith County Sheriff Smith Center Kans
1b 39.58; 7m 39.58 M
St Lawrence County Sheriff Canton N Y
1b 39.18; 2b 72.02; 100m 39.18 G

FIRE

Leavell Woods Fire Dept Jackson Miss
1b 154.25; 10m 154.25 K
Sacramento Cty Fire Hdqtrs 620 H St Sacramento Calif
Florin Calif 1b 154.19 R
West Sayville Fire Dist West Sayville N Y
1b 46.34, 46.46; 6m 46.34, 46.46 M
Walla Walla County Airport Fire Hdqtrs Walla Walla Wash 1b 154.13; 4m 154.13 C
Bailey's Crossroad Fire Dept Alexandria Va
1b 46.18 M
City of West Palm Beach Fire Hdqtrs West Palm Beach Fla 1b 159.15; 15m 159.15 G
Valhalla Fire Dist Valhalla N Y
1b 46.14, 46.26; 7m 46.26 M
East Farmingdale Fire Co East Farmingdale N Y
1b 46.46; 5m 46.34; 46.46 R
East Meadow Fire Dist East Meadow N J
1b 46.10; 4m 46.22 L
Penfield Fire Co Inc Penfield N Y
1b 154.31; 5m 154.31 M
Shelby City Fire Hdqtrs Shelby N C 4m 156.21 GM
Bellport Fire Dist Bellport N Y 1b 46.46 M

FORESTRY

S C Forestry Dept Box 357 Columbia S C
Nr Bishopville S C 1b 159.27 M
Nr Bambery S C 1b 159.27 M
Idaho State Forestry Dept 702 Military Dr Couer d'Alene Idaho
Nr Craigmont Idaho 1b 172.22, 159.45 C
Nr Coeur D'Alene 1b 159.45, 172.22 C
Chacolet Park Idaho 1b 159.45 M
Craigmont Idaho 1b 172.22 C
Louisiana Forestry Comm Box 1269 Baton Rouge
La DeQuincy La 1b 31.38, 31.50 M
Chatham, Town of, Mass Forestry Dept 2m 31.34 G
Michigan Forestry Dept Box 68 Roscommon Mich
Stephenson Mich 1b 40.58, 46.66 M
Alabama State Dept of Conservation 607 Monroe St Montgomery Ala
Tuscaloosa Ala 1b 170.475 G
Northport Ala 1b 172.275, 159.45 G
Georgia State Forestry Comm Box 811 Waycross Ga
Milledgeville Ga 1b 159.39 M
Danielsville Ga 1b 159.39 M
Douglas Ga 1b 159.39 M
Nr Kingsland Ga 1b 159.39 M
Nr Woodbury Ga 1b 159.39 M
Nr Rochelle Ga 1b 159.39 M
Nr Thomaston Ga 1b 159.39 M
Nr Uvalda Ga 1b 2226 X
Nr Girard Ga 1b 2226 X
Nr Rosier Ga 1b 2226 X
Nr Brooklet Ga 1b 2226 X
Nr Lambert Ga 1b 2226 X
Cook County Ga 1b 159.39 M
Coffee County Ga 1b 159.39 M
Sumter County Ga 1b 159.39 M
Ben Hill County Ga 1b 159.39 M
Polk County Ga 1b 159.39 M
Paulding County Ga 1b 159.39 M
Douglas County Ga 1b 159.39 M
Atkinson County 1b 159.39 M

HIGHWAY MAINTENANCE

California State Hiway Maint Dept Capitol Bldg Sacramento Calif
Black Mt Calif 1b 47.02, 47.10 R
1rs 952-960 mc band
Haywood Calif 1q 952-960 mc band
Burlingame Calif 1q 952-960 mc band
San Jose Calif 1q 952-960 mc band
Ingham County Road Comm Mason Mich
1b 46.86; 16m 46.86 M
W Va Hiway Maint Dept Box 410 Buckhannon W Va
Nr Weston W Va 1b 37.94, 37.98 G
Mass Dept of Pub Wks 100 Nashua St Boston Mass
Sandwich Mass 1b 46.90 G
Princeton Mass 1b 46.90, 46.98 G
Boston Mass 1b 46.90, 46.98 G

SPECIAL EMERGENCY

Buzzetti, R J DVM Alden Iowa 1b 47.62; 2m 47.62 M
Patek, Theodore B Randolph Wis 1b 47.62 M
Blewer, John M D Danville Cal 1m 161.49 L
Born, W R Story City Iowa 1b 47.46 M
Hagyard, Davidson & McGee Vets Lexington Ky
1b 47.62; 1m 47.62 M
Akard Funeral Home Bristol Tenn
1b 47.50; 6m 47.50 M

(Continued on page 28)

NEW APPLICATIONS

(Continued from page 27)

Dixon, James T DVM Winston Salem N C
1b 47.46; 1m 47.46 M
Knoppenberger, R E Bucyrus Ohio
1b 47.50; 2m 47.50 M
Agee, H V O'Neil Nevada Wells Nevada
2b 37.90 M
Schneider, Robert F Postville Ia 1b 47.62 M
Weldy, Maurice L DVM Wakarusa Ind
1b 47.54; 2m 47.54 M
Little, R D DVM Jefferson O 1b 47.54; 1m 47.54 M
Claugus, F W DVM Barnesville Ohio
1b 47.58; 2m 47.58 M
Collins, Wayne D DVM Winston Salem N C
1b 47.62; 1m 47.62 M
Leomords, Leo L DVM Hastings Neb
1b 47.54; 1m 47.54 M
Morris, Harry Zachary La 1b 47.54; 2m 47.54 M
Rieke, Lloyd L Sterling Colo 1b 47.62; 2m 47.62 M
Lewis, Ralph W MD Lockport N Y
1b 47.66; 2m 47.66 M
Kjar, Harold A DVM Lexington Neb
1b 47.46; 1m 47.46 M
Soderholm, L G MD Hillsboro Ore
1b 47.58; 5m 47.58 M
Lamb, Hugh L DVM Athens Tenn 1b 47.62 M
Moyle Alton I MD Union Grove Wis
1b 47.62; 1m 47.62 M
Fruit, David J MD Merton Wis
1b 47.58; 1m 47.58 M
Dolphin Ambulance Serv Pasadena Calif
1b 47.46; 10m 47.46 M
Sterner, E F DVM Ionia Mich 1b 47.58; 4m 47.58 M
Loften, Robt D & Young, Robt M Osage Iowa
1b 47.62; 2m 47.62 M

