PRICE—TWENTY-FIVE CENTS

FM

JULY 1941

JULY 1, 1941
TELEVISION GOES COMMERCIAL, USING
FM FOR AUDIO ········ AM FOR VIDEO

THE COMPLETE AND AUTHORITATIVE SOURCE OF INFORMATION ON FREQUENCY MODULATION ★ ★ *Edited by M. B. SLEEPER*

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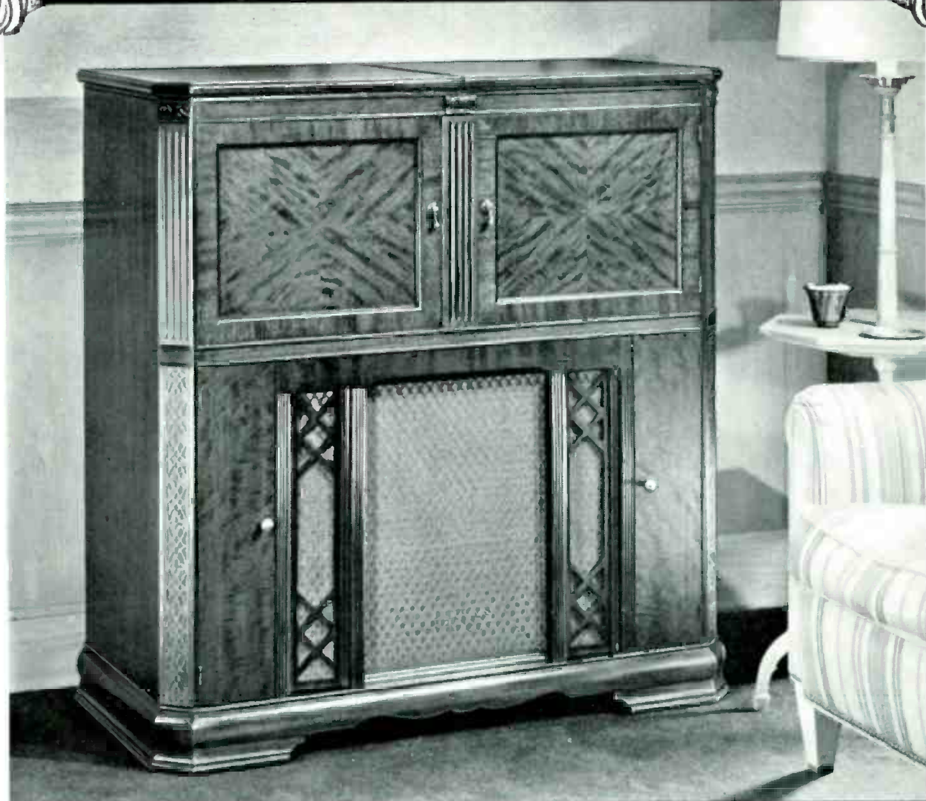
Only Zenith has this



MICROSTATIC FREQUENCY MODULATION *plus* RADIORGAN TONE COLOR CONTROL

FOUR STYLINGS AVAILABLE

Zenith FM Receivers are available in Chairside, Console, Spinet and Radio-phonograph combination stylings — all in fine hand-rubbed finish — all designed for FM-AM reception.

★

ASK YOUR ZENITH DISTRIBUTOR

Phone — write or wire your Zenith distributor today for complete information on all the Zenith Microstatic Frequency Modulation Receivers.

Modern radio listening demands receivers designed for FM-AM reception. New FM stations are going on the air all over the country—many more are planned. Public interest and, more important, public buying are growing with amazing rapidity . . . And Zenith is ready now with a wide selection of FM-AM receivers incorporating fourteen points of definite superiority. You need these Zenith FM-AM models on your sales floor—otherwise you are not selling modern radio.

Model illustrated is 12-H-678 permitting four band reception. Also plays and automatically changes phonograph records. Available in mahogany or walnut finish.

ZENITH

AMERICA'S OLDEST MANUFACTURER OF FINE RADIOS FOR THE HOME

Interesting Facts about

FM MAGAZINE

3. Why is the circulation of *FM* MAGAZINE growing so rapidly among executives and engineers in every branch of the radio industry?

That is because it contains so much practical, useful, and authoritative information which cannot be found elsewhere!

Typical are the articles written for *FM* MAGAZINE on the economics, planning, engineering, and performance of broadcast stations, illustrated by facts, figures, and photographs. *Such information is to be found in no other publication.*

FM MAGAZINE carries complete engineering data on new transmitting, receiving, and studio equipment, with specifications and circuits. *Such data is found in no other publication.*

Present activities and future plans of the leading broadcast stations and manufacturers, indicating trends of radio progress, are discussed by their chief executives and engineers in *FM* MAGAZINE. *This is an exclusive feature.*

FM MAGAZINE is the only reference source on emergency communications, and is recognized as such by state, county, and municipal police officials and public utility engineers. *Another exclusive feature.*

Articles on school radio systems, laboratory equipment, the FM Handbook series, coverage maps, data on the status of FM broadcasting, and similar exclusive information are reasons why 90% of the subscribers still ask: "Let me have all the back numbers available."

Now, with the July issue, its field of usefulness is broadened further by covering commercial television developments.

These are some of the reasons why *FM* MAGAZINE provides complete and concentrated coverage of the Management Group of the radio industry.

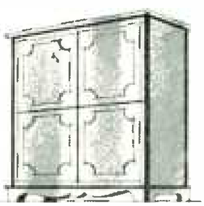
M. B. SLEEPER, *Editor and Publisher*

THE RADIO ENGINEERING NEWS JOURNAL OF BROADCASTING, COMMUNICATIONS, AND TELEVISION

3 reasons why other dealers envy the man who handles STROMBERG-CARLSON

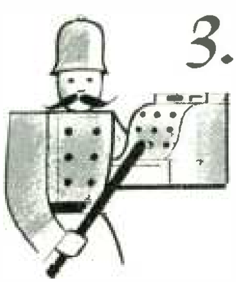
1. THE FRANCHISE:

The Stromberg-Carlson franchise is a document whose value is jealously guarded. To obtain it a dealer must prove himself worthy to represent this pioneer line of high-fidelity radio receivers and radio-phonographs. One fact alone enables you to judge how this policy of careful selection and controlled distribution protects the individual dealer—more men today want the Stromberg-Carlson franchise than ever before.



2. A HIGH UNIT OF SALE:

The Stromberg-Carlson line is deliberately planned for selling up. Each chassis series—in progression—has all the features of the preceding series, plus certain specific and demonstrable added features. When you realize the importance of a high unit of sale, you realize it means that you sell fewer sets, but make far more net profit. The larger the sales unit—the more dollars come in and the fewer sets to uncrate, deliver, install, service, and the fewer trade-ins and finance problems. The Stromberg-Carlson line provides just that—since its average unit of sale is high; yet the line is completely competitive.



3. PROFIT PROTECTION:

Because Stromberg-Carlson hand picks its dealer and controls distribution, the franchise holder's profits are better protected. A Stromberg-Carlson is not a "shopping" item. As a result the dealer works within a more stable price structure. Not only this, but he reaps the benefit of Stromberg-Carlson's great national advertising campaign, with fewer dealers to share the active prospects it creates.

TO TOP OFF THESE BENEFITS, a Stromberg-Carlson dealer has the rich opportunity of growing with a firm that for 47 years has blazed the trail in voice transmission and reception . . . that leads the way in FM, with more field experience than any other manufacturer . . . and that today has its FM—AM sets in more homes than all other makes combined! See the new 1942 line at your local distributor's showing and you'll agree, *"There is nothing finer than a Stromberg-Carlson."*

STROMBERG-CARLSON

ROCHESTER, NEW YORK

THE FINEST RADIO FOR STANDARD PROGRAMS • THE ONLY RADIO FOR FM AT ITS BEST

TO those who have not seen television in its present stage of perfection, there is a real surprise coming. Despite many discouragements and costly delays, the last two years have been spent to good advantage in working out refinements of equipment and technique which not merely put television in direct competition with the movies but, in many respects, go the movies one better.

The only weak link today lies in the problems of individual home installations, but that will be eliminated as service men gain practical experience.

With the degree of perfection now achieved, adequate sponsorship of programs to cover the cost of broadcasting seems assured.

Manufacturers are even confident that the sale of receivers will not be restricted by the necessarily high cost, as compared to straight radio sets.

What attitude the OPM will take toward the manufacture of television receivers we do not know at this time. The FCC can say "yes" to commercial broadcasting, and the OPM can still say "no" to the production of equipment.

Meanwhile, at least at this writing, three television stations are preparing to go on the air in New York City on July 1st, one is ready and another will follow in Philadelphia, one or two are set to start in Chicago, and in other cities it is understood that transmitters are being groomed for the air.

Lack of definiteness is due to the fact that final tests and adjustments are still being made.

It certainly looks as if television is under way this time in earnest.

FM

THE RADIO ENGINEERING NEWS JOURNAL OF BROADCASTING, COMMUNICATIONS & TELEVISION

VOL. 1 | JULY, 1941 | NO. 9

CONTENTS

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M. B. SLEEPER, *Editor and Publisher*

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The publishers will be pleased to receive articles, particularly those well illustrated with photos and drawings, concerning all phases of FM developments. Manuscripts should be sent to the publication office, at Newton, Mass. Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will FM Magazine be responsible for their safe handling in its office or in transit.

Advertising correspondence, copy, and cuts should be addressed to the advertising office at Newton, Mass.

FIG. 1. FASTEN THIS PAGE ON THE WALL AND STAND BACK ABOUT EIGHT FEET. THEN YOU WILL SEE ABOUT THE SAME AMOUNT OF DETAIL AS IN AN ACTUAL TELEVISION IMAGE OF 525 LINES. THIS IS A SCENE FROM ONE OF THE FRANKLIN FIELD FOOTBALL GAME SERIES TELEVISED BY PHILCO

A Review of Philco

TELEVISION PROGRESS

Part I—Program of Research on Methods, Standards, and Physical Equipment, Carried on from 1928 to 1941

BY E. N. ALEXANDER *

SHORTLY after the false boom in mechanical television in 1926 and early 1927, the Philco Corporation decided to investigate this new communication medium. To pursue this investigation, Philco built and staffed the necessary experimental laboratories, studio, and transmitting facilities to receive from the Federal Communications Commission in January 1932 an experimental television broadcasting license and call letters W3XE. This was one of the first electronic television systems in the United States on the air and so licensed.

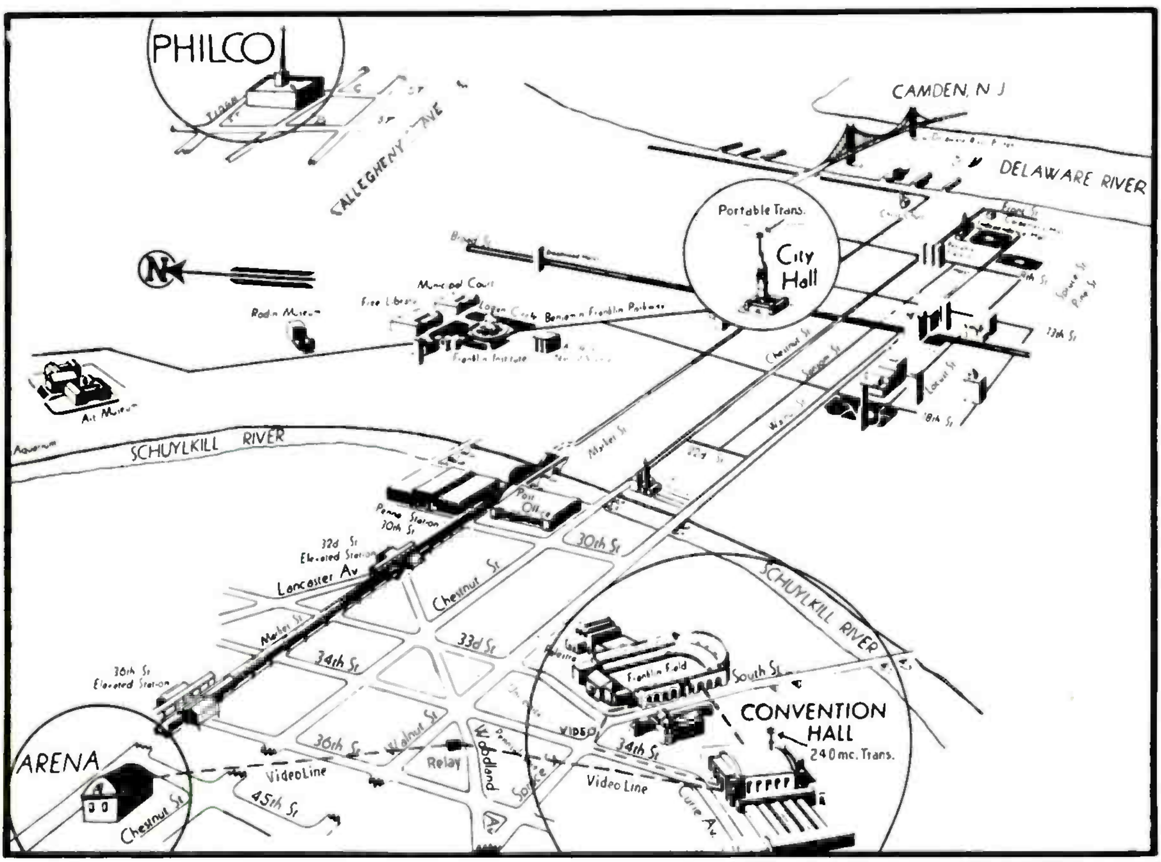
Philco's television broadcast experience might well be considered a record since, from 1932 to date, it has operated W3XE and its associated relay transmitter W3XP a total of almost 6,000 hours.

In its authorization of commercial television the Federal Communications Commission has prescribed a minimum 15 hour broadcast week. Our log of almost 6,000 hours on the air, on that basis, would total over seven years of continuous operation.

Naturally only a small portion of these

* Program Manager, Philco Radio & Television Corporation, Philadelphia, Pa.

FIG. 2. BIRD'S-EYE MAP OF PHILCO'S CONNECTIONS FOR HANDLING REMOTE TELEVISION PICKUPS



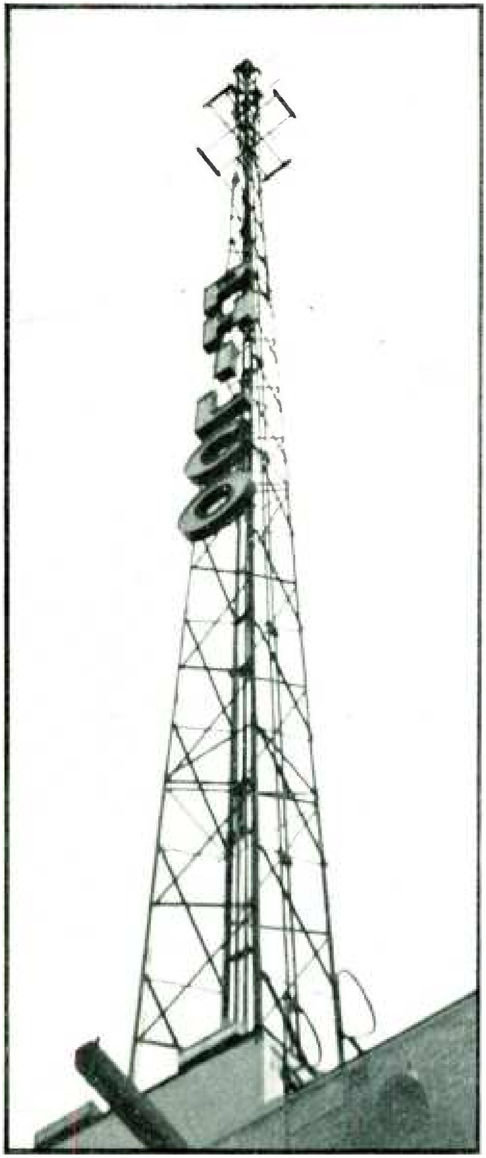


FIG. 3. MAIN STATION ANTENNA FOR VIDEO AND AUDIO SIGNALS, ATOP PHILCO FACTORY

transmissions were of entertainment programs, since the period 1932 to 1939 was dedicated to research, experimentation, and development to aid in determining acceptable television standards. Since the readers of *FM* Magazine are drawn from all branches of the radio industry, perhaps some of the outstanding developments and contributions to the art of television resulting from this program of research would be of interest.