POWER UTILITY

Blue Ridge Elec Memb Corp 104 N Mulberry St
Lenoir N C 1qs 954 G
Hilbriten Mtn N C Irs 958 G
Planters Elec Memb Corp Millen Ga
Sylvania Ga 1b 47.74 G
Pacific Pr & Lt Co 920 SW 6th Ave Portland Ore
Yale Dam Wash 2b 6745 M
Merwin Dam Wash 2b 6625 M
Niagara Mohawk Pr Co 300 Erie Blvd Syracuse N Y
Oswego N Y 1b 47.82 G
Croghan N Y 1b 47.82 G
Gouverneur Village N Y 1b 47.82 G
Landcaster County Gas Co Lancaster Pa
1b 47.94; 35m 47.94 G
Virginia Elec & Pr Co 7th St Richmond Va
Suffolk Va 1b 48.14 R
Indian Gas & Wtr Co Shelbyville Ind 1b 48.26 M
Manitowoc Pub Utilities 817 Franklin St
Manitowoc Wis 1b 153.41; 10m 153.41 G
Intermountain REA 301-317 Broadway Littleton Colo
Squaw Mtn Colo 1b 952.96, 37.58 G
Littleton Colo 1b 952.96 G
Fairport, Village of, N Y 1b 47.94; 50m 47.94 G
Kansas Pr & Lt Co 808 Kans Ave Topeka Kans
1b 37.62 G
Parsons Kans 1b 37.62 G
Montana-Dakota Utils Co 831 2nd Ave S Minneapolis Minn
Lemmon S D 1b 48.26 G
Ellendale N D 1b 48.26 G
Hettinger N D 1b 48.26; Ir 75.58 G
Mobridge S D 1qs 75.70 G
McIntosh S D 1rs 73.10 G
Pacific Gas & Elec 245 Market St San Francisco Cal
Lakeport Calif 1b 158.25 L
Cent Louisiana Elec Co Inc 529 Monroe St
Alexandria La
Oakdale La 1b 47.98 M
Eunice La 1b 47.98 M
Crowley La 1b 47.98; 50m 47.98 M
Government Service Inc Fontana Dam N C
1b 153.71; 10m 153.71 R
Lake Superior Dist Power Co Athens Wis 1b 48.30 G
Salt River Project Agricultural Imp & Pr Dist
Box 1980 Phoenix Ariz
Mesa Ariz 1b 153.71 M
Glendale Ariz 1b 153.71 M
Cherry-Todd E C Inc Valentine Neb White River S D
1b 48.46 M
McPherson City Wtr & Elec Dept McPherson Kans
1b 153.65; m 153.65
Southeastern Elec Coop Durant Okla
1b 48.14; 10m 48.14 M
Detroit Edison Co 2000 Ind Ave Detroit Mich
Wayne Mich 1b 48.18 L
Potomac Edison Co 55 E Wash St Hagerstown Md
Ridgeley W Va 1b 952, 954, 956, 958 W
Clearspring Md 2r 952, 954, 956, 958 W
Sideling Hill Md 2r 952, 954, 956 958 W
Dans Mtn Md 2r 952, 954, 956, 958 W
Williamsport Md 1q 952, 954, 956, 958 W
KBR Rural Pub Pr Dist 213 N Main Ainsworth Neb
Nr Ainsworth 1b 48.38; 1qs 75.58; 1qr 72.30; 10m 48.38 G
Puerto Rico Wtr Resources Authority San Juan PR
1b 6805 M
Rio Piedras P R 1b 6685 M
S C Elec & Gas Co 141 Meeting St Charleston S C
Calhoun Falls S C 1b 37.86 M
Cent Maine Pr Co 9 Green St Augusta Me
Pittsfield Me 1b 47.98 M

Livermore Falls Me 1b 47.98 M
Metropolitan Dist 115 Broad St Hartford Conn
West Hartford Conn 1b 48.10 L
Georgia Power Co Box 1719 Atlanta Ga
Glenville Ga 1b 37.62 G
Austell Ga 1b 37.62 G
Griffin Ga 1b 37.62 G
Matanuska Elec Assn Palmer Alaska 1b 158.19 G
Electric Energy Inc Box 165 Joppa Ill
Nr Joppa Ill 2usr 6625, 6685, 6745, 6805 M
Washington Water Pr Co 825 W Trent Ave
Spokane Wash
Cabinet Idaho 1b 153.71 G
Lebanon, City of, Tenn 1b 37.50; 12m 37.50 M
Peru, City of, Ind 1b 153.41; 6m 153.41 M
Alabama Power Co 600 N 18th St Birmingham Ala
Headland Ala 1b 37.68 M
Auburn Ala 1b 37.68 M
Monroeville Ala 1b 37.68 M
Butler Ala 1b 37.68 M
Frontier Power Co 300 N Commercial Trinidad Colo
Nr Trinidad Colo 1b 48.02 M
Walsenburg Colo 1b 48.02; 6m 48.02; 3p 48.02 M
Orcas Pr & Lt Co Eastsound, Orcas Isl Wash
Friday Harbor Wash 1b 48.06; 1tb 48.06 G
Eastsound Wash 1b 48.06; 25m 48.06 GX
Homestead, City of, Fla 1b 158.19; 10m 158.19 M

PIPELINE PETROLEUM

Lafayette Exploration Co Box 555 Lafayette La
2m 30.66, 30.70, 30.74, 30.78, 30.82 L
Republic Natl Gas Co M & W Tower Bldg Dallas Tex
Benedium Camp nr Rankin Tex
1b 49.10; 1rs 72.70 G
Midland Tex 1qs 75.98; 3tb 49.10; 20m 49.10 G
Ohio Oil Co 539 S Main St Findlay Ohio
Bridgeport Ill 1b 48.58; 30m 48.58 M
Esso Standard Oil Linden N J 1b 153.35 M
Texas Co Fort Arthur Tex 1b 153.11 M
Port Neches Tex 1b 155.11 M
John W Mecom 2906 Gulf Bldg Houston 2 Tex
Nr Harvey la 1b 30.74; 1tb 30.74 RL
Mud Supply Co 217 Pioneer Bldg Lake Charles La
Houma La 1b 2.292 X
Tenn Gas Transmission Co Box 2511 Houston 1 Tex
Summersville Ky 1b 33.26 M
Rothschild Oil Co Santa Fe Spgs Calif
1b 48.90; 12m 48.90 X
Buckeye Pipeline 137 W North St Lima Ohio
Wakeman Ohio 1b 33.22 M
Humble Pipeline Co Box 2220 Houston Tex
Schleicher County Tex 1b 48.86 G
Sutton County Tex 1b 48.86 G
Ashland Oil & Refining Co 1409 Winchester Ave
Ashland Ky
Midland Tex 1b 49.06 M
Socony Vacuum Oil Co Inc 917 1st Nat Bank Bldg
Wichita 1 Kans
Hill City Kans 1b 49.06 R
Palco Kans 1b 49.06 R
Palco Kans 1b 49.06 R
Zurich Kans 1b 49.06; 10p 39.06; 35m 49.06 R
Nr Milpitas Calif 1b 48.82 L
Nr Needles Calif 1b 48.82 L
Nr Hinckley Calif 1b 48.82 L
Nr Hollister Calif 1b 48.82 L
Louisiana Nat Gas Corp 708 Pioneer Bldg Lake Charles La
Church Point La 1b 48.82 M
Garner Drilling Co Box 335 Hebbronville Tex
1b 48.82; 2tb 48.82; 13m 48.84 M
La Gloria Corp Box 637 Falfurrias Tex 1tb 48.98 M
Pan American Pipeline Co Nels Esperson Bldg Houston 2 Tex
Christoval Station F Tex 2usr 6625, 6685 M
Carlsbad Tex 1usr 75.90 M
Orden Tex 1usq 73.26 M
Standard Oil Co Box 160 Casper Wyo
1b 153.17; 25m 153.17 M
Hugh Kirkpatrick Inc Mission Tex
1b 33.18; 12m 42.98 M
Va Gas Transmission Corp Box 215 Falls Church Va
Paris Va 1b 33.38 L
Warrentown Va 1b 33.38 L
Atlantic Seaboard Corp Box 215 Falls Church Va
Files Creek Comp Sta West Va 1b 33.38 L
Petersburg West Va 1b 33.38 L
Bel Air Md 1b 33.38 L
Boldman Ky 1b 33.38 L
Rock Springs Md 1b 33.38 G
Southern Union Gas Co 1104 Burt Bldg Dallas Tex
Alameda New Mex 1b 158.31; 1p 158.31 R
Service Pipeline Co Box 1979 Tulsa Okla
Nr Hays Kans 1b 49.14 R
Wichita Kans 1b 49.14 R
Stafford Kans 1b 49.14 R
Nr Neodesha Kans 1b 49.14 R
Nr Hudson Kans 1b 49.14 R
Nr Valley Center Kans 1b 49.14 R
Nr Haven Kans 1b 49.14 R
Nr Humboldt Kans 1b 49.14 R
Nr Natona Kans 1b 49.14 R

FOREST PRODUCTS

Tarter, Webster & Johnson Inc Deleker Calif
1b 49.46; 15m 49.46 G
Tomahawk Timber Co Ely Minn 1b 49.22 G
Forest Center Minn 1b — 5m — G
Pacific Lumber Co Scotia Calif
Elk Riv Camp nr Eureka Cal 1b 49.26 G

(Continued on page 30)

NEW APPLICATIONS

(Continued from page 29)

Yager Logging Camp nr Carlotta Cal 1b 49.26 G
Kappler Lumber Co Liberal Ore
1b 153.05; 15m 153.05 M
Crosby Forest Products Corp Picayune Miss
Rural Miss 1b 49.34 L
Zadra 8ros Logging Co Box 206 Plains Mont
1b 153.11; 10m 153.11 G
Great Northern Paper Co Millinocket Me
2b 49.54; 6m 49.54 M
Rosboro Lumber Co 8ox 247 Springfield Ore
1tb 49.66; 13m 49.66 GX
Brown Co Berlin N H 1tb 49.42; 5m 49.42 M

SPECIAL INDUSTRIAL

Copperweld Steel Co Warren Ohio
2b 152.87; 20m 152.87 R
Holder Constr Co Snyder Tex 1b 43.14; 15m 43.14 L
R H Wright & Son Inc Ft Lauderdale Fla
1b 154.49; 40m 154.59 G
Certified Concrete Co Rock Island Ill
1b 154.49; 20m 154.49 G
Brooks & Turner Well Servicing Co Coahoma Tex
Big Spring Tex 1b — — L
Snyder Tex 1b, 1tb, 10m L
Reo Motor Inc Lansing Mich 1b 154.49; 50 m 154.49 M
A & A Asphalt Paving Co 8irmingham Mich
1b 49.98; 5m 49.98 M
Keystone Steel & Wire Co Peoria Ill
1b 154.49; 10m 154.49 M
McEnery Co Inc Erie Pa 1b 43.10; 25m 43.10 M
Lehigh Vly Coop Farmers 1000 N 7th St
Allentown Pa 1us 74.22 G
Nr Bethlehem Pa 1b 43.14; 1usr 73.22, 50m 43.14 G
8lythe Milling Co Blythe Calif
1b 152.99; 10m 152.99 M
Freeport Sulphur Co New Orleans La
Garden Isl Bay La 1b 4ch bet 6425-6575 M
Venice La 2b 4ch bet 6425-6575 M
Bay Ste Elaine La 1b 4ch bet 6425-6575 M
Leeville La 2b 4ch bet 6425-6575 M
Myrtle Grove La 2b 4ch bet 6425-6575 M
New Orleans La 1b 4ch bet 6425-6575 M
Port Sulphur La 3b 4ch bet 6425-6575 M
Grand Ecaille La 2b 4ch bet 6425-6575 M
8ethlehem Steel 701 E 3rd St Bethlehem Pa
Beaumont Tex 1b 49.98; 12m 49.98 L
Raymond Thomas Inc Box G Five Points Calif
1b 49.78; 35m 49.78 G
Vincent Kovacevich Rte 8 8ox 347 Fresno Calif
Nr Fresno 1b 49.70; 13m 49.70 G
Dowell Inc Kennedy Bldg Tulsa Okla
Bossier City La 1qs 75.62 G
Nr Fillmore La 1qr 72.06 G
Independent Eastern Torpedo Co 8reckenridge Tex
Bossier City La 1qs 72.06 G
Nr Fillmore La 1qr 72.06 G
Sapelli Constr Co 691 Liberty St Springfield Mass
1b 152.93; 3p 152.93; 12m 152.93 M
J L Foutz 8ox 307 Farmington N Mex
1b 49.90; 20m 49.90 M
Tuller Constr Co 95 Monmouth St Red Bank N J
Morrisville Pa 1b 25.50; 19m 25.50 M
Everett & Clark Contractors Plattsburg Mo
1b 49.86; 10m 49.86 M
Raiford G Trask Farms 8ox 448 Castle Hayne Rd
Wilmington N C
Wrighteboro N C 1b 43.14; 11m 43.14 M
Heard & Heard Inc PO Drawer L Refugio Tex
Corpus Christi Tex 1b 49.50 M
Refugio Tex 1b 49.50 M
Falfurrias Tex 1b 49.50 M
Kingville Tex 1b 49.50 M; 50m 49.50 M
R W Jones Elec Co 171 Pond St Sharon Mass
1b 43.06; 6m 43.06 G
Western Co Midland Tex 1b 43.02 G
Hobbs N Mex 1b 43.02 J
Haliburton Oil Well Cementing Co Duncan Okla
Hobbs N Mex 1b 75.62 G
Lovington N Mex 1b 72.10 G
Flora Engineering Co 56th & Holly St Denver Colo
8m 49.86; 1tb 49.86; 4p 49.86 M
Kingston Bituminous Prods Co Kingston N J
1b 43.06; 25m 43.06 M
Nugent Mining Co Du Bois Pa 1b 49.98 M
Lanes Mills Pa 1b 49.98; 10m 49.98 M
Arkansas Vly Alfalfa Milling Co 8ox 277 Wiley Colo
1b 43.18; 6m 43.18 M
8auman 8ros 699 Industrial Rd San Carlos Calif
1b 43.10; 6m 43.10 M
Naramore Welding & Constr Co Mayville Okla
1b 49mc band L
Pentzien Inc 1504 Dodge St Omaha Neb 12m 42.98 M
Green Giant Co (Blue Mt Div) Dayton Wash
Nr Pomeroy Wash 1b 152.99 M
Waitsburg Wash 1b 152.99 M
Bradford Weston Inc 116 Rockland St Hingham Mass
1b 43.14; 25 p & m 43.14 M
Wakefield Ready Mixed Concrete Co Wakefield Mass
1b 152.93; 30m 152.93; 3p 152.93 M
R H Morrison Co 2705 Dawson Signal Hill Calif
1b 152.93 G; 8m 152.93 R
U S Rubber Co Port Neches Tex
1b 154.49; 10m 154.49 M
Edward E Morgan Co Inc 8ox 4327 Fondreau Sta
Jackson Miss
Grenada Miss 1b 43.10; 12m 43.10 K
J P Gibbons Inc Midland Tex 1c 75.86 G
North Rankin Tex 1b 49.90; 1r 72.42 G
Odessa Tex 1b 49.90; 2tb 49.90; 1sq 75.86; 50m 49.90 G
S A Camp Farms PO Bin D Shafter Calif
Acequia Idaho 1b 27.43; 25m 27.43 M

LOW-POWER INDUSTRIAL

Chesapeake & Potomac Tel Co of Va
703 E Grace St Richmond Va 12m 42.98 M
W H Gahagan Inc 90 8road St New York N Y
4m 154.59 M
Fletcher Aviation Corp 190 W Colo 8lvd
Pasadena Calif 26m 154.57 M
Pacific Dredging Co 14409 S Paramount 8lvd Paramount Calif
Pt Mogu Calif 2m 154.57 M
Interstate Petroleum Communications Co 1319 Shell Bldg Houston Tex 2m 154.57 M

RELAY PRESS

Hearst Corp 8th Ave & 57th St New York N Y
1b 173.27 L
Richards Fuel Oil Inc Somerville N J
1b 35.90; 12m 35.90 M
Northern Transfer Co Box 1538 Anchorage Alaska
Mt View Alaska 1b 35.86; 15m 35.86 M
Anchorage Alaska 1b 35.86; 15m 35.86 M
Thomas Anderson Transportation & News Air Agency
Anchorage Alaska 1b 173.22; 10m 173.22 M

D9

Dallas, City of, Tex Main & Harwood 2p 24.55 X
Port of N Y Authority 111 8th Ave New York N Y
1p 24.55 X
Cork Rendering Co Box 134 Marianna Fla
1b 43.10; 15m 43.10 M
International Cementers Inc 6505 Paramount 8lvd
Long Beach Calif
Midland Tex 1qs 75.50 G
Odessa Tex 1r 72.82 G

COASTAL MARINE & RELAY

Southwestern 8ell Tel Co 1010 Pine St Louis Mo
Nr La Marque Tex 1b 2.506; 1m 2.110 U

OTHER MARINE

Interstate Petroleum Comm Inc 1319 Shell Bldg
Box 2648 Houston Tex 1mm 2.134, 2.206

ALASKAN FIXED PUBLIC

Earl B Mollohan Pilot Point 8ristol 8ay Alaska
Lower Ugashik Lake Alaska 1b 2.430, 3.190 X
Catholic Soc of Alaska 8ox 1390 Fairbanks Alaska
Andreafski Alaska 1b 3.092, 3.190 X

De Coursey Mt Mining Co Inc Anchorage Alaska
1b 2.986, 3.385, 5.137, 3.105, 4.495 K