DC Transmission ★ Seven years ago, we developed the transmission of DC components in television pictures. This development enables the transmitting operator to have complete control over the range of tones in the reproduced picture. This conception has subsequently been adopted by the B.B.C. in England and the American television stations.

High Fidelity Picture Transmission ★ We have endeavored constantly to obtain the highest order of fidelity in television. As a part of this program, we sponsored the 6-mc. channel in an effort to achieve more than the 343 lines then generally believed acceptable. Philco was the first to transmit a 441-line picture. This was done in a television demonstration at the Franklin Institute, Philadelphia, in January 1937. This, however, did not satisfy our engineers. They have constantly experimented to achieve greater picture fidelity and are now pleased with the decision of the industry to employ better than 500 lines as the television standard for the United States of America. On May 3, 1941, the Federal Communications Commission of the United States approved 525 lines as standard. W3XE has been broadcasting experimentally on 525 lines since September 16, 1940.

Sesqui-Sideband Transmission ★ In addition to demonstrating the superiority of increased line structure for higher picture fidelity, we further advocated for the same purpose sesqui-sideband transmissions. As early as 1936 Philco initiated experimentation on sesqui-sideband filters. During 1938 we designed, built, and installed the first sesqui-sideband television picture filter and were first on the air with a successful sesqui-sideband program transmission. This development has made it possible to achieve higher picture fidelity within the allocated channels.

Ion Spot Trap ★ A few years ago, the most objectionable ion spot, the dark spot which appeared on picture tubes after short periods of use, had almost become an accepted limitation of these tubes. To remove this defect, our engineers developed a unique type of construction for the electron gun and tube. That annoying ion spot is now a thing of the past.

Flat-Faced Tubes ★ Another accepted limitation of the television picture tube was its so-called "onion" or bulbous shape. It was thought necessary to make the viewing surface of the tube convex so as to withstand the external pressure over the large evacuated volume. This shape, however, resulted in optical distortion of the picture as well as acting as a

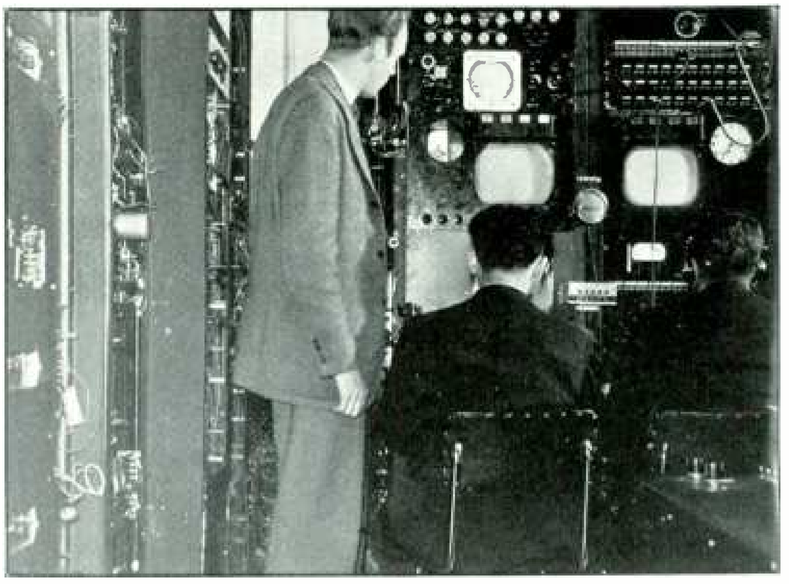


FIG. 4. "STAND BY"—SCENE IN THE TOWER CONTROL ROOM, DIRECTLY BENEATH THE TELEVISION ANTENNA, AS DIRECTOR WARREN WRIGHT READIES A TELEVISION SHOW

convex mirror to pick up extraneous light reflections from every direction in the room, regardless of the position of the viewer. Our research engineers believed that these disadvantages would be objectionable to the viewers. As a result, they developed the Philco flat-faced safety tube which, by virtue of its perfectly flat glass viewing surface, ⅝-in. thick, not only eliminated the optical limitations of its predecessor but, in addition, it has been found to be a tube of unusually safe construction.

Black-and-White Pictures ★ During 1935, green colored television pictures were generally considered satisfactory. Our engineers were of the opinion that black-and-white contrast was a primary requisite of the viewing public, and in February, 1935 they developed and demonstrated black-and-white television pictures of such outstanding merit that now most television pictures approach this black-and-white contrast.

Rectangular Tubes ★ Philco has originated and built rectangular-shaped cathode-ray picture tubes which accommodate a considerably larger-sized picture than the circular type, since they have less evacuated volume and are, therefore, less hazardous.

Television Transition Effects ★ To secure wipes, fades, dissolves, roll cuts, and other transitions commonly associated with motion picture production technique, our engineers invented new and improved mixing amplifiers for multiple television camera operation. These amplifiers permit the director of a television program to use the same transition effects that the movies have found so desirable to maintain continuity and to enhance interest. Application of this invention will aid materially in lending a smooth, "professional" appearance to television productions.

240-Mc. Transmission ★ In order to relay television programs from remote points to the main television transmitter for rebroadcast, we have successfully conducted a series of both test and program transmissions on 240 mc. These tests, of course, cover transmitting and receiving

> THIS is the first information made public concerning a television research and development program on which Philco has spent over $10,000,000.
>
> Pushing ahead steadily and quietly, Philco has climaxed its efforts by producing an elaborate weekly schedule of television programs, although the audience is limited to members of its own organization.
>
> This has been done to check transmitter and receiver performance, program technique, and audience reaction. Philco has not offered television sets for sale to the public.
>
> The conclusion of Mr. Alexander's article will appear in the August issue of FM Magazine.

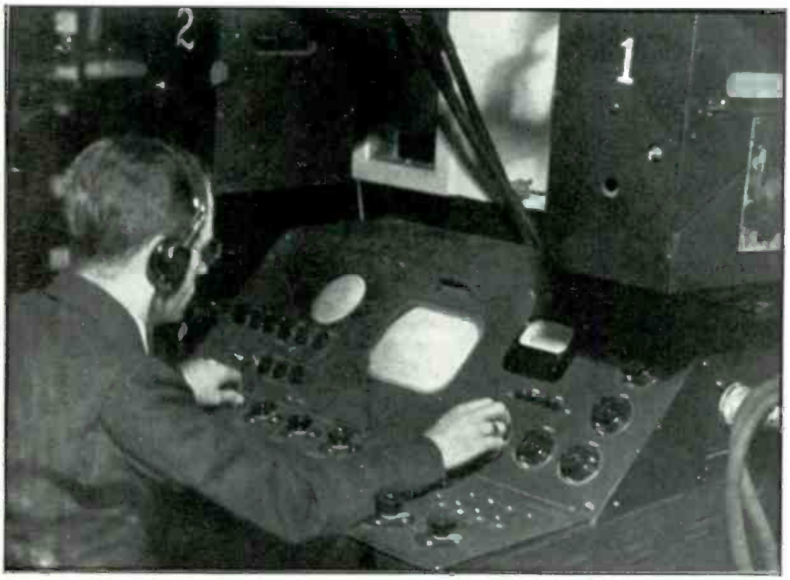
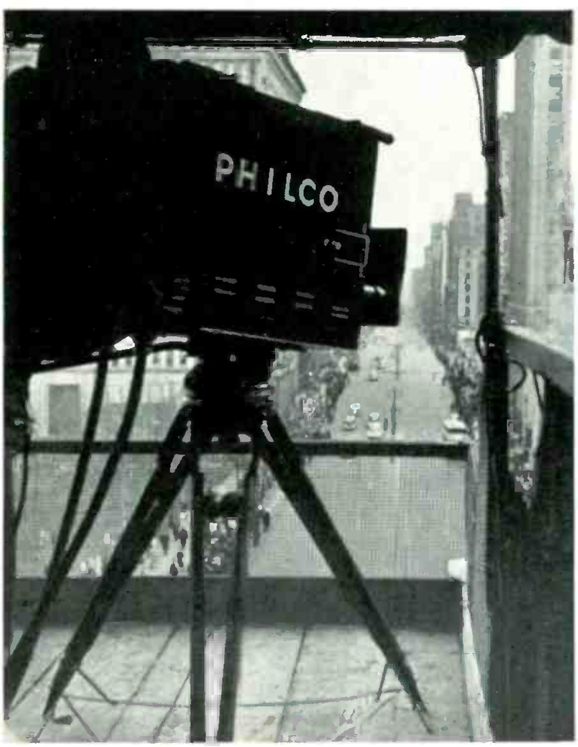


FIG. 5. PHILCO STUDIOS USE TWO TELEVISION CAMERAS FOR TRANSMITTING FULL-LENGTH MOVIES. THE MONITORING CONSOLE IS LOCATED BETWEEN THE CAMERAS

circuits, apparatus and technique, and have emphasized the importance of these high frequency channels in future television work.

Frequency Modulated Sound ★ The Federal Communications Commission in their report of May 3, 1941, requires that the sound accompanying television broadcasts be transmitted by frequency modulation. Five years ago, our engineers developed an FM circuit which is now used not only in our television sound transmissions, but also in our FM radio receivers, with exceptionally good results.

FIG. 6. CAMERA FOCUSED ON BROAD STREET, READY TO TELEVISE MUMMERS' PARADE



Cable Transmissions ★ In conjunction with the remote program originations, we have conducted extensive research into the problem of transmitting video frequencies with fidelity by wire. Some of this work has been done in conjunction with the Bell Telephone Laboratories, and many experimental program transmissions have been made over a matched telephone-pair wire-link of considerable length. Further, Philco research laboratories have developed special balancing amplifiers to permit the use of long lengths of ordinary cable for the transmission of these frequencies on temporary installations.

The results of these studies will be most appreciated with the advent of numerous remote transmissions when television reaches a commercial basis.

Push Button Tuning ★ We have used push buttons for convenient, accurate tuning for the selection of television sound and picture channels since early 1938.

Built-in Antennas ★ As in standard broadcast receivers, Philco was early to develop and demonstrate a practical built-in antenna sys-

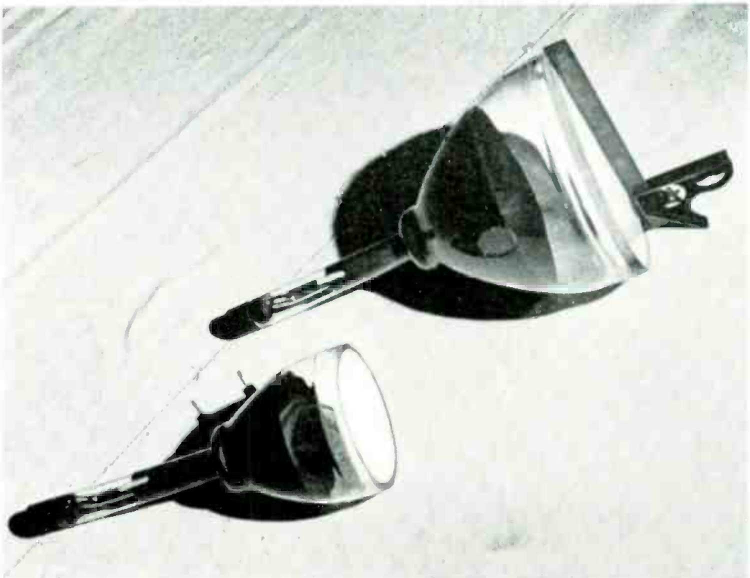


FIG. 7. HEAVY PLATE GLASS FRONTS PHILCO FLAT-FACED PICTURE TUBES. THUS, INTERFERING REFLECTIONS SEEN ON CONVEX SCREENS ARE ELIMINATED

tem for television receivers. The advantages of such a system are:

1. The material reduction of diathermy, automobile and other forms of man-made interference with a resulting improvement in the signal-noise ratio, by simply rotating the antenna control at the receiver and making use of its directional properties.
2. The elimination of costly and unsightly outside television antenna structures in most cases where the receiver is located in a primary service area.
3. A television receiver incorporating this plug-in-and-operate feature is as moveable for cleaning or room rearrangement as a comparable radio model.

Natural Color Television ★ Considerable space has been given in the newspapers recently to the possibility of natural color television. We produced experimental color television more than three years ago. Many additional problems remain to be solved, but the solution of these problems is looked for in the years to come.

Synchronizing ★ *Electrical and Mechanical Synchronizing Generator.* In the belief that television pictures are no better than the synchronizing which holds them in position, during 1934 we instituted a comprehensive program to stabilize and improve synchronizing circuits. One of the first milestones of progress was the electro-mechanical synchronizing generator. At that time, the most reliable method known for generating synchronizing impulses was the mechanical disc synchronizing generator. We realized that in a system such as this, minute inaccuracies were unavoidable. To remove these inaccuracies and

FIG. 8. EIMAC 1,500-T TUBES ARE USED IN THE FM SOUND TRANSMITTER

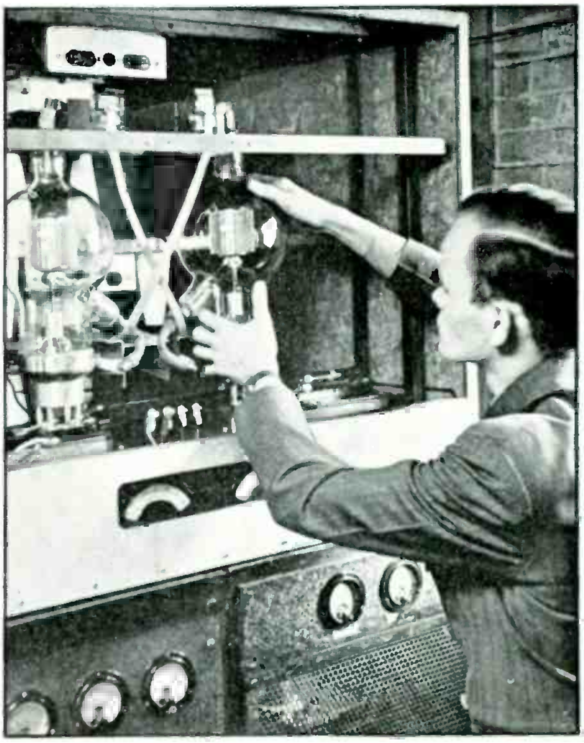
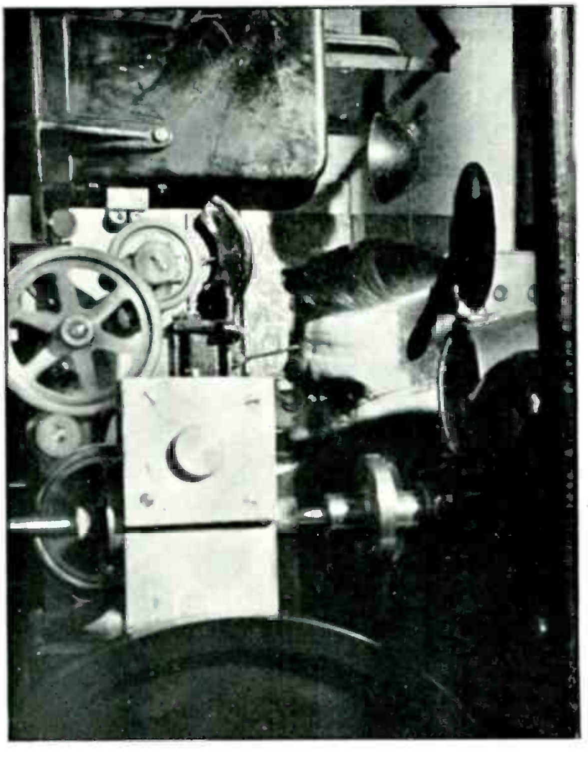


FIG. 9. SOUND CONTROL AT FRANKLIN FIELD HAS 4-POSITION MIXING AMPLIFIER AND COMPLEX ORDER SYSTEM CONNECTED WITH A TOTAL OF 5 TELEVISION CAMERAS

improve the resultant synchronization, our research engineers invented a combined electro-mechanical synchronizing generator. This electro-mechanical synchronizing generator has proved to be the logical step to all electronic synchronizing now accepted generally by the television industry.