RAILROAD

Chicago Milwaukee St Paul & Pacific RR 516 W Jackson Blvd Chicago Ill
Milwaukee Mis 1b 160.77, 160.41 T
Erie RR Co 101 Prospect Ave NW Cleveland Ohio
Hammond Ind 1b 159.87, 160.05 O
Chicago Great Western RR Co 309 W Jackson Blvd Chicago 6 Ill
St Joseph Mo 1b 159.57, 160.17 S
Stockton Ill 1b 159.57, 160.17 S

TRANSIT UTILITY

Albuquerque Bus Co Albuquerque N Mex
1b 44.50; 10m 44.50 M
Wichita City Lines Inc Wichita Falls Tex
1b 44.58; 5m 44.58 M
Majestic Limousine Serv Inc New Rochelle N Y
1b 44.50; 20m 44.50 L

AUTO EMERGENCY

Centerline Auto Serv Centerline Mich
1b 35.70; 1m 35.70 G
Bernard R Reiser Racine Wis 1b 35.70; 6m 35.70 M
Crooks Super Serv Flat Rock Mich
1b 35.70; 2m 35.70 X
Ardon Auto Sales & Serv Bellingham Wash
1b 35.70; 10m 35.70 M

TAXICABS

90 Cab Co Ketchikan Alaska 1b 152.33; 4m 157.59 C
Yellow Cab Co Westplains Mo
1b 152.27; 5m 157.53 M
Belmont Cab Glasgow Ky 1b 152.39; 5m 157.65 M
City Cab Bay City Tex 1b 152.39; 5m 157.65 M
Grays Radio Cab Fulton Ky 1b 152.27; 2m 157.53 D
OK Taxi Harvey Ill 1b 152.33; 10m 157.59 G
Hockville Taxi Towanda Pa 1b 152.27; 10m 157.53 M
Cullens Taxi Crisfield Mo 1b 152.27; 6m 157.53 G
342 Taxi Cab Brawley Calif 1b 152.45; 5m 157.71 M
East Side Cabs Columbus O 1b 152.45; 20m 157.71 M
Grove Park Cab Atlanta Ga 1b 152.33; 14m 157.59 M
Crowder Cabs West Pt Ga 1b 152.33; 12m 157.59 M
Joanna E Ponte Lawrence Mass
1b 152.39; 6m 157.65 M
Blackies Taxi Nashua N H 1b 152.45; 6m 152.45 R
Shorty's Cab Freemont Ohio 1b 152.27; 6m 157.53 M
State Taxi Co Milford Mass 1b 152.33; 6m 157.59 M
Novato Taxi Novato Calif 1b 152.27; 6m 157.53 M
Peoples Cab Co Dundalk Md 1b 152.33; 50m 157.59 G
Harry's Taxi Serv Silvan Springs Ark 2b 152.27 R
Southside Cab St Petersburg Fla
1b 152.39; 25m 157.65 M
AC Dispatching Serv Houston Tex
1b 152.45; 8m 157.71 M
City Cab Brownsfield Tex 1b 152.27; 10m 157.53 M
Central Ave Cab Milton Mass 1b 152.27; 6m 157.53 M
Dixie Cab 553 Ellis St Augusta Ga
Camp Gordon Ga 1b 152.27; 10m 157.53 M
Rambo Sales & Serv Stoughton Wis
1b 35.70; 2m 35.70 R
Taxi #1 Breckenridge Tex 1b 152.39; 10m 157.65 G
Range Rider Cab Miles City Mont
152.39; 5m 157.65 M
Berkley Cab Berkley Mich 1b 152.39; 10m 157.65 M
Checker Cab Assoc Monterey Cal
1b 152.45; 10m 157.71 M
Kelly Cab Co Albia Ia 1b 152.27; 5m 157.53 M
Penn-Harris Taxi Serv Co Harrisburg Pa
1b 152.39; 30m 157.65 G
Free Bros Taxi Cab Greenville Ala
1b 152.45; 10m 157.71 M
Woodsons Taxi Riverhead L I N Y
1b 152.39; 2m 157.65 M
Checker Cab Colville Wash 1b 152.27; 3m 157.53 C
City Cab Valley City N D 1b 152.33; 5m 157.59 M
1b 152.27; 8m 157.30 M
Galvans Taxi Brownsville Tex
1b 152.45; 18m 157.71 M
Globe Trotter Taxi Serv Bastrop La
1b 152.45; 2m 157.71 C
Greyhound Taxi Sacramento Calif
1b 152.33; 20m 157.59 M
City Cab Co Colorado City Tex
1b 152.27; 8m 157.30 M
Vets Taxi Ft Fairfield Mo 1b 152.45; 5m 157.71 M
Southwest Cab Co Atlanta Ga
1b 152.33; 10m 157.59 L
Publix Cab Denver Colo 1b 152.45 M
Pumps Taxi Fremont Ohio 1b 152.33; 10m 157.65 M
Community Taxi Bethpage NY 1b 152.45; 5m 157.71 L
B & F Taxi Dumont N J 1b 152.33; 6m 157.59 G
Milford Red Cab Co Milford Mass
1b 152.33; 8m 157.59 R
GI Cab Co Akron Ohio 1b 152.39; 65m 157.65 G

HIGHWAY TRUCKS

E L Long Motor Lines Inc Hiway 25 Greenville S C
1b 35.86; 25m 35.86 M
Ware Shoals S C 1b 35.86 M
Spartanburg S C 1b 35.86 M
Wise Oil & Fuel Cambridge Md 1b 35.74; 5m 35.98 8
Higgins Oil Co Christiansburg Va 1b 35.90 M
Plains Gas Inc Box 1019 Lubbock Tex
Lorenzo Tex 1b 35.78 G
Spade Tex 1b 35.78 G
Abernathy Tex 1b 35.7B G
Keenan Welding Supply Co Box 44, Albany Ga
Cairo Ga 1b 35.82 M

DESIGN OF CROSSOVER NETWORKS

PART 2 — WINDING CHOKES — USE OF ELECTROLYTIC CAPACITORS — LEVEL CONTROLS — MERITS OF SLOW & FAST-CUTOFF NETWORKS — *By* SAUL WHITE*

PART 1 of this article, which appeared in RADIO COMMUNICATION for January, 1952, was devoted to a discussion of the *raison d'être* of crossover networks, and included circuit diagrams and charts for determining component values, as well as as a list of the factors to be considered when selecting crossover frequencies. This second, concluding part will be concerned with level controls, specific information on components, and general design considerations.

Coil Construction:

Data for winding inductor coils of any size from .05 to 40 millihenries is given in Fig. 7. Two coil-form sizes are shown, with inductance curves for each. The smaller form should be used for coils of 1.5 millihenries or less, and the larger for inductors of higher values.

Cores should be of wood or other non-magnetic material. Pieces of broom handle or 1-in. dowel can be used. Side pieces are cut from masonite or some similar material, and secured to the core by means of brass screws.

The coils should be wound with No. 17 enameled copper wire. This provides a reasonably high value of Q, so that the full theoretical attenuation rate beyond the crossover frequency can be obtained. If No. 17 wire cannot be procured, it is permissible to use a smaller size for inductances below 1 millihenry, or a larger size for the range above this value. The same number of turns as for No. 17 wire should be employed. For convenience in purchasing the wire, the scales at the right side of the chart in Fig. 7 give the approximate weight of wire for the specified number of turns.

Air-core (so-called) coils are preferred for use in crossover networks because they cannot be overloaded. The inductance of such a coil is independent of signal level, and the reactance increases linearly with frequency. Iron in the core of a crossover network coil, or a can or shield close to the coil, can cause non-linear operation with resulting generation of harmonics and intermodulation.

*Chief Engineer, University Loudspeakers, Inc., 80 S. Kensico Ave., White Plains, N. Y.