FIG. 10. PROJECTIONIST LOOKS AT IMAGE ON CAMERA TUBE DURING MOVIE PROGRAM

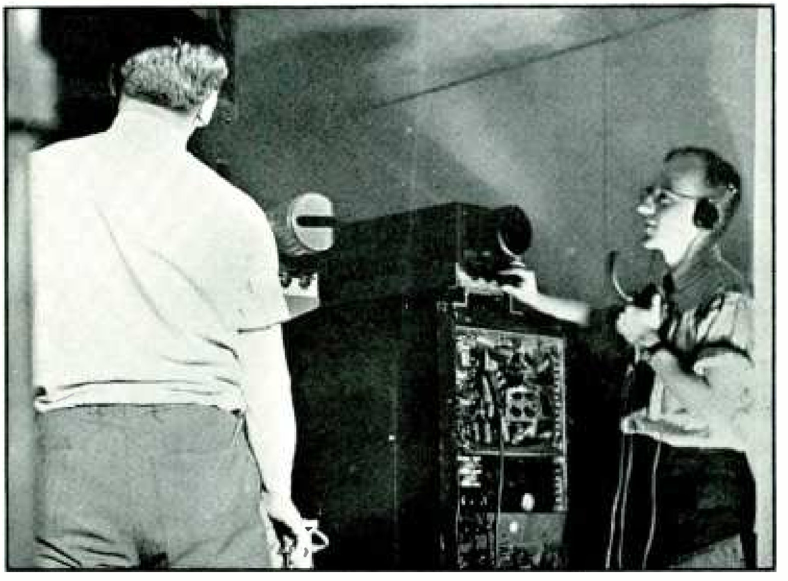


Quenched Synchronizing ★ The next step in this program was the invention of the quenched synchronizing circuits. These circuits made the synchronizing oscillators insensitive to extraneous or static pulses except at the time synchronizing pulse was expected. This resulted in the most stable synchronizing pulse then conceived.

Noise Discriminating Circuits ★ Noise discriminating circuits and noise gates, as applied to the synchronizing pulses, were then produced. The increase in effectiveness in the synchronizing pulses resulting from the use of these circuits has been generally realized as shown by the use of these circuits today.

Automatic Synchronizing Control ★ Realizing that synchronizing oscillator systems are cumbersome, costly, and difficult to operate manually, and that a minimum number of controls would be welcomed by the public, pioneering was done in the field of automatic synchronizing control. Field tests of this system have proven most satisfactory.

Narrow Vertical Synchronizing Pulse ★ Another type of synchronizing improvement developed by Philco was the narrow, vertical pulse which, because of the definite distinction made between the horizontal and vertical pulses, made these pulses more readily distinguishable at the receiver.



SCENE IN THE TELEVISION BOOTH DURING A REMOTE PICK-UP, USING TWO CAMERAS

Alternate-Carrier Synchronizing ★ These synchronizing studies led to the development of alternate-carrier synchronizing. This system uses synchronizing pulses on an alternate transmitter carrier higher in frequency than the picture carrier. This alternate carrier is only present for the duration of the synchronizing pulse, and replaces the picture carrier which is present at all other times. Actual field test measurements of this system show a *five times increase* in synchronizing signal from the same transmitter power. This development, we believe, will extend appreciably the effective service area of any television station, enabling trouble-free reception in areas where the picture was formerly destroyed by static from such everyday devices as vacuum cleaners, kitchen mixers, electric razors, doorbells, and automobiles. We are, therefore, proposing that this synchronizing method be adopted by the industry as standard.

EDITOR'S NOTE: *Part 2 of Mr. Alexander's article will appear in the August issue of* FM *Magazine. In this concluding part he will deal with the development of television program technique, tested by the reactions of W3XE's private audience.*

FM STATIONS PREFERRED FOR NATIONAL DEFENSE

If the United States should declare war on Germany, it is quite possible that FM broadcast stations will be permitted to operate without restriction, while AM broadcasting may be seriously curtailed.

The reason is that FM signals do not, normally, carry beyond the horizon, which means a distance of 50 to 75 miles, and cannot be used as beacons for hostile aircraft approaching our shores.

On the other hand, 50-kw. AM transmitters along the seaboard give dependable signals, adequate for operating radio homing devices, 1,000 miles or more out to sea. Thus, with very simple equipment, pilots can fly straight to any of our important cities.

It is a well-known fact that signals carry more effectively from the United States in the direction of Europe than they do from Europe to the West.

Of course, FM signals are heard occasionally at surprising distances, but these cases are so rare and unpredictable that enemy aircraft could not depend upon such stations to serve as radio beacons.

In case it is found necessary to close down AM stations, even though for only periods of emergency, owners of A-FM receivers within FM service areas may become listening posts of great importance to their communities.

FM SPOT NEWS

Notes and comments, personal and otherwise, that have to do with FM activities

New York: WOR's FM station W71NY will go to full power with a new 10-kw. W.E. transmitter about August 1st.

Baton Rouge: W45BG, operated by WJBO, is on the air, using an RCA installation.

Silent Switches: Introduced by G.E., Schenectady, to control motors up to 5 H.P., so that FM mikes will not hear them.

Frank Kennedy: Don Lee, chief engineer, is getting ready to install W.E. FM transmitter on 1,700-ft. Mt. Lee, at Hollywood, Calif. Call will be K45LA. A 6-bay turnstile on a 70-ft. mast will be erected on a 230-ft. tower.

New Hampshire: State police are using Motorola FM transmitter to talk back to headquarters from patrol cars.

Chicago: Zenith is pushing 50-kw. FM transmitter toward early completion, under direction of J. E. Brown. This will boost W51C's present low-power service greatly.

G.E.: Contrary to reports, they will have a new and larger A-FM line soon. One model houses the Translator in what appears to be a row of books.

New Jersey: Has appropriated $120,000 for state-wide, 2-way FM police system.

New York City: Is now running tests and measurements preparatory to shifting from AM to 2-way FM for police communication.

Dick Devaney: Of Pittsburgh's Radio Electric Shop reports: "It looks as if this is going to be an FM year in this City."

FCC: Has loosened up on New York City's FM applications by granting C.P.'s to Interstate Broadcasting Company, W59NY; Muzak Corporation, W47NY; Municipal Broadcasting System, W35NY.

FM Promotion: Philco will use transcriptions on 400 stations to promote their new A-FM line of radio receivers and combinations.

John E. Lingo: Of Camden, N. J., will supply an additional mast to increase the height of Major Armstrong's antenna at Alpine.

John Woodward: Has left Cleveland's FM station WBOE to join the engineering firm of Ring & Clark, Washington, D. C.

Rural Service: FCC complains that AM stations do not attempt to give adequate rural service.

PHILCO'S A-FM TABLE MODEL IS PRICED AT $49.50. DELIVERIES ARE JUST STARTING

This is another reason for action on applications for FM C.P.'s.

Los Angeles: C.P. has been granted to Standard Broadcasting Company for 45.1 mc., covering 5,000 square miles, 3,000,000 population.

Freed Radio: Included in fall line of A-FM sets will be models with tuned RF amplification for extra distance, improved static suppression.

F. M. Link: If a loud noise is heard on West 19th Street, New York City, it will be because increased business now has the factory walls bulging to the bursting point.

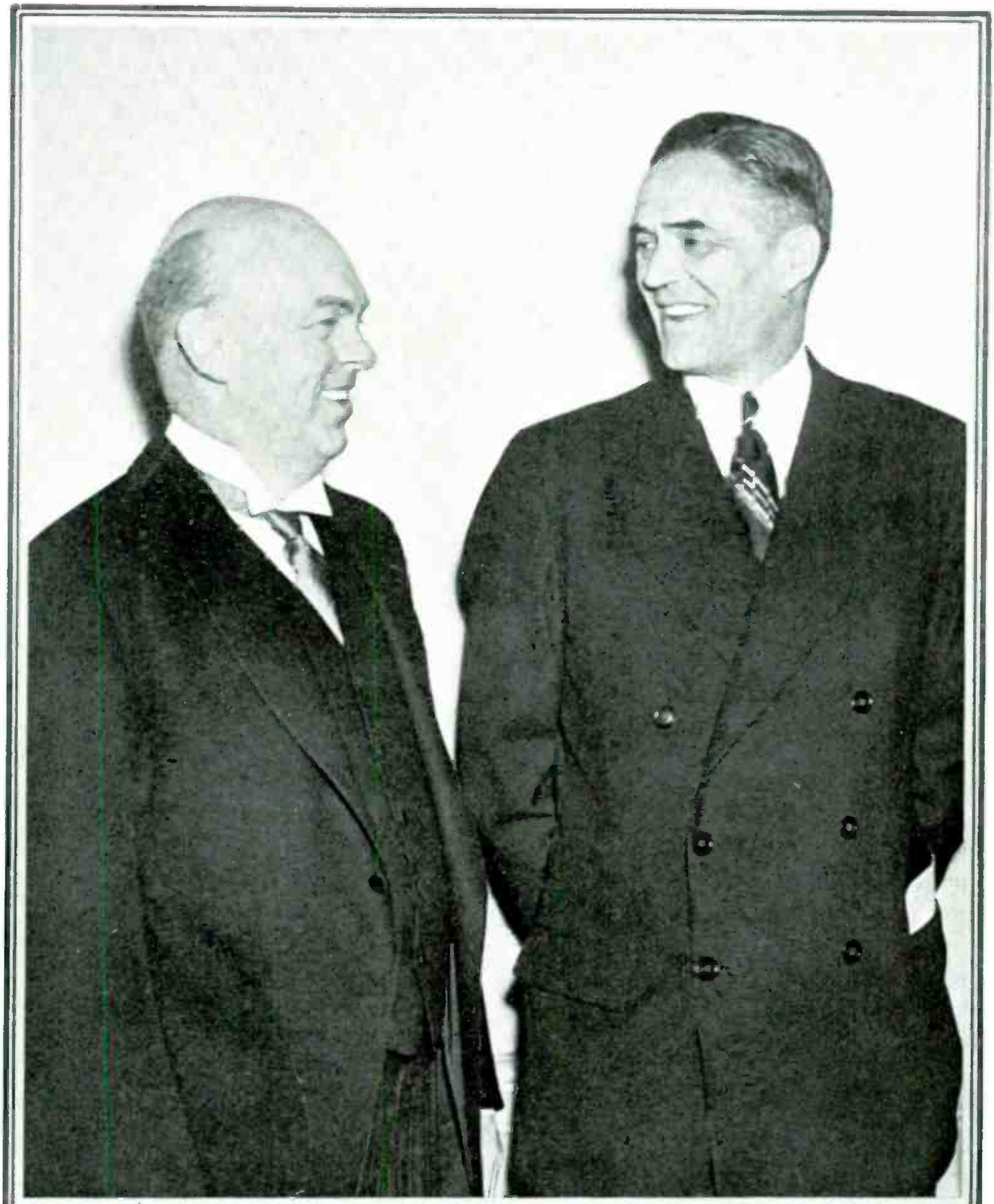
Klaus Landsberg: Of DuMont is getting ready to follow a television transmitter to Television Products, Inc., Los Angeles, where he will install the equipment and carry on as chief engineer.

Static: Current enthusiasm over FM's elimination of summer static reminds us that when Major Armstrong first demonstrated his sound recordings of AM and FM reception made during a thunder storm at Haddonfield, N. J., in 1935, engineers listened dubiously, were not impressed by lack of grinders from FM receiver.

RCA: Now has literature on 2-way emergency FM equipment ready for distribution.

WTIC: What happened to the high-power FM transmitter they were going to put on the air months ago?

Doc Caldwell: Editor of Radio Today has an FM speaker concealed in a clump of evergreens in his garden at Greenwich, Conn. Free of summer static, he says music sounds as if it comes from an orchestra hidden in the trees.



NEWS PICTURE

Franklin Institute Award: This year presented to Major Edwin H. Armstrong, left, Professor of Electrical Engineering at Columbia University. The Franklin Medal is awarded each year, from a fund established by the late Samuel Insull, "to those workers in physical science or technology, without regard to country, whose efforts have done most to advance the knowledge of physical science or its application." The award to Major Armstrong was not only in recognition of his invention of Frequency Modulation, but of his Superheterodyne circuit invention and other essential contributions to the radio art. At the right, above, is Ralph A. Bard, Assistant Secretary of the Navy, who received the Cresson Medal.

2-WAY LINK FM EQUIPMENT DATA

Circuit Analysis of 25-UFM Transmitter and 11-UF Receiver, Part 2

BY FREDERICK T. BUDELMAN *

11-UF Receiver Data ★ The 11-UF receiver is an 11 tube crystal-control, single frequency, frequency modulation, superheterodyne receiver designed particularly for the reception of frequency modulated signals of the type generated by the 25-UFM mobile transmitter.

Frequency range—30-40 mc.
Frequency deviation—±15 kc.
Audio response—±3 db. 300-3000 cycles (sharp cutoff filter attentuates frequencies above 3000).
Power supply—External—usually vibrator VPA-3A.
Power input—6v. at 6.5 amps. 39 watts.
Output impedance—500 ohms.
Control—Remote—coördinated with 25-UFM control.
Weight—17½ lbs.
Size—9 by 13 by 7½ ins. high.
Power output—1½ watts, 2⅓ watts peak.

The 11-UF receiver utilizes 11 tubes in a unique multiple superheterodyne circuit. The tube types and their uses are as follows:—

1-6SJ7—RF amplifier
1-6K8—First detector
1-6V6—Crystal oscillator-multiplier
1-6K8—Second detector, crystal oscillator
1-6SJ7—IF amplifier
1-1852—First limiter
1-1852—Second limiter
1-6H6—Discriminator
1-6H6—AVC, squelch filter
1-6C8G—First audio, squelch
1-6K6GT—Audio output

Two quartz crystals are employed to insure stable receiving conditions under all variations of temperature and humidity as well as under the severe vibration encountered in mobile service. The double IF system makes possible excellent band pass characteristics with a very favorable image ratio.

Two tuning meter jacks are located on the front of the receiver chassis. One is of the conventional AVC plate current type as commonly used on equivalent amplitude receivers, and the other is to permit adjustment of the balance of the discriminator circuit. The former requires the use of a 0 to 10 milliampere meter while the latter requires a 50 to 100 microammeter, center zero type preferred.

*Chief Engineer, F. M. Link, 125 W. 17 St., New York City.

Receiver Circuit Analysis ★ The antenna input of the 11-UF is designed to feed from a 70 ohm concentric line. A 6SJ7 serves as a high gain RF amplifier with tuned circuits in both grid and plate for maximum efficiency. AVC is applied to the grid of the RF amplifier and plate current variations may be utilized to actuate a tuning meter thus facilitating alignment of the receiver. A closed circuit jack in the cathode circuit will accommodate a 0-5 or 10 ma. meter for this purpose.

The output of the RF amplifier is converted to the first IF frequency of 5,000 kc. in the following 6K8 first detector by beating against the output of the local oscillator.

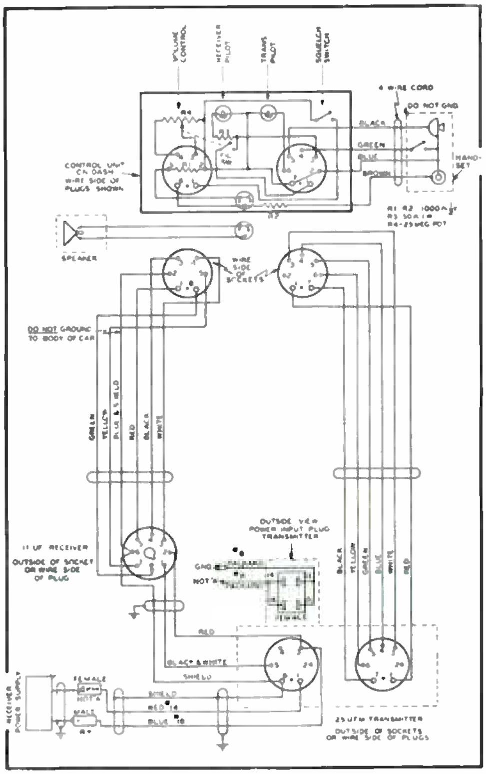
The local oscillator is a crystal controlled beam power pentode, 6V6. The tank circuit is tuned to the fourth harmonic of the crystal and a portion of the voltage appearing across it is injected into the first detector to obtain the desired frequency conversion.

The 5,000 kc. output of the first detector, after passing through the IF transformer T3, is again converted in the following 6K8 second detector to the final intermediate frequency of 456 kc. This is accomplished by using the oscillator portion of the 6K8 tube as an aperiodic oscillator with a 5,456 kc. crystal connected between plate and grid. This crystal is of the same high quality as the signal frequency crystal.

The beat between the 5,000 kc. output of the first detector and the 5,456 kc. crystal result in the final intermediate frequency of 456 kc. which is amplified, passed through the IF transformer T4 and applied to the 6SJ7 IF amplifier. Here it is further amplified and applied to the grid of the first limiter, 6AC7/1852.

The output of the 6SJ7 IF amplifier is also coupled to one of the diode sections of the 6H6 AVC tube where it is rectified. The resultant negative voltage is applied to the control grids of all the preceding tubes with the exception of the first detector for automatic volume control.

The two following stages utilize 6AC7/1852 tubes as current limiting amplifiers, and the circuits and actions of the two stages are identical. The tubes are operated at low plate and screen voltage, 75 volts, and without bias except that derived from the grid leak and condenser combinations R42C27, and R48C32. These stages act as class C amplifiers, giving no increase in output current or voltage once the impressed grid voltage has exceeded a threshold value of about 2 volts RMS. Voltages above this value cause increasing rectification in the grid circuit, automatically setting up a bias to limit the peak plate current. Due to the low plate and screen voltages the saturation occurs at a low level of grid voltage. The time constant of the grid leak and condenser is chosen to be long compared to the IF frequency, 456 kc., but short enough to follow rapidly fluctuating, high frequency noise peaks.



WIRING DIAGRAM OF THE DASHBOARD CONTROL BOX AND CABLES TO RADIO EQUIPMENT

By cascading two such stages, the limiting effect of one tube is multiplied by the limiting effect of the other and essentially perfect limiting is obtained. Furthermore, by properly proportioning the circuit constants of the first limiter, the input to the second limiter grid is maintained at the optimum voltage for most effective action.

Sufficient gain is incorporated in the receiver so that the smallest incoming signal which could be considered comparable with the noise generated in the grid circuits of the first tube, i.e. about .5 uv, causes saturation of the second limiter. The first limiter is in turn saturated by signals of 5 uv. or over. The AVC circuit maintains the input to the first limiter at an optimum level.

The output of the second limiter, free of amplitude variations, is fed through the discriminator transformer T7 to the 6H6 balanced detector. The primary and secondary of the discriminator transformer are coupled both inductively and capacitively. Two voltages of different phase are thus applied to each half of the 6H6. The discriminator is so adjusted that when a steady carrier, 456 kc., is received, the voltages applied to the two halves of the 6H6 cause equal and opposite currents to flow through the load resistors R53 and R54. Thus the resultant voltage appearing across the two resistors is zero.

If any other frequency than 456 kc. appears at the discriminator, the out of phase components at the 6H6 will be unbalanced and a positive or negative resultant voltage will appear across R53 and R54. The sign and magnitude of this voltage will follow the impressed IF frequencies rather than amplitude changes in it. In this manner an audio voltage, varying in amplitude, is derived from the frequency variations of the incoming signals. The fact that the resultant DC output voltage of the discriminator and detector should be zero when a carrier of the correct frequency is impressed, is useful to assist in tuning this transformer. A jack is connected through filter resistors R22 and R23 to the output of the 6H6 so that a sensitive microammeter (0-100 center zero type preferred) may be plugged in and the necessary adjustments made for zero reading.

The audio frequency output of the discriminator is passed through a restorer network consisting of R23 and C21 where some of the high frequency pre-emphasis introduced at the transmitter is removed. The audio frequency is then applied to the second grid, G2, of the dual triode audio amplifier 6C8G. The first triode section of the 6C8G is used to disable the second triode section when no carrier is received. Under this condition the grid G1 of the first triode is essentially at ground potential causing plate current to flow through R27 and putting the plate P1 at or near ground potential. Since cathode K2 is held at a relatively high positive potential by the voltage divider R19, R20 and R26, the audio triode section is cut off, and no audio output can be heard. When a signal is received, the negative voltage appearing across the limiter grid resistor R48 is taken off through the filter resistor R47 and applied to the squelch control potentiometer R43. A portion of this voltage is applied through resistors R44 and R51 to G1 and cuts off the squelch triode. When this happens the plate P1 and grid G2 assume the potential existing at the junction of R19, R20, R26 and R27. Thus the audio triode functions as a normal self biased amplifier with cathode resistor R26. The operating point of the squelch triode, and therefore the squelch sensitivity, may be varied by setting the squelch grid more or less negative by means of the squelch adjustment R43 to compensate for existing noise conditions. The switch in the plate of the squelch triode is primarily intended to render the receiver operative during alignment and servicing.

The squelch delay diode, in the grid circuit of the squelch triode, acts as a slow action, fast release delay on the squelch to prevent the receiver from opening on high level noise peaks that are of short duration. The delay circuit is composed of the diode, a 5 megohm resistor R51, and a .05 mfd. condenser C40. As previously stated, the grid of the squelch triode and, hence, C40 is at ground potential when no signal is received. When a noise peak is received and rectified in the detector, a negative voltage appears across the squelch potentiometer R43 and is applied through the isolating resistor R49 and R51 to C40 and squelch grid. However, C40 is at ground potential and it will take an interval of time to charge it to a sufficiently negative potential through the 5 megohm resistor R51 to cut off the squelch triode. Before C40 can accumulate sufficient charge, the noise peak is already past and the squelch has not opened. To prevent the charge in C40 from accumulating during successive noise peaks it is quickly discharged through the diode during the intervals between peaks. During these intervals, R43 is at ground potential and hence, positive with respect to the recently charged condenser C40. By placing the diode between R43 and the condenser C40, it will conduct the charge off C40 very rapidly and reset it for the following cycle when the next peak comes in.

Due to the design of the limiters, the squelch circuits and the audio amplifiers, an excellent degree of noise discrimination is obtained in the 11-UF. The squelch may be set so that a signal of less than one microvolt will completely open the receiver while noise peaks of very high intensity will not be received.

The 6C8G audio amplifier is followed by a 6K6GT output pentode with the volume control in the grid of the output tube and located at the remote control point.

A sharp cut off filter precedes the output of the receiver to attenuate frequencies above 3,000 cycles. This results in crisp and penetrating speech that makes for good intelligibility under the adverse noise conditions encountered in mobile applications.

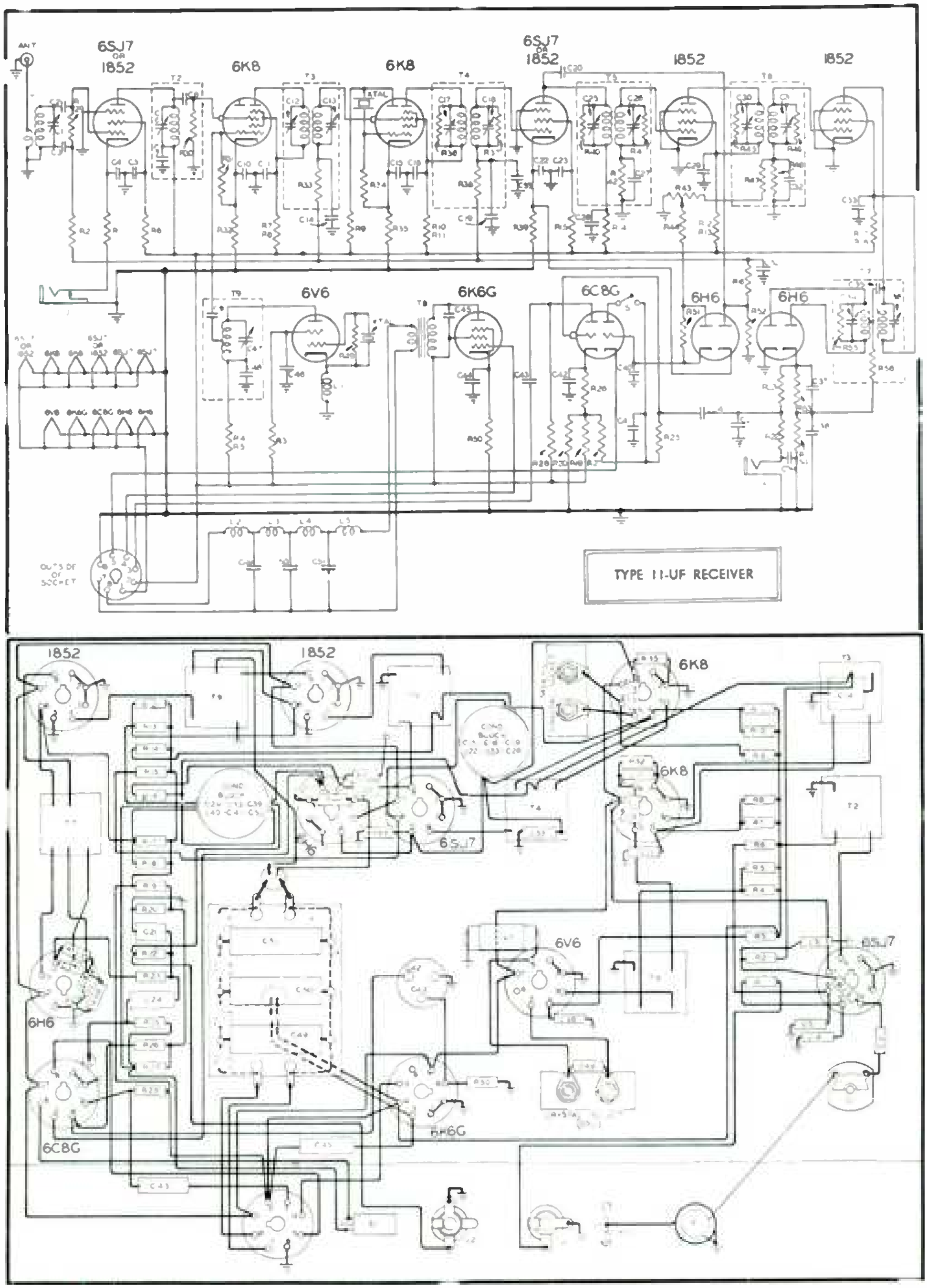
Maintenance of 11-UF Receiver ★ The receivers are carefully tuned at the factory to the specified operating frequency and need not be retuned upon installation. However, routine maintenance checks should include realignment of the antenna transformer, the RF transformer T2, the 5,000 kc. transformer T3, the oscillator transformer T9 and the discriminator transformer secondary T7. The correct settings of these transformers have been marked with red and these markings should be used as a guide in making any adjustments.

The equipment needed for tuning these stages is a 0–5 or 0–10 ma. tuning meter, a 0-50 or 0-100 microammeter, preferably of the center zero type, a 250-volt meter, and a source of signal on the carrier frequency that can be attenuated to a low value.

The oscillator tuning can be checked by measuring the voltage between the tuning condenser shaft on T9, and ground. Tuning should be adjusted accurately for maximum voltage. With some frequency crystals, more than one voltage peak may be observed and the factory marking of the correct setting should be used as a guide to arrive at the proper point.

With the tuning meter plugged into the jack so marked, a signal just strong enough to give a noticeable deflection on the meter is applied to the receiver input. It should be noted that for these adjustments the signal source *must* be accurately adjusted to the proper frequency. Signal generator calibration charts are not accurate enough for this purpose. The input signal should either be obtained by direct pickup from a crystal controlled transmitter or from a signal generator which has been adjusted to zero beat against a crystal controlled transmitter on the correct frequency. The 5,000 kc. transformer T3 and the RF transformer T2 are adjusted for minimum current on the meter. In adjusting the secondary of the 5,000 kc. transformer, it is possible to tune it to the 5,456 kc. crystal rather than the incoming signal. This condition will result in the decrease of the tuning meter reading almost to zero and thus it can easily be recognized and avoided. Here too, the factory marking should serve as a guide. With the antenna connected to the receiver, the antenna adjustment is next tuned to a weak radiated signal for minimum meter reading. It should be stressed that tuning of the RF stages should be made to as weak a signal as possible, since strong signals cause large AVC voltages to appear at the tubes and result in slight mistuning.

The discriminator transformer secondary is next adjusted by inserting the microammeter into the jack marked "BALANCE." While a strong signal is being received, adjust the secondary of the transformer for zero reading of the meter. Since the polarity of the voltages appearing at the balance jack will change with tuning, if a zero center microammeter is not



SCHEMATIC AND PICTURE DIAGRAM OF THE LINK 11-UF RECEIVER USED FOR 2-WAY EMERGENCY COMMUNICATION. THIS RECEIVER OPERATES WITH THE 25-UFM TRANSMITTER

available a polarity-reversing switch on the microammeter will facilitate the making of this adjustment. A thoroughly insulated screw-driver must be used when making this ad-

VOLTAGE CHART — TYPE 11-UF RECEIVER

Pin No.	R.F. 6SJ7	Conv. 6K8	Conv. 6K8	I.F. 6SJ7	Lim. 1852	Lim. 1852	Disc. 6H6	A.F. 6C8G	A.F. 6K6	A.V.C. 6H6	Osc. 6V6
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	±6.3V	0	0	0	0
3	0	95	100	0	0	0	−50	160	235	−2*	50–125
4	0	95	100	0	0	0	−3*	75	250	−0.5*	125
5	4.1*	0	−2.8*	4*	0	0	−20	0	0	0	0
6	135	0	45	140	57	70	−37	0	0	−0.3*	0
7	±6.3V	±6.3V	±6.3V	±6.3V	±6.3V	±6.3V	0	±6.3V	±6.3V	±6.3V	±6.3V
8	250	2.2*	2.6*	230	57	70	0	0	25	3.9*	0

Power supply voltage — 250 volts.