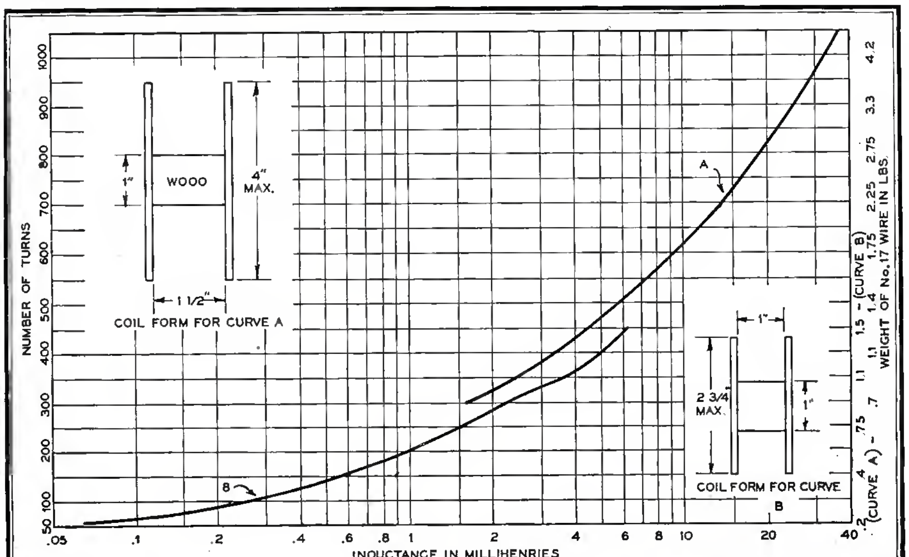


FIG. 7. TURNS OF NO. 17 ENAMELED COPPER WIRE REQUIRED FOR INDUCTANCES OF .05 TO 40 MH.

The Capacitors:

Any commercial type of paper-dielectric capacitor is satisfactory for use in these networks. In all cases, except when 500-ohm speakers are used, the peak AC voltage in voice-coil circuits is limited to not more than 30 volts. Accordingly, the rated working voltage of the capacitors can be any figure exceeding this. Where large values of capacity are required, it may be necessary to connect a number of capacitors in parallel. Generally, paper capacitors up to 4 mfd. are readily available.

Good-quality electrolytic capacitors can be employed where it is necessary to obtain very large values of capacity. It is advisable to use two electrolytic capacitors, each of the specified capacity, connected back-to-back in series. This is illustrated in Fig. 8. If can-type capacitors are used, and they are of the type which utilizes the cans as negative terminals, it is preferable to make the cans common so that the circuit is unaffected should they touch together.

Motor-starting capacitors can be used also. These are AC or non-polarized electrolytic capacitors. Actually, such a unit consists of 2 ordinary electrolytic capacitors wired back-to-back within a single container.

Single polarized capacitors can be used in voice-coil circuits, providing their rated working voltage is many times the maximum likely to be encountered. Under such conditions, oscilloscope observations disclose no significant waveform distortion. It should be borne in mind, however, that when an AC voltage is impressed on an ordinary single electrolytic capacitor, some shunting or leakage may occur during the negative half-cycles because of the relatively low inverse resistance of the capacitor. Also, high transient voltages may approach the capacitor's maximum inverse voltage rating, which could cause unsymmetrical reproduction of the original waveform and, eventually, complete breakdown.

Two capacitors connected back-to-back provide better symmetry. During one half-cycle, one of the capacitors acts as a low resistance while the other, operating at proper polarity, serves as the specified capacity. Conditions are reversed during the alternate half-cycle of applied voltage. Effectively, only one capacitor is operative at any instant. That is why *each* capacitor should be of the value required in the circuit.

The reader may find it surprising that electrolytic capacitors are deemed suitable for use in crossover networks, since most literature on the subject deprecates their application for this purpose. However, no justification has been found for this prejudice. Critical tests have shown that, operating in crossover network circuits, they can be fully as satisfactory as paper-dielectric units. Electrolytic capacitors wired back-to-back have been investigated carefully for evidence of rectification, and it has been concluded that there is no need for hesitancy in employing them. However, they should be fresh stock, in well-sealed metallic or plastic containers.

An electrolytic capacitor should have an extraordinarily long life if it is not subjected to high temperature. Thus, a crossover network should not be located near a tuner or amplifier, which can produce considerable heat.

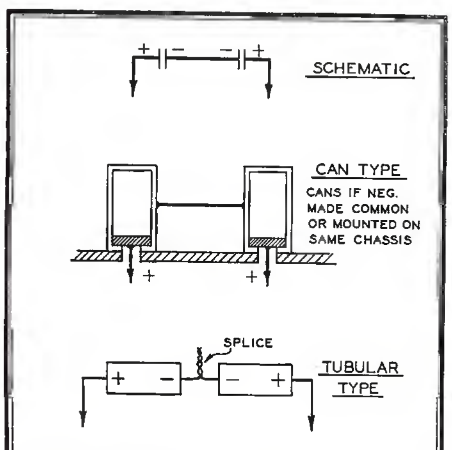


FIG. 8. HOW ELECTROLYTICS SHOULD BE WIRED

One other precaution should be taken. Commercial tolerances on electrolytic capacitors permit wide variations from the nominal value. Since the actual capacity may be as much as ±50% from the indicated value, it is advisable to have the capacity of each unit checked before it is used.

Level Controls:

Speakers are not all of the same efficiency. Thus, even if each speaker in a 2 or 3-way system is fed at identical signal levels, the output from the speakers may be unbalanced considerably. A tweeter, in particular, is likely to be out of balance with the rest of the system because of its extremely high efficiency.

Obviously, some means for adjusting the outputs of the individual speakers to compensate for differences in efficiency would be desirable. This can be accomplished simply by the insertion of wire-wound potentiometers, as shown in Fig. 9, between the outputs of the crossover network and the appropriate speakers. In a 2-way system, a single level control for the tweeter is sufficient in most cases; in a 3-way system, it may be desirable to employ level controls for the tweeter and the mid-range speakers.

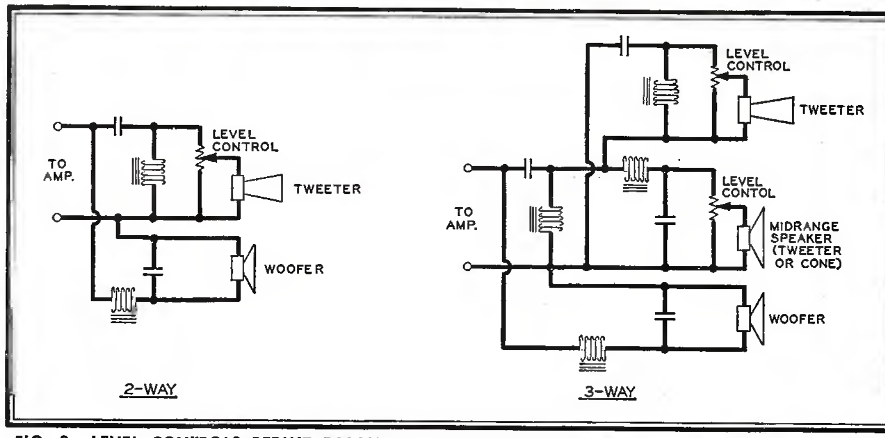


FIG. 9. LEVEL CONTROLS PERMIT BALANCING OUTPUTS OF SPEAKERS OF VARIOUS EFFICIENCIES

Because the attenuation rate should be uniform with respect to angular rotation of the level control, the potentiometer used should have a logarithmic taper. Unfortunately, only linear tapers are available in the low-resistance wire-wound controls generally employed for this purpose. While such controls provide the required volume regulation, most of the attenuation occurs in about one-third the total angular rotation.

In most literature on the subject, the resistance of the control is specified as equal to or slightly higher than the impedance of the associated speaker voice-coil, so that the total load on this branch of the network is relatively constant regardless of attenuator setting. However, a more critical analysis shows that it is preferable to make the resistance of the control at least 2 or 3 times as great as the voice-coil impedance, for the following reasons:

1. Whatever the setting of the control, the speaker is shunted to some extent. If the control is comparable in impedance to the speaker voice-coil, then the maximum output of the speaker is reduced considerably by the shunting action of the control. On the other hand, if the resistance of the control is high in relation to the associated voice-coil, the shunting effect is negligible at maximum volume setting.

2. When attenuation of the speaker output is desired, it does not matter whether or not the load in this branch of the network is constant. With a high-resistance control, attenuation is achieved both by voltage division and by load mismatch. As the attenuation is increased, the mismatch is increased also; this may result in a desirable reinforcement of sound output from the other speaker or speakers. The extent of this reinforcement depends on the output regulation of the amplifier. At best, the increase is slight.