Meter resistance: 25,000 ohms-per-volt. All readings taken on 250-volt scale except those marked *, which were taken on 10-volt scale. No signal input, squelch OFF.

For no signal input, squelch switch ON, readings on 6C8G pin 3 — 240 V.; on pin 4, 65 V.; and on pin 6, 13 volts.

justment since even a small amount of metal in contact with the tuning condenser shaft will cause the tuning to change. The primary of the discriminator transformer T7 is sealed at the factory and need never be adjusted. It will be found that this circuit is so "band-spread" and over-coupled, that there is no possible change in tuning of the primary that cannot be compensated for by readjusting the secondary. When any of the tubes associated with the foregoing circuits are changed, the circuits should be retuned. The small variations encountered in tunes may cause a marked detuning at ultra high frequencies.

Sensitivity Check ★ If a signal generator whose output is calibrated in microvolts, or one whose output can be attenuated to a low level, is available, the sensitivity of the receiver can be checked. When the receivers are shipped from the factory, their sensitivity is such that a signal of one microvolt or less, when applied to the antenna connector, will cause the squelch to open when the squelch switch is in the ON position and the squelch control set to its most sensitive position, i.e. completely counter clockwise. If a signal generator whose output can be attenuated but which is not directly calibrated is available, it can be checked against a new receiver. The attenuator setting at which the squelch circuit just opens can be noted and other receivers can be checked for sensitivity against this criterion.

11-UF Service and Tests ★ Alignment of the RF and oscillator stages may be made whenever it is thought that the sensitivity of the receiver has fallen off due to detuning, but nothing is to be gained by retuning the IF transformers since their adjustment is so broad that once they are set at the factory, the adjustment will hold. However, should the frequency of the receiver be changed, or any of the IF transformers replaced, readjustment can be made in accordance with the following instructions:

In setting up the receiver for operation on a frequency in the 30 to 40-megacycle band other than that for which it was tuned at the factory, or if a complete realignment of the receiver is desired, a crystal of the right frequency for the new operating frequency is inserted in the crystal socket beside the 6V6 oscillator tube. The oscillator frequency is one-half the difference between the signal and the 5,000 kc. IF frequency, and the crystal is ground to one-quarter the oscillator frequency. The oscillator is adjusted by reading the voltage between the condenser shaft on T9 and ground while tuning the condenser for maximum voltage. Since sometimes more than one voltage peak may be observed, the calibration stamp on the transformer should be used as a guide to the approximate setting. The stamp reads from 1 to 10, and the red line on the tuning condenser shaft should be set opposite the number corresponding to the last digit of the new frequency, i.e. for 38 mc., set at 8.

After the oscillator has been tuned, the RF transformer T3 may be adjusted. While feeding a strong signal on the new signal frequency into the antenna, insert a tuning meter into the tuning meter jack and tune T3 for minimum current. This transformer is marked in the same manner as the oscillator and the approximate setting can be arrived at in the same manner. The antenna transformer may next be adjusted for minimum current in the tuning meter. Once the approximate setting of the tuning controls is determined in this manner, the signal input is decreased until only a slight indication is obtained on the tuning meter and the adjustments on T1, T2, T3, T4 and the primary of T5 set carefully for minimum current in the tuning meter. The secondary of T5 is after the AVC circuit and hence is adjusted for maximum current reading. The last IF transformer T6 is past the AVC circuit and the tuning meter will give no indication of proper tuning; rather a signal just strong enough to open the squelch is received and adjustment made for maximum squelch opening or maximum audio. The input signal should be decreased if necessary during this adjustment in order to keep the squelch just on the edge of opening so that a sharp indication may be had. It will be noticed when making these adjustments that the tuning is very broad and only a slight difference in the operation of the receiver results from any changes in adjustment. The discriminator transformer is next adjusted by inserting a center-zero microammeter in the jack marked "BALANCE" and adjusting the secondary of T7 for zero reading in the meter while receiving a strong signal. Since plate voltage is brought out to the tuning condenser shafts, the primaries can be differentiated from the secondaries by checking for plate voltage to identify the primary or plate adjustments. After the discriminator transformer has been balanced, the signal should be removed from the receiver and the balance meter reading noted. If this reading is not zero, the primaries of T6, T5 and T4 are readjusted until the reading is zero. This adjustment must be made with no signal input and the antenna cable entirely disconnected in order to accurately center the pass band characteristics of the IF stages. The receiver is now in tune and only the antenna tuning need be adjusted upon installation.

Receiver Failures ★ The receiver normally emits a loud hiss when no carrier is being received and the tracing of this hiss through the receiver presents a simple method of localizing failures that might occur. If the RF and two mixer tubes are removed from their sockets, most of the loud hiss should disappear. The remaining hiss is due to the noise generated in the grid circuit of the IF amplifier. When the second converter 6K8 is plugged in, the hiss should rise nearly to maximum level. When the first 6K8 converter is added, the hiss will increase slightly, apparently indicating that most of the noise comes from the second 6K8. This is actually not true, since the noise generated in the grid of the first 6K8 merely overrides and masks the noise previously heard. When the RF stage is added, a similar effect takes place but no increase in hiss level is normally heard since the second limiter is already saturated with noise. It is suggested that the service engineer familiarize himself with the sound of a normal receiver by removing the first converter, then the second and then the first IF amplifier. Then, if a failure should occur in the receiver, he will be able to localize it by the absence of the hiss. A voltmeter check can be rapidly made of the suspected stage since the plate voltages of the amplifier stages appear on top of the transformers at the tuning condenser shafts.

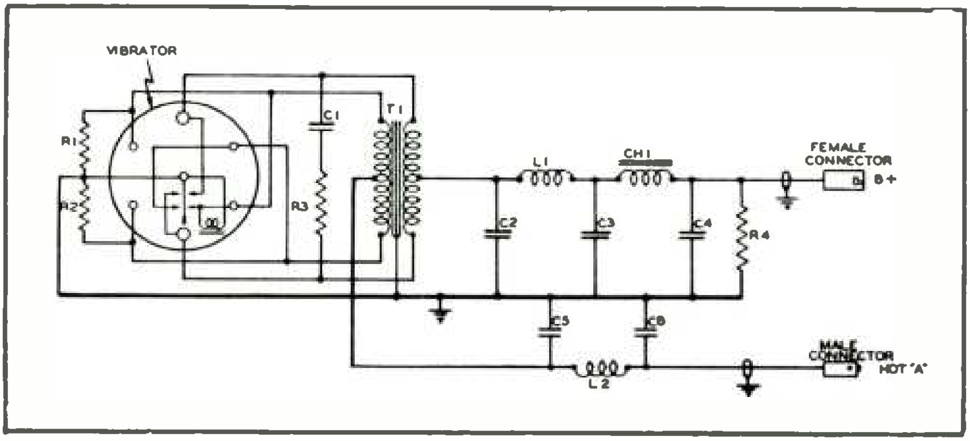
A weak oscillator tube will result in insufficient injection to the first converter and this in turn cause a tendency to regeneration or even oscillation in the converter. Detuning of the oscillator will cause the same condition and therefore the oscillator tuning should be checked in routine maintenance inspection. The condition of the oscillator can be readily checked by noting the plate voltage rise measured at the oscillator tuning condenser shaft on T9. The oscillator plate voltage is dependent on the frequency of the crystal used. The lower the crystal frequency the lower the voltage.

The tuning meter reads the plate current of the 6SJ7 RF amplifier and thus check on the condition of this stage can easily be made. Furthermore, the operation of the entire receiver up to the plate circuit of the first IF amplifier can be checked by noting the tuning meter reading with a signal applied to the input. Since the AVC voltage is taken off the plate of the first IF amplifier, decrease of the tuning meter reading with increase in signal input indicates that the receiver is operative up to that point. Sensitivity of the receiver to that point can be measured if a calibrated source of signal is available. It should require not more than 10 to 15 microvolts input to the antenna to cause a noticeable deflection in the tuning meter.

The 6K8 converter tubes may vary considerably in efficiency as converters at ultra high frequencies. Therefore a check on the sensitivity of the receiver should be made whenever one of them is changed. Tube testers offer no sure method of testing tubes for operation at high frequencies and a much more rapid and satisfactory method of determining tube deterioration is by substituting a tube known to be good in place of the suspected tube and noting the difference in receiver operation.

Squelch operation is obtained by utilizing the negative voltage caused by the rectified signal in the last limiter grid circuit and thus another check is provided. With the squelch control set to its most sensitive position, a signal of at most 1 microvolt should fully open the squelch and cause the receiver to operate. Weakening of the squelch tube generally manifests itself in failure of the squelch circuit to close and therefore a need to increase the setting of the squelch control in a clockwise direction. Here, too, the best criterion for judging the efficiency of the tube is to substitute a tube known to be good in place of the one suspected.

Other failures that may arise would be of the well-known resistor or condenser failure type that should be easily localized, since they manifest the same symptoms in an FM re-



SCHEMATIC OF THE VOLTAGE SUPPLY UNIT FOR THE 11-UF RECEIVER

ceiver as in an AM set. Reference to the voltage chart, circuit diagram and parts list should simplify the solution of this type of failure.

Receiver Power Supply Data ★ The VPA-3A power supply is a synchronous vibrator B supply designed for use with the 11-UF receiver in mobile applications. It incorporates the most efficient and long-lived vibrator and circuit available, and affords a very reliable and economical method of obtaining B voltages. Its characteristics are:

Input—6.0 v. at 3.5 amp.
Output—250 v. at 60 ma.
Type of vibrator—Synchronous Type 525
Mounting—Base, with removable cover for servicing
Size—8½ by 4¼ by 5 ins. high
Weight—7¼ lbs.

Receiver Power Supply ★ The primary input to the power supply goes through the filter network C6, L2, C5 to prevent noise voltages from the vibrator getting back into the primary leads. The condensers C6 and C5 are of special low impedance construction, while the method of winding L2 was developed for maximum filter action. The primary voltage is applied to the center tap of the primary winding of the power transformer T1. The outer ends of the primary winding are alternately grounded by the vibrator contacts, causing current to flow through the primary first in one direction and then in the other. The alternating currents thus generated set up magnetic fields in the core which in turn induce voltage in the high voltage secondary winding. Buffer resistors R1 and R2 on the primary, and buffer condenser-resistor C1, R3 on the secondary tend to tune the transformer windings and reduce arcing at the vibrator contacts. The alternating voltage at the transformer secondary is mechanically rectified by a second set of contacts on the vibrator, thus eliminating the need for a separate rectifier tube.

Since the vibrator alternately grounds the opposite ends of the secondary winding in synchronization with the AC voltage generated therein, the DC output voltage appears at the secondary center tap. Both ripple and "hash" voltages are present as AC components of the output voltage. C2 and L1 act as hash filters, while C3, CH1, and C4 reduce the ripple voltage to a very low value. R4 acts as a bleeder to discharge the filter condensers and prevent accidental shock to personnel from accumulated charges. Input and output connections are made by means of polarized bayonet connectors.

Servicing the Power Supply ★ The vibrator power supply has a minimum of parts, only one of which, the vibrator, is subject to wear and deterioration. Consequently, normal maintenance consists only in checking the condition of the vibrator element. Due to recent improvements in vibrator and vibrator circuit design, these power supplies provide B voltage in a very reliable manner. Vibrator failure is almost always preceded by a considerable period of decreasing output voltage. Periodic checks of the output voltage of the power supply will usually indicate deterioration well in advance of failure. The 11-U.F. receiver will operate normally on voltages well below 200, giving ample factor of safety.

With the exception of vibrator replacement, few possibilities of failure are present. An open electrolytic filter condenser causes hum in the receiver output, while a leaky or shorted unit

(CONCLUDED ON PAGE 45)

FM ADVANCES ON ALL FRONTS

Set Manufacturers Swing to A-FM Models as FM Broadcasting Spreads and Summer Static Accelerates Public Demand

BY M. B. SLEEPER

WITH the rapid action characteristic of the radio business, public demand for sets which provide FM tuning in addition to AM broadcast and short-wave reception is putting the mark of obsolescence on straight AM models. The month of June, ushering in summer static, has proved to be the turning point of the shift which is ending the era of AM sets as definitely and suddenly as, a few years back, all-wave receivers pushed one-band sets into the discard.

Stand-Outs Give in ★ The last argument of the stand-outs, that there are many sections where there is no FM broadcasting, has now fallen. Even in those areas, people who are ready to buy new sets now want FM tuning because they are confident that they will have the new programs before long, and undoubtedly they will.

At the time when all-wave sets were brought out, there were even fewer places where short-wave stations could be heard. But that made no difference. Dealers had to meet the demand for all-wave tuning or lose their customers to those who did. What the public wants, it gets — if not at one place, then at another. This situation prevails again today, with regard to A-FM receivers.

Even the argument advanced by the stand-patters that there won't be any more FM stations because manufacturers of transmitting equipment are tied up with Government orders does not carry conviction any more. Listeners know that if there is any delay, it will be only temporary, and that there will be plenty of FM stations on the air long before good sets bought now will be obsolete.

FM Springs Surprises ★ In times past, when technical improvements have been introduced, the first demand has appeared in the cities, trickling off into the rural districts. This time, the reverse is true, and for a very good reason:

AM stations, located principally in the population centers, give limited primary service beyond the metropolitan audiences. Rural listeners have had to make the best of what they could hear through heavy background noise, natural static, noise from leaky power lines, and squeals from inter-station interference. Furthermore, daytime fading of AM signals practically restricted the use of radio sets to evening hours.

FM has changed the rural picture entirely, delivering clear, clean signals with as much power during daylight hours as after dark! The resulting sales have surprised the distributors and delighted the dealers. To quote two examples from many at hand: A dealer in Waterville, Maine, has sold forty high-priced A-FM sets in two months where probably not one AM receiver of the same price has been sold in the last two years. One jobber's salesman has opened fifty-three accounts on A-FM sets in less than eight weeks among dealers who had long ago quit trying to sell models above $24.95.

Furthermore, the expensive models with 3-gang tuning condensers are out-selling the lower-priced 2-gang types. That is because tuned RF amplification is absolutely necessary to give sufficient sensitivity under unfavorable conditions, and to provide adequate limiter action to overcome static.

At the same time, a tremendous market is developing in the cities for A-FM sets. In Detroit, for example, where dealers had stocked up in anticipation of W45D's debut, every A-FM receiver and FM tuner was cleaned out in less than a week after the station went on the air.

Now, we have just been informed that at a dealer showing held recently in Pittsburgh, the local distributor booked orders for his entire quota of A-FM sets, even though FM broadcasting has not yet started in that area.

First A-FM Showings ★ The first new A-FM lines to be shown in June were those of Stromberg-Carlson and Philco. In every city where these sets were displayed to the dealers, orders for A-FM models far exceeded those on straight AM sets. In some cases, the ratio was eight to one.

Red Herring ★ Stories have been going around that radio set production will be cut so greatly because of National Defense contracts that manufacturers will abandon plans to produce A-FM receivers. Perhaps those who are overstocked with straight AM models wish that might be the case, but it isn't.