The range of practical potentiometer resistance values is from 2 to 6 times the impedance of the associated speaker voice-coil. The exact value is not critical. In most cases, a choice should be made on the basis of availability.

General Design Considerations:

Three types of deterioration in reproduction can be experienced with crossover networks. Oddly enough, these troubles are most often associated with over-designed networks, or where too steep a cutoff has been obtained.

First, LC resonance may be responsible for two objectionable effects. The system can be shock-excited, at some frequency determined by the L and C values, by any transient signal. The result is a short but perceptible rough burp. Proper amplifier output regulation and feedback will prevent this phenomenon. Normally, too, the resistive component of the voice-coil impedance is sufficient to reduce the tuned-circuit *Q* enough so that this condition is not apparent. However, the damping effect of the speaker alone may not be sufficient with multi-element networks.

Another resonance trouble is limited to series-type networks, in which the capacitive and inductive reactance cancel at the crossover frequency and the amplifier is virtually short-circuited. Thus, a deep hole in the overall system response

(Concluded on page 36)

IMPROVING THE AIR-COUPLER

PART 3 — A FIXED BASS-BOOST CIRCUIT TO COMPLEMENT THE AIR-COUPLER RESPONSE CURVES — EXPERIMENTAL LINES OF ATTACK — *By* ROY F. ALLISON

PARTS 1 and 2 of this article described the construction and performance of the new Dual and Triplex Air-Couplers, which provide bass response smoother and more extended than that of the original design. It was shown also in Part 1 that conventional bass-boost circuits could not be employed with the old Air-Coupler because of the response peak at 50 cycles. The usual bass-boost circuit accentuated the peak, causing the response to turn muddy and boomy.

If the response curve is less peaked, as for the new Couplers, using a bass-boost circuit designed for maximum effect at some very low frequency will eliminate the distortion-producing effects of bass-boost — provided, of course, that neither the speaker nor the amplifier is overloaded. Such a circuit can be designed to complement a given speaker system, and can be installed permanently in the amplifier to be used with it. Thus, fixed equalization is provided for a given speaker installation.

The ideal method of equalization is that provided by a selective negative feedback circuit. Those who can do so are urged to employ this means to provide a permanent boost beginning at 100 cycles, and attaining maximum boost of about 10 db at 20 cycles, in order to complement the response curve of the Air-Coupler. Such feedback circuits must be designed individually for each amplifier, and so cannot be described here.

However, the simple losser circuit of Fig. 15 has been developed for universal application. It can be employed with any amplifier by replacing the input grid resistor with the components shown. Its insertion loss is about 12 db at 200 cycles, which may require additional amplification in some cases.

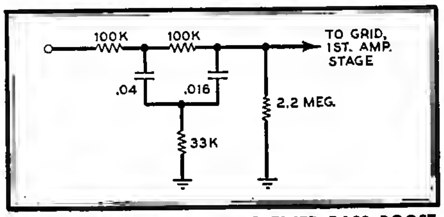


FIG. 15. CIRCUIT PROVIDING FIXED BASS BOOST

Taking the output level at 200 cycles as 0 db, the boost action of this circuit has been measured as follows:

Frequency	Boost in DB
200 cycles	.0
150	.0
100	.52
80	1.7
60	3.5
50	4.7
40	6.1
35	6.7
30	7.7
25	8.5
20	9.3

This information is plotted in dashed lines above the response curves of the Dual and Triplex Air-Couplers, in Fig. 16. It can be seen that, in both cases, essentially flat output is provided down to about 16 cycles. Of course, the term *flat* is generally interpreted more liberally when referring to speaker enclosures than for other equipments. Often, speakers with 10 to 15-db variations in output within certain frequency ranges are claimed to be "flat" in such ranges.

Conclusion:

These two new Air-Couplers should provide flexibility sufficient to meet the requirements of any installation. There is no doubt that, performance-wise, they are much better than the first model.

It is probable that the Air-Couplers can be further improved. An interesting series of experiments could be made, for instance, with the speakers of very low-frequency cone resonances introduced recently. Trials of wider Air-Couplers, with 3 or more internal columns, should produce some interesting data. And the final answer on reflex design has not yet been obtained.

However, we are convinced that any further improvements would be less noticeable to the ear than to a meter. It is difficult to imagine an audible improvement in performance over that of the present Air-Coupler designs.

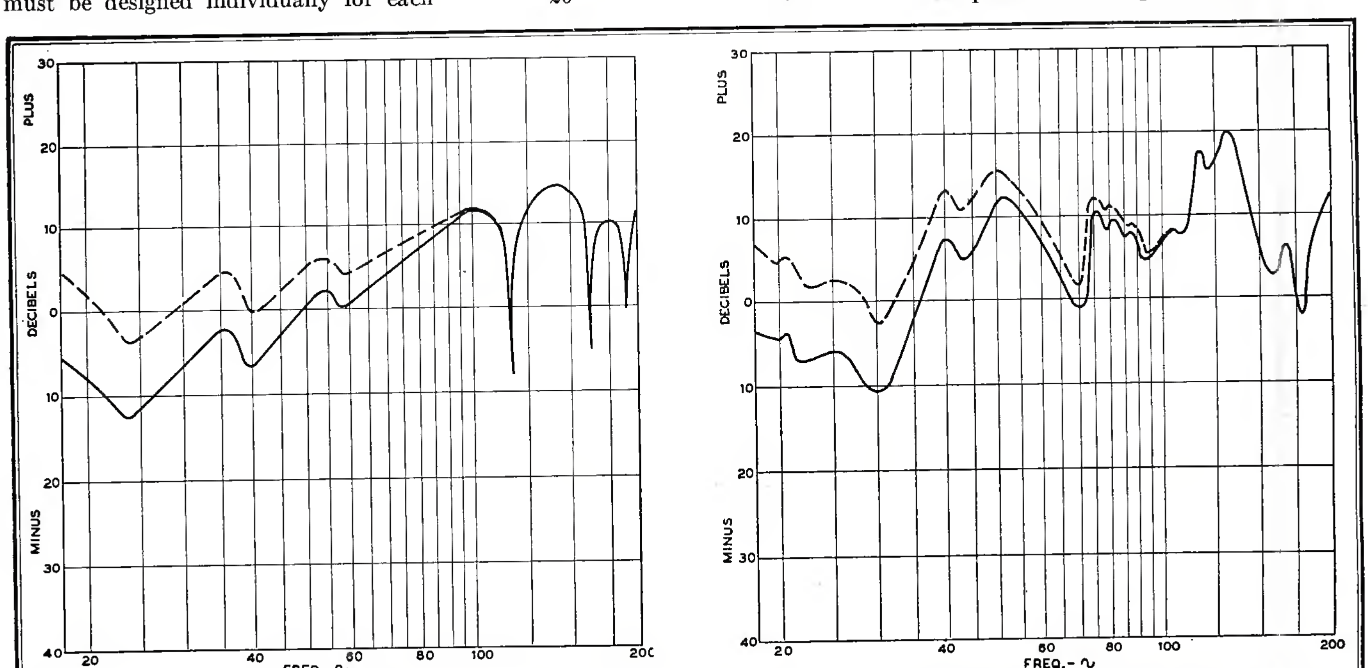


FIG. 16. DASHED LINES SHOW OVERALL AMPLIFIER-COUPLER RESPONSES FOR DUAL AND TRIPLEX AIR-COUPLERS, LEFT AND RIGHT RESPECTIVELY, WHEN THE BASS-BOOST CIRCUIT DESCRIBED ABOVE IS ADDED TO THE AMPLIFIER. SOLID LINES SHOW THE RESPONSES OF THE AIR-COUPLERS ALONE

SPOT NEWS NOTES

(Continued from page 9)

fit of those who may want this information, it is Alprodco, Inc., Kempton, Ind., or Mineral Wells, Texas.

New Appointments:

Dr. Ralph Brown, director of research at Bell Laboratories since 1946, and a member of the Bell System for more than 30 years, has been appointed vice president in charge of research. Also, Dr. J. B. Fisk has been appointed director of research, physical sciences; Dr. H. T. Friis, director of research, high frequency and electronics; Dr. W. H. Doherty, director of research, electrical communication; and Dr. R. M. Burns, director of chemical and metallurgical research.

TV Transmitter Equipment:

Du Mont is setting up a new sales and engineering organization to handle new TV equipment business following the lifting of the freeze. Eastern, central, and western areas will be headed by district managers, and field representatives will be appointed in principal cities to provide assistance in planning, design, and installation of new TV transmitters and studios. The New York area will be handled from factory headquarters at 1000 Main Avenue, Clifton, N. J., under the direction of James B. Tharpe, sales manager of the division.

West Coast Engineering Offices:

Sprague Electric has opened an engineering office and noise-suppression laboratory at 11325 Washington Boulevard, Culver City, Calif. Manager is Thomas S. Bills, formerly in charge of quality assurance at Sandia Corporation.

End Product of Engineering:

As every business man knows, the speed and quality of long-distance telephone service, and the convenience it affords, have been improved steadily since 1945. While rates have increased, the major item of extra cost is the 25% federal tax. Meanwhile, our other principal communication service, the U. S. Mail, has deteriorated at an accelerated rate to the point where, after a piece of mail is deposited with the Post Office, it's anybody's guess as to when it will be delivered. Now, as a premium price on this element of uncertainty, to support the continuation of outmoded practices, and to pay salaries of postmasters who qualify only as political favorites, the Government has upped the postal rates, and on some classes of mail as much as 100%. No wonder the use of the telephone has increased to the extent that

(Concluded on page 40)

CROSSOVER NETWORKS

(Continued from page 33)

can be produced at this frequency. Again, the effect is minimized by feedback.

Second, phase distortion increases with the complexity of the network. This type of distortion was considered unimportant until recent years. Certain investigations have shown that it is discernible to some extent, although not to everyone.

Third, transient distortion in the crossover region is increased by sharp attenuation at cutoff. Excessively steep rolloff, in the order of 18 db or more per octave, should be avoided except for special applications.

It can be inferred from the foregoing discussion that the simple 6 db-per-octave network shown in Fig. 1 is least likely to affect the reproduction adversely. This is true, to a limited extent; however, with the quarter-section network, there is a fairly wide frequency range in the region of crossover where appreciable power is fed to two speakers, because of the slow rolloff. Networks providing attenuation at 12 db per octave, such as those of Fig. 2, are capable of excellent performance.

VHF SLOT ANTENNA

(Continued from page 12)

the slots. Another is to raise the resonant frequency by restricting the dimensions of the cavity behind each slot. This practice made it possible to use slots only ¾ wavelength long, thereby obtaining a more directive radiation pattern in the vertical plane. Fig. 3 shows the vertical radiation pattern of the complete acrial, calculated from the measured radiation pattern of a single tier of 4 slots. On this basis, the power gain is estimated to be about 9 db.

The method of feeding the slots in such a manner as to improve the bandwidth has been described elsewhere,[2] and need only to be outlined here. Fig. 4 illustrates the principle in a simplified form. It is convenient to suppose that the slot is energized by a small floating generator. An improvement in bandwidth is obtained because the vertical rod behaves as a direct earth connection at one frequency only, when it is exactly ½ wavelength long. At other frequencies it introduces a series reactance, which is arranged to compensate for the

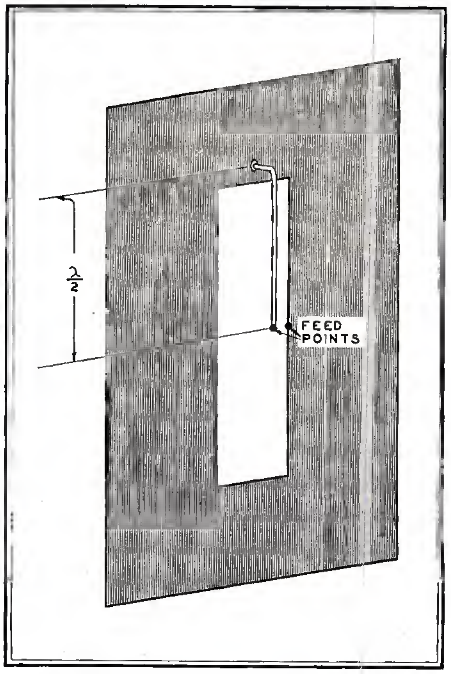


FIG. 4. METHOD OF FEED FOR SLOT RADIATORS

reactance of the slot. Thus, at lower frequencies, the reactances of the slot and the rod are positive and negative respectively, while at higher frequencies the reverse is true. In this way, the total

(Concluded on page 38)

[2] "Wideband Folded Slot Aerials," by G. D. Monteath, *Proc. I.R.E.*, 1950, Vol. 97.

DESIGN DATA for AF AMPLIFIERS — No. 17 Positive Feedback

PART 1 — HOW POSITIVE FEEDBACK CAN BE USED IN CONJUNCTION WITH NEGATIVE FEEDBACK TO REDUCE DISTORTION TO EXTREMELY LOW VALUES

IN RECENT years, there has been considerable effort expended toward determining the value of positive feedback employed in conjunction with conventional negative feedback. It has been found possible, through the use of positive feedback, to reduce overall amplifier distortion to the vanishing point with relatively simple circuitry. Also, by means of positive current feedback, improved loudspeaker damping can be obtained. This Design Data Sheet discusses the first application. The second will be the subject of Sheet No. 18, which will appear in a forthcoming Issue.

Positive feedback can be instrumental in reducing amplifier distortion because of the fact that most distortion is produced by the power amplifier, or output stage. If the positive feedback is applied over a voltage-amplifier stage, the distortion produced by that stage is increased. However, the total gain of the amplifier without negative feedback is increased also. This permits the use of increased negative feedback, which is normally taken around the complete amplifier circuit. In most cases, the overall distortion is reduced considerably without a sacrifice of gain.

Thus, suppose that an amplifier has been designed with sufficient gain to provide for 20 db negative feedback. Without feedback, the total distortion of such an amplifier may be about 6%, with 5% produced by the output stage and output transformer and 1% by the voltage-amplifier stages. With negative feedback of 20 db, the total distortion should be about .6%. Then, suppose that positive feedback in the order of 12 db is provided by an inner loop around the voltage amplifier stages. The distortion contributed by these stages is increased to 4%, while that of the output stage (assuming the same output level) remains at 5%. The most distortion possible under such conditions is 9% without negative feedback; actually, since the RMS method of addition should be used, it is nearer 6.5%. But now, providing stability is maintained, the negative feedback can be increased to 32 db for the same overall amplifier gain. The total distortion is then .16 to .25%, depending on whether the total original distortion figure is taken as 6.5 or 9%. In any case, the distortion has been reduced appreciably by the use of positive feedback.

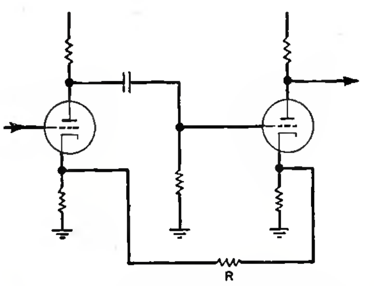


FIG. 1. A TYPICAL POSITIVE-FEEDBACK CIRCUIT

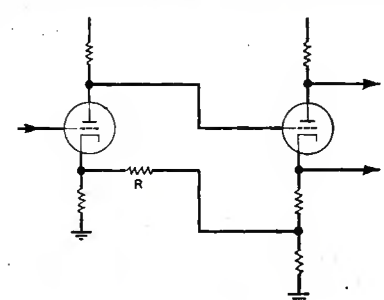


FIG. 2. HOW POSITIVE FEEDBACK CAN BE TAKEN FROM A DIRECT-COUPLED PHASE-INVERTER TUBE

Typical circuits suggested by Roddam[1] appear in Figs. 1 and 2. Fig. 1 shows cathode-to-cathode feedback applied over typical RC-coupled amplifier stages. Ordinarily, with this circuit, R must be made large to keep the amplifier stable. Because R is large in relation to the cathode resistors, no trouble is experienced because of DC bias disturbances.