It is the production of cheap AM sets that is

PAUL DE MARS TELLS STROMBERG DEALERS OF SERVICE PROVIDED BY W43B AND W39B, AND PROVES HIS STATEMENTS BY DEMONSTRATION OF FM RECEPTION

being abandoned, for the reason that a $14.95 set takes about as much priority material as a $195 A-FM console. Since there is no logical reason for asking the public, all of a sudden, to buy expensive AM sets when they have been told for the last few years that the cheap ones afford all the improvements, the advent of FM is a life-saver to manufacturers and dealers alike.

That is not because the FM end of a receiver is expensive. It is because the manufacturers have seen fit to sell the public the fallacy that the performance of cheap AM sets represented the best that radio engineering skill could provide. And that is completely false, as every engineer and dealer and serviceman knows. Sensitive, selective tuning circuits and high quality amplifiers and speakers always were and still are expensive, whether for AM or FM reception.

Chickens Come Home to Roost ★ The cluck radios hatched by the million in recent years are coming back to confuse their manufacturers in the form of the OPM's low rating of radio sets on the priority scale. Checking the production of radio sets, the OPM finds that so many sets have been sold already that there should be plenty in American homes to assure adequate dissemination of emergency warnings and instructions.

What the figures did not disclose to the OPM is the fact that most of them are $9.95 to $14.95 junk that is hardly good for more than a year's use, and that servicemen do not want to repair them when they break down because the owners won't pay enough to make such work profitable.

Now that manufacturers are being forced to discontinue these types, so that their predecessors cannot be replaced, unless materials for radio sets are given a better rating very soon, before next winter there will not be enough radio receivers in operating condition to provide complete national coverage by radio broadcasting.

During the coming season, dollar volume will probably increase somewhat over last year, because manufacturers have already planned to shift their production to the higher-bracket A-FM models, but the numerical production will unquestionably drop far below last year's figure.

Low-Priced A-FM Sets ★ So complete will be the swing to A-FM by the end of the summer, as a result of listeners' experience with FM's elimination of static interference, that some manufacturers are preparing to offer A-FM sets priced under $50. While these models will not give the tone quality which distinguishes FM from AM on original studio programs not carried by wires, and on the new high fidelity recordings, they will bring in FM programs, and will provide some degree of static reduction if operated in the immediate vicinity of the transmitters.

Dealers must be careful, however, that they do not sell such sets to people who will expect the impossible. In the public mind, FM means super-quality tone and static-free reception.

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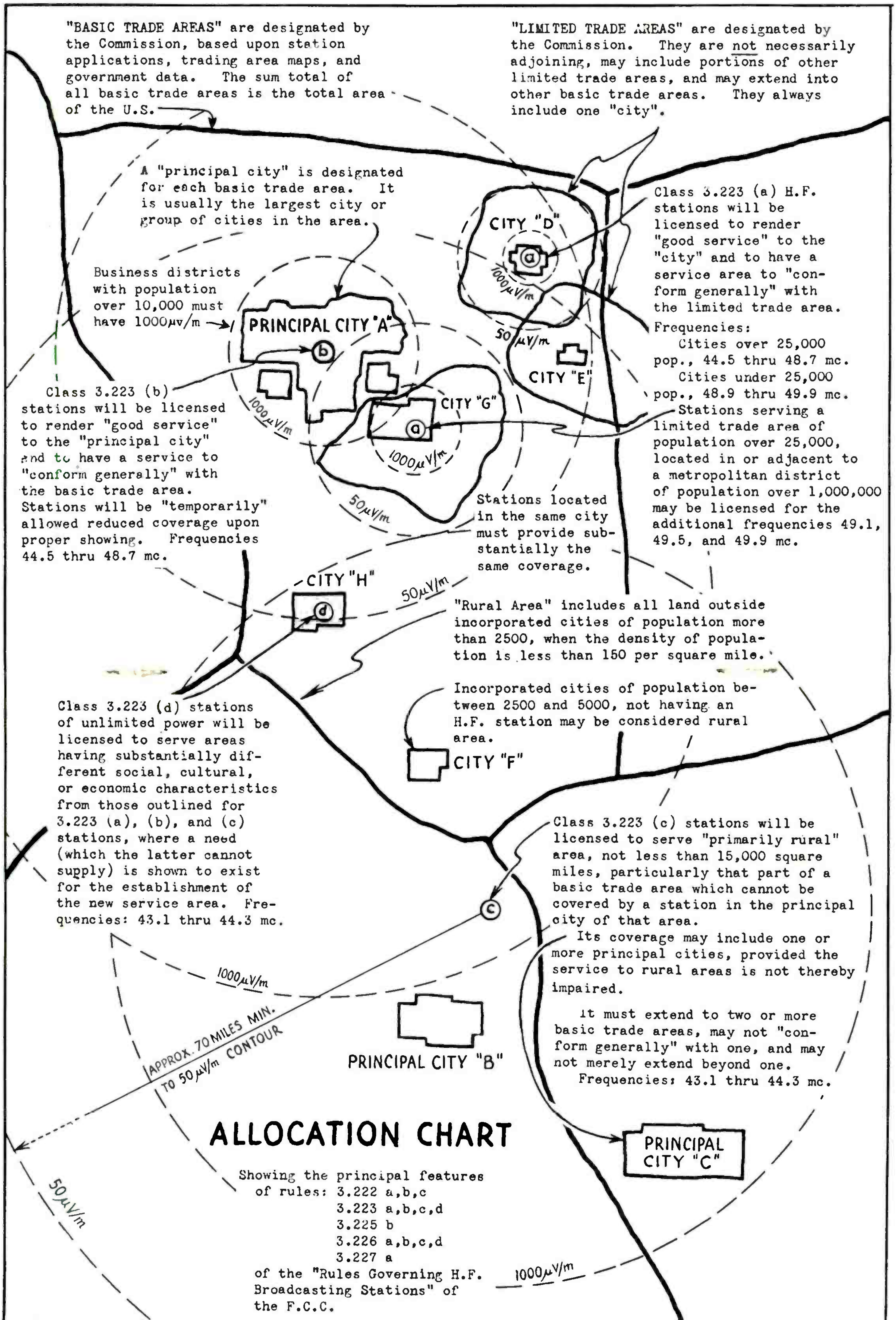


FIG. 1. ALLOCATION CHART SHOWING ESSENTIALS OF COVERAGE AREAS SPECIFIED BY THE FCC FOR VARIOUS CLASSIFICATIONS OF FM BROADCASTING STATIONS

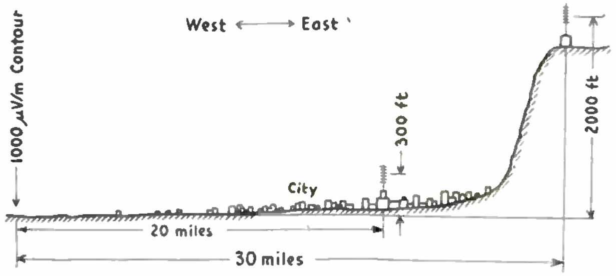


FIG. 4. THE COST OF HIGHER POWER FOR LOW ANTENNA HEIGHT MUST BE COMPARED WITH THE COST OF LOWER POWER AND A MORE ADVANTAGEOUS ANTENNA LOCATION

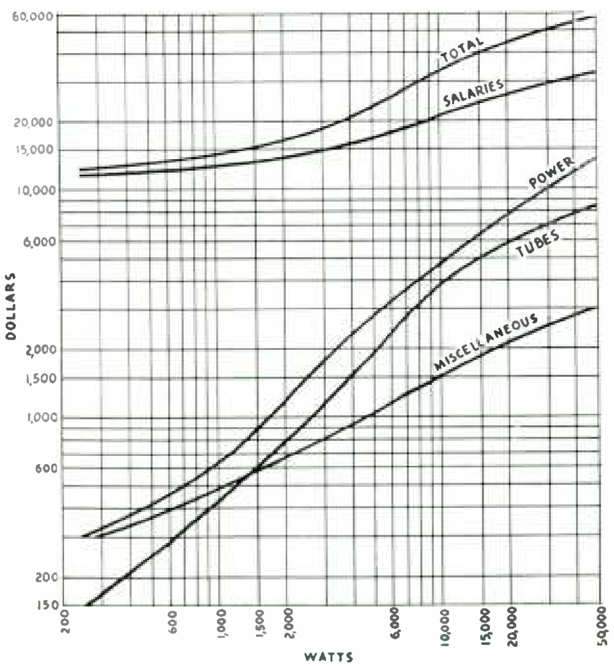
Here is a hypothetical city whose center is located 20 miles from the required western one millivolt contour. Ten miles to the east of the city is a 2,000-ft. hill, rising rather sharply. Reference to the FCC chart 41722 in the Standards of Good Engineering Practice for High Frequency Stations shows that approximately 10 kw. are required in the city with the antenna at 300 ft. elevation (on a tall building) where only about 1.5 kw. will do the job on the hilltop.

Using antennas of the various gains shown in the table, the actual power into the antenna and the yearly operating costs of such stations are listed. The six-bay directional turnstile (unsymmetrical pattern, having negligible radiation cast) is not yet commercially available but power gains of 8 should be possible.

The estimate of initial and operating costs for the various antenna combinations on page 27 is based primarily upon Mr. Guy's curves, with specific deviations to fit the particular case involved. It is included to show the source of the yearly operating costs.

The figures in the last column of the "Power in Kilowatts" table have been purposely chosen to illustrate a paradox confronting many engineers. The computations indicate that a power of 11 kw. will need to be delivered to the transmission line. According to the ruling of the Commission agreed upon by the manufacturers, a 50-kw. transmitter (until 25-kw. sets are available) will be required even if a 10-kw. set is obtainable which is capable of easily delivering 11 kw. This may involve an initial excess investment of about $30,000, in some cases prohibiting a prospective broadcaster from attempting to serve his trade area. When 25-kw. sets are available, it is to be hoped that their prices will be considerably lower than those for 50-kw. sets. Otherwise there will be a very expensive range of powers just above 10-kw.

FIG. 3. ESTIMATED AVERAGE YEARLY COST OF OPERATING 18 HOURS PER DAY



Antennas ★ The type of antenna employed depends in general upon the shape of the trading area, the relative position of the antenna site within that area, the elevation of the available site with respect to the general elevation of the area to be covered, and the transmitter power contemplated. For many installations the simple quarter wave Brown-Epstein (also called Star and whirling Joe) antenna, shown in Fig. 5, consisting of a vertical half-dipole with a 4-rod ground plane, having a field gain of 92%, will suffice when the antenna is located within a small trading area at a fairly high elevation. Currently available designs of these antennas are capable of handling transmitter power outputs between 250 w. and 3 kw. If the terrain and trading area are such as to require a certain amount of directivity, these antennas can be provided with the reflector shown, to produce a field gain of 36% in the forward direction and a reduction of 50% on the back side. The field pattern of such a radiator, approximately cardioid, can be used to advantage when the antenna site is toward one side of the trading area, or where protection is desired for a neighboring trading area. These antennas can be

FM ENGINEERING CONSIDERATIONS

Part 1. FCC Coverage Requirements; Economics of Antenna Design

BY E. S. WINLUND *

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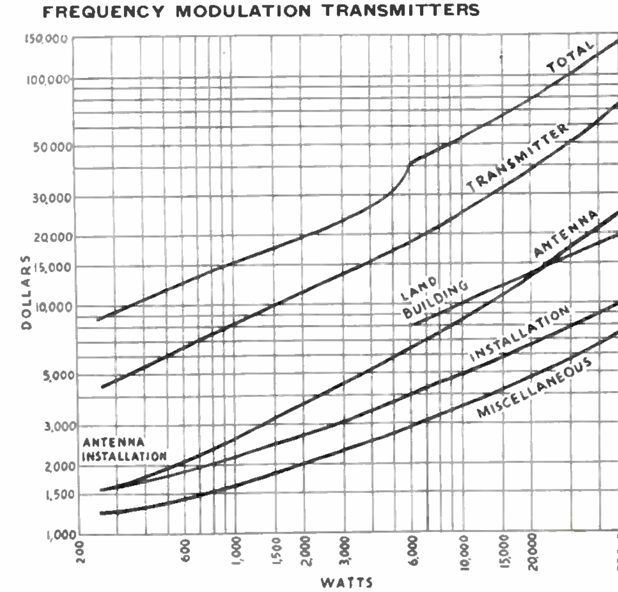
FIG. 2. ESTIMATED CAPITAL INVESTMENT FOR FREQUENCY MODULATION TRANSMITTERS



* Engineer, Transmitter Sales Department, RCA Mfg. Co., Inc., Camden, N. J.

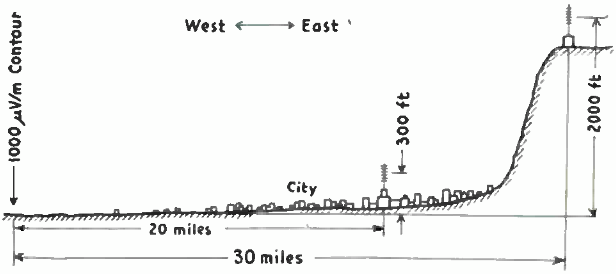


FIG. 4. THE COST OF HIGHER POWER FOR LOW ANTENNA HEIGHT MUST BE COMPARED WITH THE COST OF LOWER POWER AND A MORE ADVANTAGEOUS ANTENNA LOCATION

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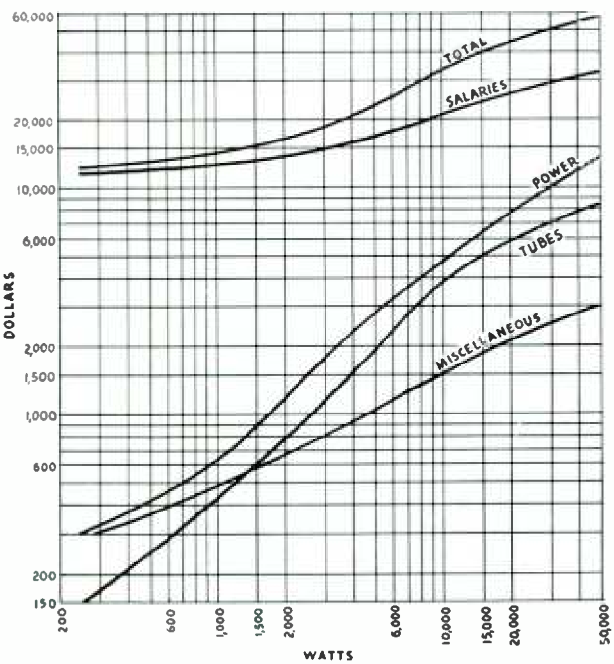