A much more satisfactory arrangement is shown in Fig. 2, where a voltage-amplifier stage is shown directly-coupled to a split-load phase inverter. Because there is very little phase-shift in the feedback loop, it is possible to employ much more positive feedback before instability is encountered. It may be desirable for this reason to make R rather small; therefore, it is necessary in most instances to select a tap on the phase-inverter cathode load such that the DC potentials at either end of R are similar, in order to avoid bias disturbances. Very often, it is possible to eliminate R entirely by adjustment of the remaining circuit components.

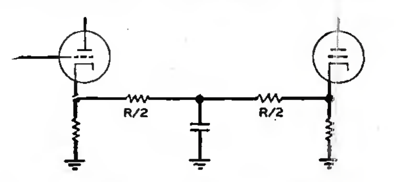


FIG 3. A CIRCUIT THAT PROVIDES POSITIVE FEEDBACK AT THE LOWER AF FREQUENCIES ONLY

There is no doubt that amplifier design requirements are more difficult to meet when it is intended to use positive feedback for, while phase shift must be kept low in order to employ extensive negative feedback, it is increased by positive feedback. One artifice to avoid instability that can be employed where a direct-coupled stage is not available is shown in Fig. 3. A capacitor is inserted from the center-point of R to ground. This shorts out the positive feedback at all but the low frequencies, where it is most often required. Since the gain of the amplifier with high values of negative feedback is substantially independent of the gain without negative feedback, the negative feedback dropping resistor need not be changed when positive feedback is employed to increase the internal gain. The overall gain with negative feedback remains relatively constant regardless of the amount of positive feedback employed. It follows, therefore, that the overall audible frequency response is not affected by the selective positive feedback circuit shown in Fig. 3.

[1] "More About Positive Feedback," by Thomas Roddam, **Wireless World**, July, 1950.

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VHF SLOT ANTENNA

(Continued from page 36)

impedance was made substantially resistive over a band of 6 mc. Within this band, the standing-wave ratio on the main feeder was not more than 0.9.

Fig. 5 shows one slot as seen from inside the cylinder. The end of a coaxial feeder, one of 32 branching out from the main feeder, can be seen in the lower right-hand corner. Its outer conductor is grounded to the screening bars. The inner conductor, passing through an insulator, is connected to a horizontal metal strip. The strip acts as a continuation of the feeder, with the inner surface of the cylinder providing the return path. At the slot, the strip is connected to the vertical rod.

Another detail that can be seen in Fig. 5 is a tapered metal plate projecting into the slot from the right-hand side. This introduces capacitance across the slot, and lowers its resonant frequency. Small changes can be made by altering the length of a vertical metal strip fitted to its left-hand edge. Additional means for adjusting the slot impedance are provided by a movable sleeve that effectively thickens part of the vertical rod, and by the horizontal strip, whose spacing from the inner surface of the cylinder can be varied.

FIG. 5. A VIEW OF ONE SLOT FROM INSIDE THE CYCLINDER. NOTE HALF-WAVE VERTICAL FEED ROD

Conclusion:

Slotted-cylinder aerials, as described above, have been installed at Wrotham and at the Midland and North-of-England television stations. It is intended also to utilize them at television stations to be erected in the future. At television stations, the feeder systems for the slot aerials will not be fitted until they are required. At Wrotham, on the other hand, it is not at present intended to install a television aerial. The center of the slot aerial is 400 ft. above the ground at Wrotham and 650 ft. above ground level at the high-power television stations.

At Wrotham, a program of experimental transmissions began on July 17, 1950, and is still in progress at the time of writing.[3] The object is to assess the advantages offered by VHF broadcasting, and to compare the merits of AM and FM. To this end, two transmissions are radiated simultaneously: AM, with a carrier frequency of 93.8 mc. at 18 kw., and FM, with a carrier frequency of 91.4 mc. at 25 kw. Peak deviation on FM is 75 kc. Pre-emphasis of 50 microseconds is used.

The transmissions are combined in a filter, situated at ground level, which prevents intermodulation between the transmitters. The powers quoted above are those generated by the transmitters. Allowance must be made for a loss of 1 db in the filter, in the main transmission line connecting the filter to the aerial, and in the distribution feeders branching out from the end of the main feeder to the individual slots.

[3] These tests have now been concluded. A report on the results has been released by the BBC, showing marked superiority of FM in all respects. For equivalent service, 10 times the signal strength was required on AM as for FM. It was estimated that Great Britain could be covered with AM service on VHF only by using 3 to 4 times the number of stations required for equivalent FM service.

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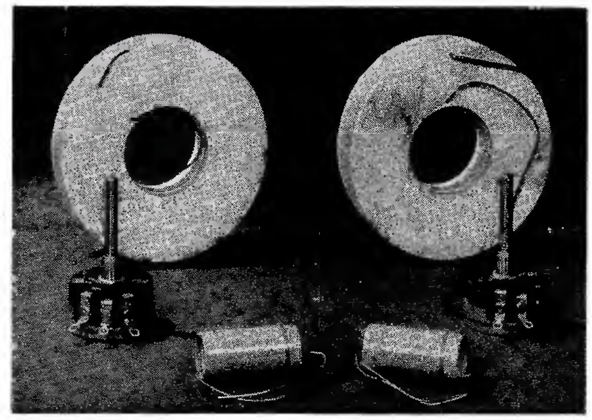

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8 ohms	1,100	6	7.00	12.00
	550	7	7.00	13.00
	350	8	12.00	17.50
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	250	19	6.00	10.00
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4 ohms	400	21	3.50	8.00
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* Complete networks include necessary capacitors and level controls. Be sure to indicate whether you want just the coils or the complete network. We recommend buying the complete network since, in some cases, as much as 640 mfd. of capacitance is required.

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SPOT NEWS NOTES

(Continued from page 35)

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Orders have been placed with International Standard Electric by Emilio Azcarraga for a 5-kw. TV transmitter to be installed at Monterey, and a 1-kw. transmitter at Guadalajara, to operate on channels 6 and 10 respectively. Most of the equipment will be supplied by Federal Telecommunication Laboratories, Nutley, N. J.

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"Receiver Troubleshooting and Repair," by A. A. Ghirardi and J. R. Johnson. Rinehart. 822 pages, price $6.75.

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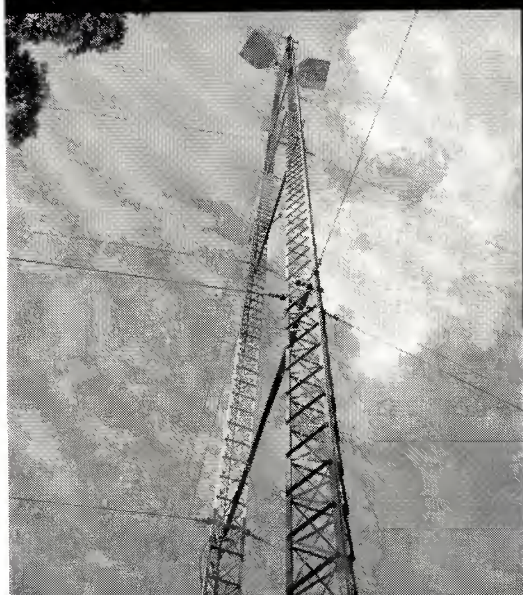

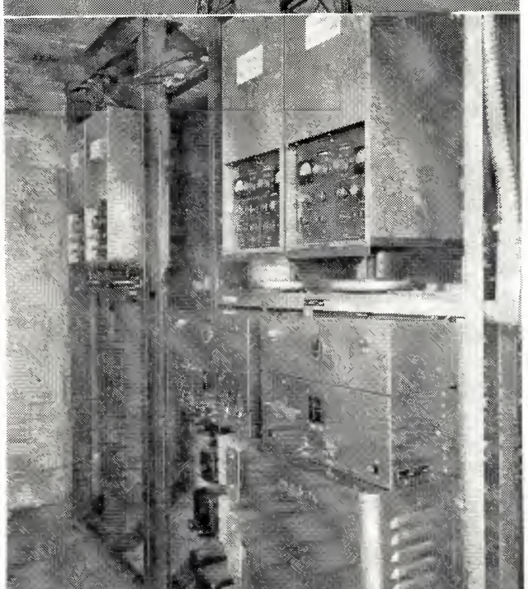

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