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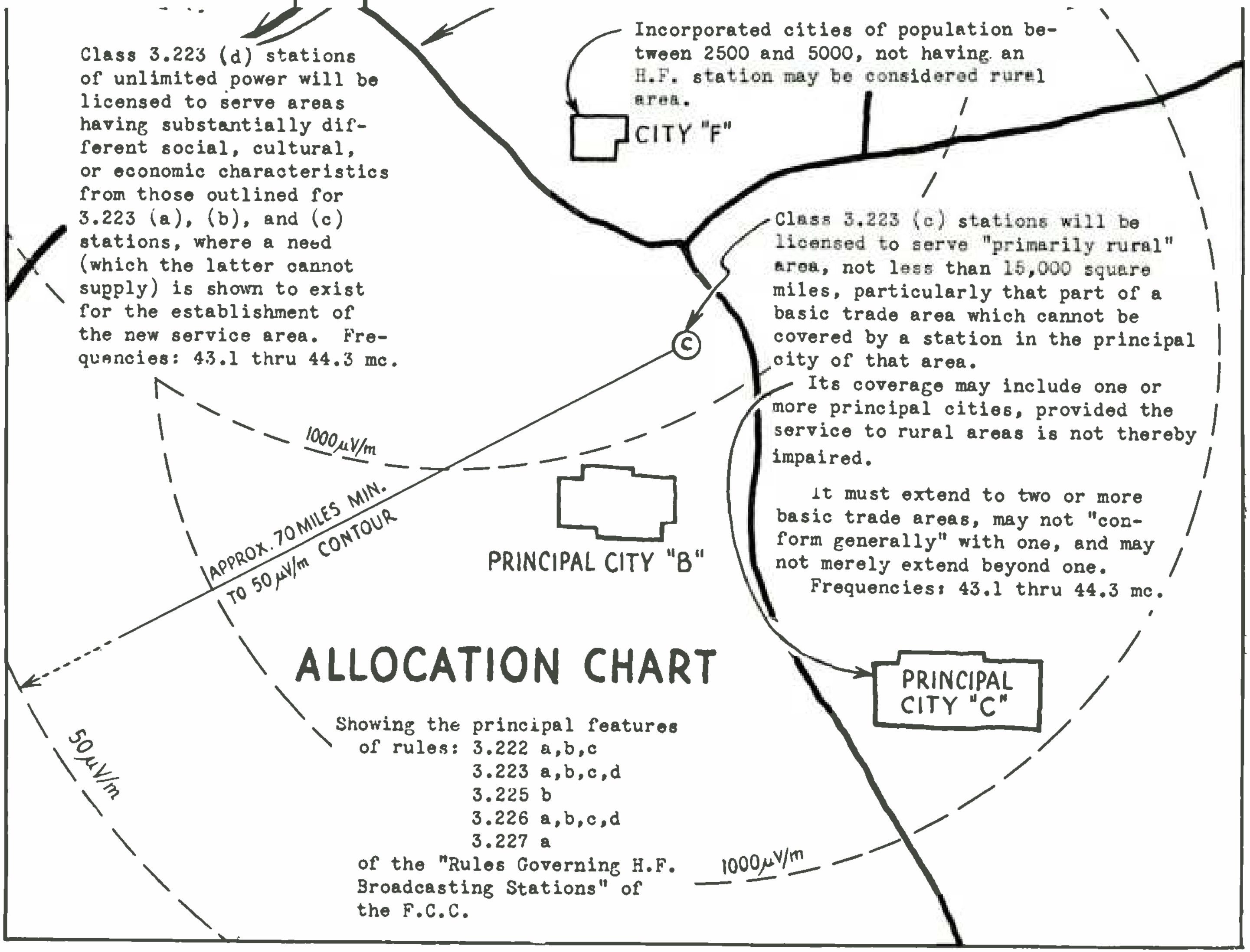
BY THE FCC FOR VARIOUS CLASSIFICATIONS OF FM BROADCASTING STATIONS



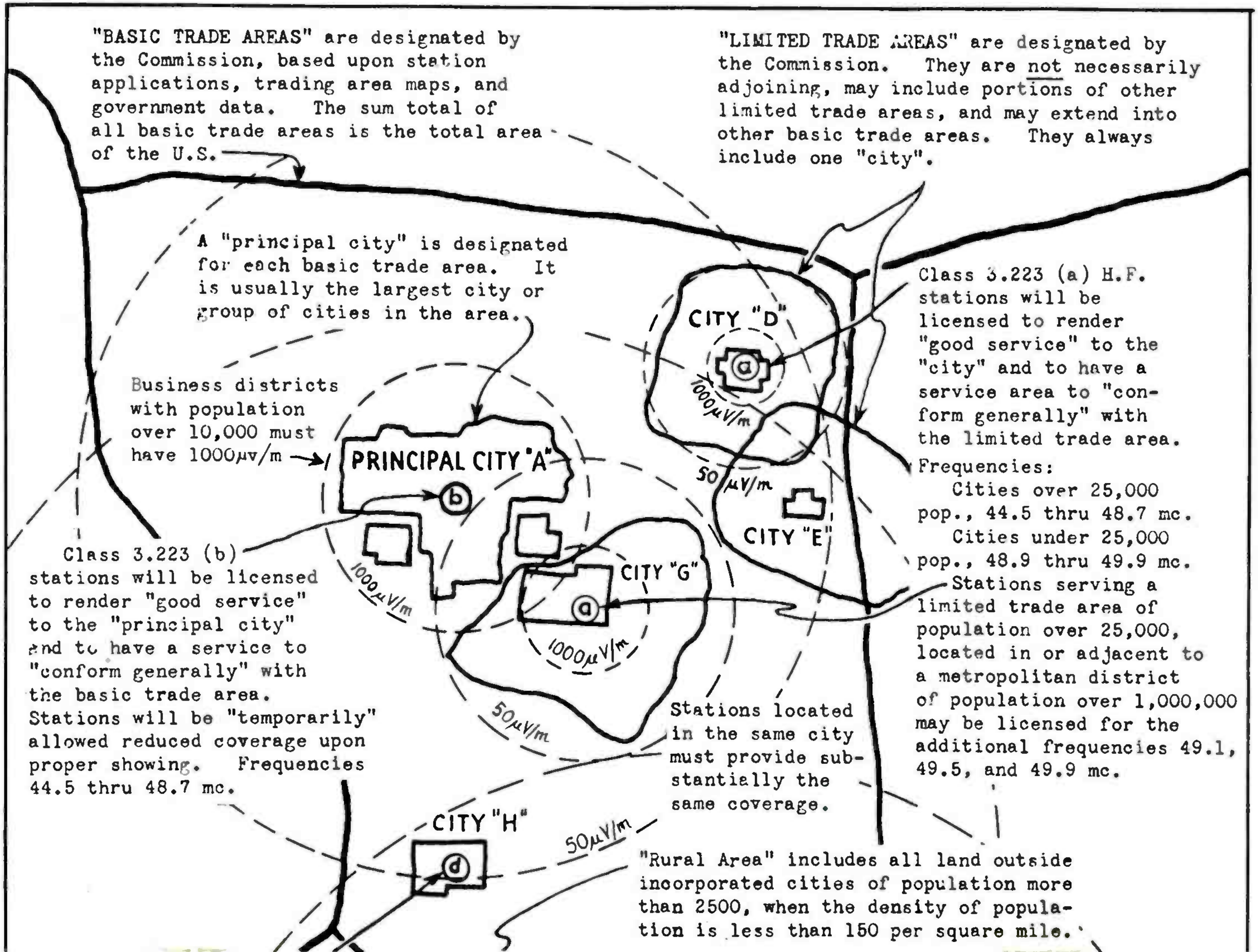


FIG. 1. ALLOCATION CHART SHOWING ESSENTIALS OF COVERAGE AREAS SPECIFIED

FM ENGINEERING CONSIDERATIONS

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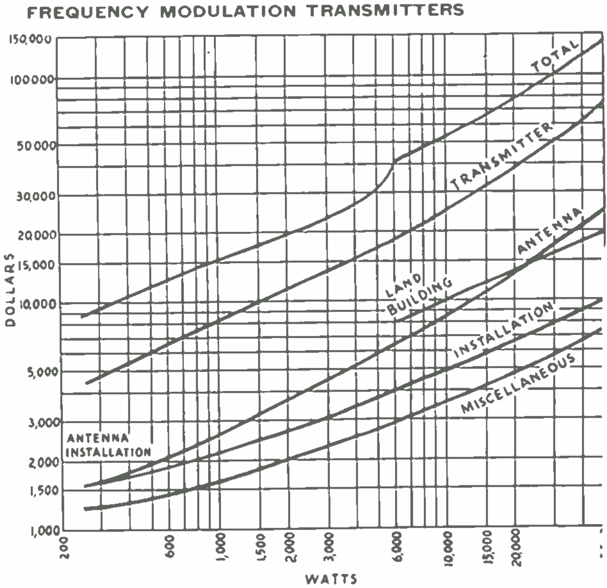

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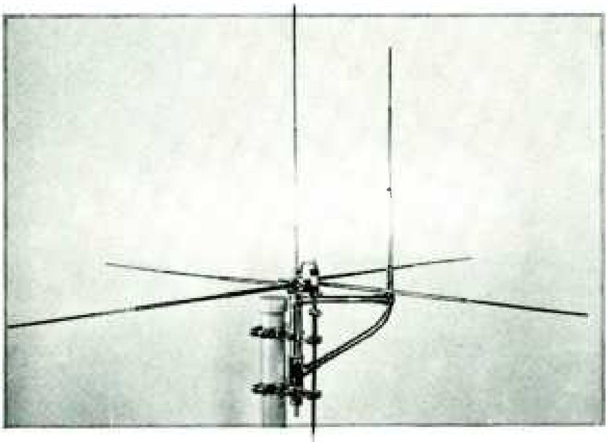


FIG. 5. SIMPLE QUARTER-WAVE STAR ANTENNA COMBINES A VERTICAL HALF-DIPOLE AND 4-ROD GROUND PLANE. THIS TYPE IS SUITABLE AT FAIRLY HIGH ELEVATION FOR A RELATIVELY LIMITED SERVICE AREA. IT CAN HANDLE AN OUTPUT OF 250 W. TO 3 KW.

purchased prefabricated for a given frequency, with complete assurance that full efficiency and matching will be provided when any 70-ohm co-axial transmission line is used between the transmitter and antenna. There are no adjustments to make in the field, and the transmitter can be made to work into 70 ohms resistance. It is virtually impossible to produce standing waves on the line as a result of variation of antenna impedance. Such an antenna is very light in weight, and therefore especially suited for installation at the top of an existing broadcast transmitter tower.

Of perhaps greater interest to designers of FM stations is the multiple layer turnstile antenna, Fig. 6, developed by Dr. G. H. Brown of the RCA Manufacturing Company. This type can be obtained from several suppliers. This antenna, like its little brother previously described, is entirely prefabricated for a given frequency. No adjustments are required in the field other than connecting the co-axial line between the bottom of the turnstile tower and the transmitter output. It is designed to have a sufficiently broad impedance to minimize phase distortion and amplitude modulation

POWER IN KILOWATTS

Antenna	.190	.362	1.25	1.5	2.4	2.8	5.4	10.0
Transmitter for 10% Line Loss	.210	.400	1.37	1.65	2.64	3.08	5.94	11.0
Nominal Trans.	.250	1.0	3.0	3.0	3.0	3.0	10.0	10.0
Location	Hill	Hill	Town	Hill	Town	Hill	Town	Town

CAPITAL INVESTMENT

Transmitter	$ 4,500	$ 9,200	$12,300	$12,300	$12,300	$12,300	$21,750	$21,750
Land, Building	5,000	5,000	0	7,000	0	7,000	0	0
Antenna	5,500	4,500	5,500	75	4,500	90	200	150
Installation	1,600	2,200	3,000	3,000	3,000	3,000	5,000	5,000
Miscellaneous	1,300	1,600	2,300	2,300	2,300	2,300	3,600	3,600
TOTALS	$17,900	$22,500	$23,100	$24,675	$22,100	$24,690	$30,550	$30,500

YEARLY OPERATING COST

Salaries	$12,000	$12,000	$13,000	$13,000	$14,000	$14,000	$17,000	$21,000
Power	300	370	800	1,000	1,500	1,600	3,200	4,000
Tubes	150	420	1,100	1,100	1,100	1,100	3,800	3,800
Miscellaneous	300	480	800	800	800	800	1,500	1,500
Depreciation [1]	2,000	2,750	3,550	2,480	3,350	2,650	4,400	4,400
TOTALS	$14,750	$16,020	$19,250	$18,380	$20,750	$20,150	$29,900	$35,700

[1] Depreciation, straight line at 20% per year of initial cost of *transmitter* and *antenna*.

from the power-output stage of the transmitter. Incorporating a new completely-enclosed design for both the radiating elements and inter-layer co-axial feed lines, this antenna has virtually none of the drawbacks of an earlier model in which the elements of successive layers were fed by open wire lines whose impedance was affected by the pole and steps mounted thereon. Experience with the previous design has led to this new and substantially foolproof design. The radiators are approximately ¼ wavelength long, and are hollow to provide for the insertion of Calrod heating units for localities where ice formation must be considered. The bays are separated by 180°, compared to the 270° spacing used by some manufacturers, since the gain per unit length of pole is identical in the two cases and the transmission-line configuration is considerably simplified when 180° spacing is used. The following table gives the field and power gains which are actually obtained in the field for turnstiles with various numbers of bays:

NUMBER OF BAYS	FIELD GAIN	POWER GAIN
2	1.12	1.27
4	1.64	2.69
6	2.04	4.15
8	2.38	5.7
10	2.6	6.7

For example, the use of a 6-bay turnstile permits the use of a 3-kw. transmitter operated at about 2.5 kw., compared with the necessity of a 10-kw. transmitter (and its attendant higher maintenance and operating costs) for use with a smaller antenna of unity field and power gain. Normally, the weight of such a turnstile is excessive for mounting atop existing broadcast transmitter towers, but there are several instances where such towers have already been designed for the load. No guy wires are necessary to support the turnstile itself.

Although there does not appear to be much choice between horizontal and vertical polarization, most of the antennas currently manufactured employ the former. The turnstile antenna, of course, obtains its power gain by concentrating toward the horizon the portion of the radiated power which otherwise would be radiated at very high and very low angles.

The actual co-axial radiating elements of a 3- to 50-kw. 6-bay turnstile antenna are approximately 2 ins. in diameter. The maximum voltage introduced in any part of the system is about 300 volts for 10-kw. antenna input and 670 volts for 50-kw. input. Insulation is ceramic and is designed with long leakage paths on those portions exposed to the weather. Good pre-fabricated, high-gain turnstile antennas unquestionably are worth much more than their cost in power savings, and it seems likely that horizontally polarized direc-

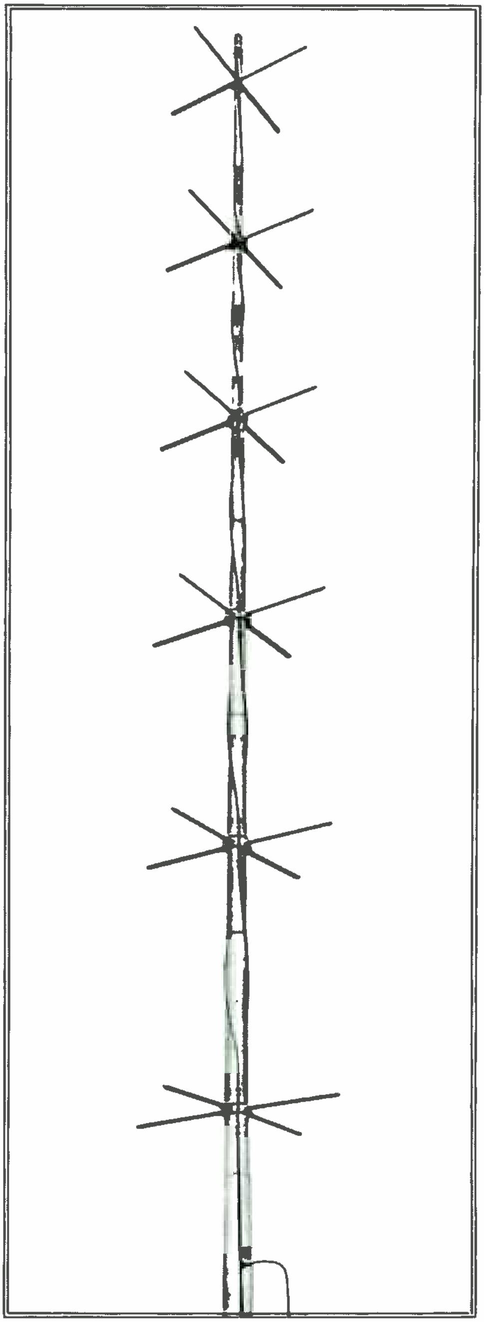


FIG. 6. THIS TYPE OF MULTIPLE-LAYER FM ANTENNA IS LOW IN COST, AND IS AVAILABLE FROM SEVERAL SUPPLIERS

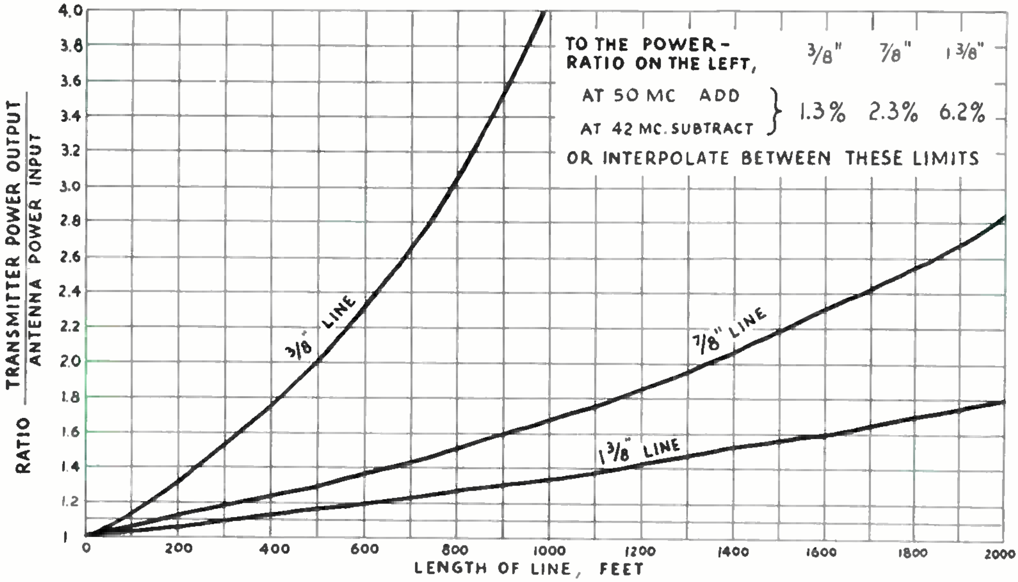


FIG. 7. LINE LOSS OF CONCENTRIC TRANSMISSION CABLE, AT 46 MC. CORRECTIONS FOR HIGHER AND LOWER FREQUENCIES ARE GIVEN ABOVE

tional and circular turnstile antennas will be employed by the majority of FM stations.

Another item of cost often overlooked in planning high-frequency stations is the loss of power in the transmission line. Fig. 7 shows an evaluation of this loss for several sizes of co-axial lines, worked out by Mr. R. D. Duncan, Jr., of the RCA Manufacturing Company. The size of line, of course, depends upon the power to be handled, but in many cases where long runs are absolutely necessary, it will unquestionably pay in power savings to employ lines considerably over-sized. On the other hand, it is obviously always more economical, other things being equal, to locate the transmitter close to the antenna. Experience with installations of various sizes and power ratings has indicated that a transmission line loss of the order of 10% in power can be normally expected.

Open-wire lines at ultra-high frequencies, operated well away from buildings, may have less loss than co-axial lines, but when brought near steel building columns or transmitter frames they are liable to have greater loss. More important, a co-axial line has no external field and is therefore electrically very much easier to handle at these frequencies. Its field cannot get into other equipment, and the presence of other equipment cannot affect antenna tuning.

Experience has shown the following transmission line sizes to be adequate for transmitter power outputs:

250 w. or less	70 ohms	3/8 in. O.D.
.5 to 3 kw.	70 ohms	7/8 in. O.D.
5 to 10 kw.	70 ohms	1 3/8 ins. O.D.
11 to 50 kw.	70 ohms	3 1/8 ins. O.D.

RCA transmitters are designed for use with the above sized lines. The use of a push-pull line composed of the same size of single-line units does not reduce the loss.

EDITOR'S NOTE.—*Part 2, covering details of FM transmitting station equipment, will appear in the August issue.*

W71NY ISSUES PROGRAM BULLETINS

Station W71NY, FM affiliate of WOR, New York, is publishing a weekly program bulletin which can be obtained by those who ask to receive it.

There still persists among many dealers in W71NY's area the idea that the FM transmitter is putting out the same programs as WOR. An examination of the FM bulletin, however, discloses the fact that, on some days, not a single WOR broadcast is used on the FM station.

This fact should be emphasized by the radio dealers, both because W71NY is furnishing a separate type of entertainment that cannot be heard from AM sets, and because 71 is using programs planned particularly to bring out the superior quality of FM reception. Requests for the weekly program bulletins should be addressed to Station W71NY, New York City.

NEW PILOT A-FM FEATURES

Circuit and Service Data on "Conqueror" Chassis

BY EDWARD JAHNS *

RUMORS that National Defense requirements would curtail seriously their production of A-FM receivers are entirely without foundation, for the fact is that the sharp increase in demand for sets capable of receiving FM programs is causing the Armstrong licensees to put more pressure on A-FM development, and to advance production schedules.

Production Plans Advanced ★ At Pilot Radio, for example, we have gone "all out" on a completely new A-FM series, engineered to include new circuit developments and additional features which, under normal conditions, might not have been released for production until next year!

This was done to give listeners in FM broadcasting areas the full advantage, right now, of static-less summer reception from the new stations already on the air, and those which are in the final stages of completion.

Improved Static Elimination ★ Experience with FM reception in various parts of the country, under a variety of conditions, confirmed the wisdom of using a stage of tuned RF amplification with a 3-gang condenser in previous Pilot models. Not only does tuned RF amplification give greatly increased receiving range, but it gives an enormous increase in the effectiveness of static elimination by delivering a strong signal, even from weak stations, to the limiter.

Pilot A-FM sets are manufactured under Armstrong license, and make full use of the Armstrong noise-eliminating circuits. Thus, unlike AM receivers, the FM circuits employed give greater freedom from extraneous noises as well as tube noises as a result of increased sensitivity.

Two Tuned RF Stages ★ Now, in the Pilot Conqueror chassis, we have gone a step further in reducing noise and increasing sensitivity by using two stages of tuned RF amplification on FM, and one stage on AM. Consequently, excellent performance can be obtained from simple antenna arrangements. However, it must be emphasized that, in general, the greatest efficiency from any radio receiver is provided by an outside antenna of correct design, properly installed.

Cabinet Styles ★ The Conqueror chassis, with bass and tweeter speakers, is available in a

*Chief Engineer, Pilot Radio Corporation, Long Island City, N. Y.

THE PILOT "CONQUEROR" CHASSIS IS AVAILABLE IN A WIDE RANGE OF CABINETS

variety of radio-phonograph cabinets, and with a single speaker, in a table cabinet. In the latter form, it is suited to a wide range of special-purpose applications.

SPECIFICATIONS

Voltage: 110–125 volts, 50–60 cycles
Type of Circuit: Armstrong frequency modulation and superheterodyne
Tuning range:
  Broadcast, 535 to 1,720 kc.
  Short-wave, 5.6 to 19.8 mc.–53.6 to 15.1 m.
  FM, 41.8 to 40.3 mc.
Types of Tubes:
  Two 6AC7 FM RF amplifiers
  6SK7 AM RF amplifier
  6SA7 AM oscillator-converter
  6SA7 FM converter
  6J5 FM oscillator
  Two 6AC7 FM-AM IF amplifiers
  6SQ7 AM detector, AVC rectifiers, FM squelch control
  6H6 FM discriminator
  6H6 FM tuning rectifier
  6SJ7 High-grain AF amplifier
  6J7 Cathode-loaded driver
  Two 6L6 Class AB2 power amplifiers
  5U4G Rectifier
  6U5 Tuning Indicator
Output: 45 watts maximum
Intermediate Frequency: AM, 455 kc. FM, 4.3 mc.

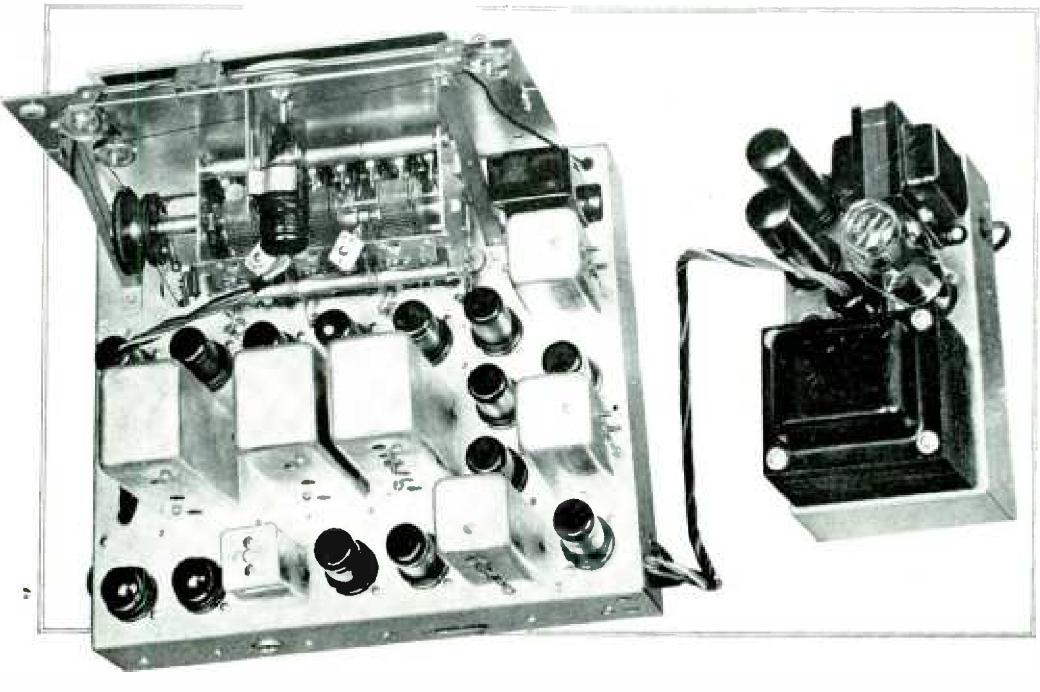
GENERAL INFORMATION

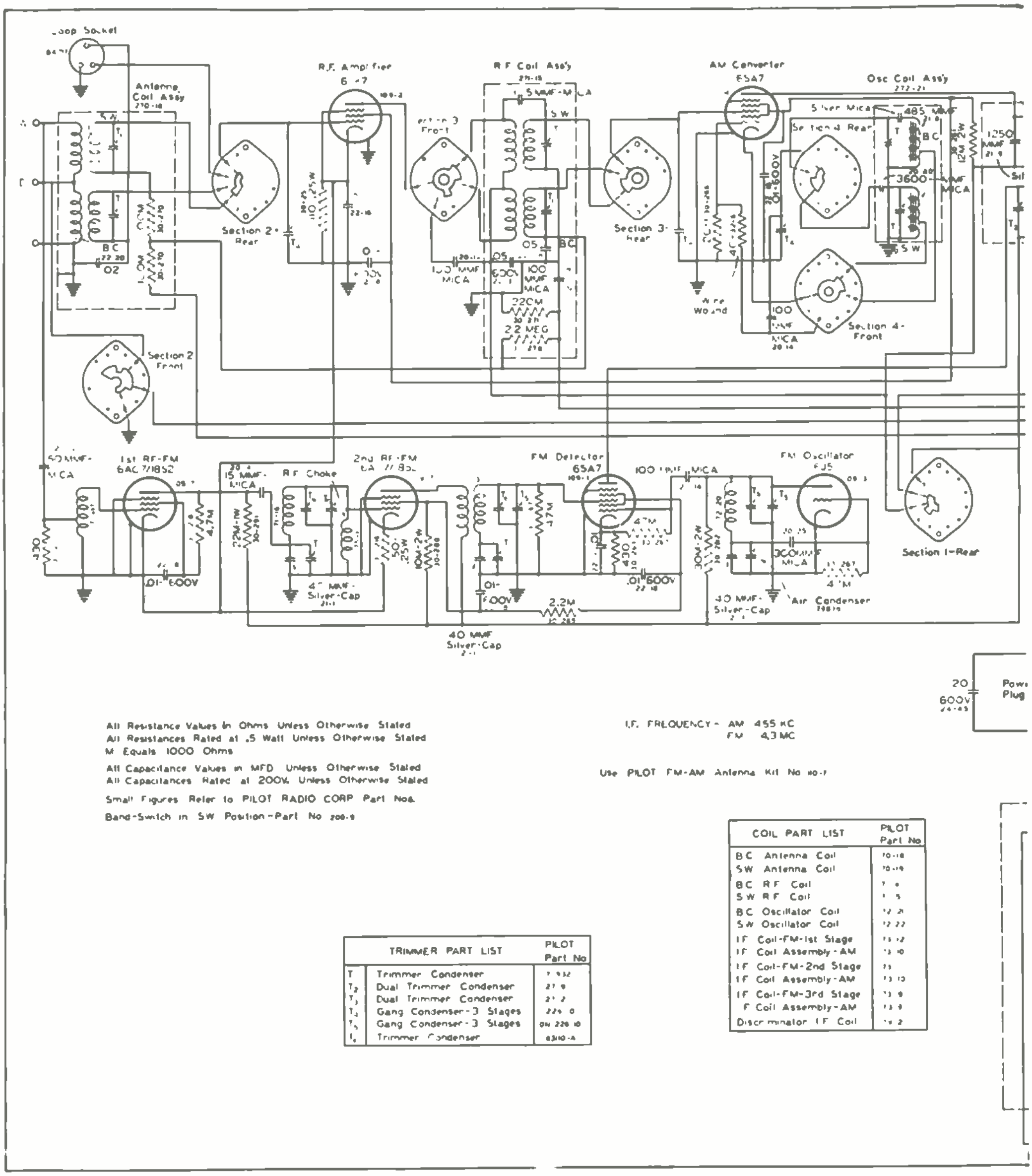
Volume Control ★ From left to right, the first control on the chassis is for the volume. This is provided with low-level bass and treble compensation, giving natural tone at low volume.

Tone Control ★ The tone-color control provides adjustable bass and treble compensation at higher audio levels. The knob operates a pointer, indicating on the dial scale:
  Bass — high bass and lowered treble tone.
  Music — full bass and full treble tone.
  Voice — lowered bass and lowered treble tone.
  Treble — lowered bass and full treble tone.
The amount of bass and treble compensation increases as the volume is lowered, in order to retain the balance of tones generally lost at low volume. This is done to compensate for the audio-discrimination effect of the average human ear, which varies with sound intensity and tone. This control should be used in conjunction with:

Harmonic Control and QAVC Switch ★ This control provides a very sharp cut-off of the higher audio frequencies, and operates in an inverse feed-back circuit. Usually, it is desirable to keep this control at less than maximum setting when listening to recorded or live programs on AM and phonograph, so that unwanted hiss, particularly on phonograph record reproduc-

POWER SUPPLY AND 45-WATT AUDIO OUTPUT ARE CARRIED ON A SEPARATE CHASSIS





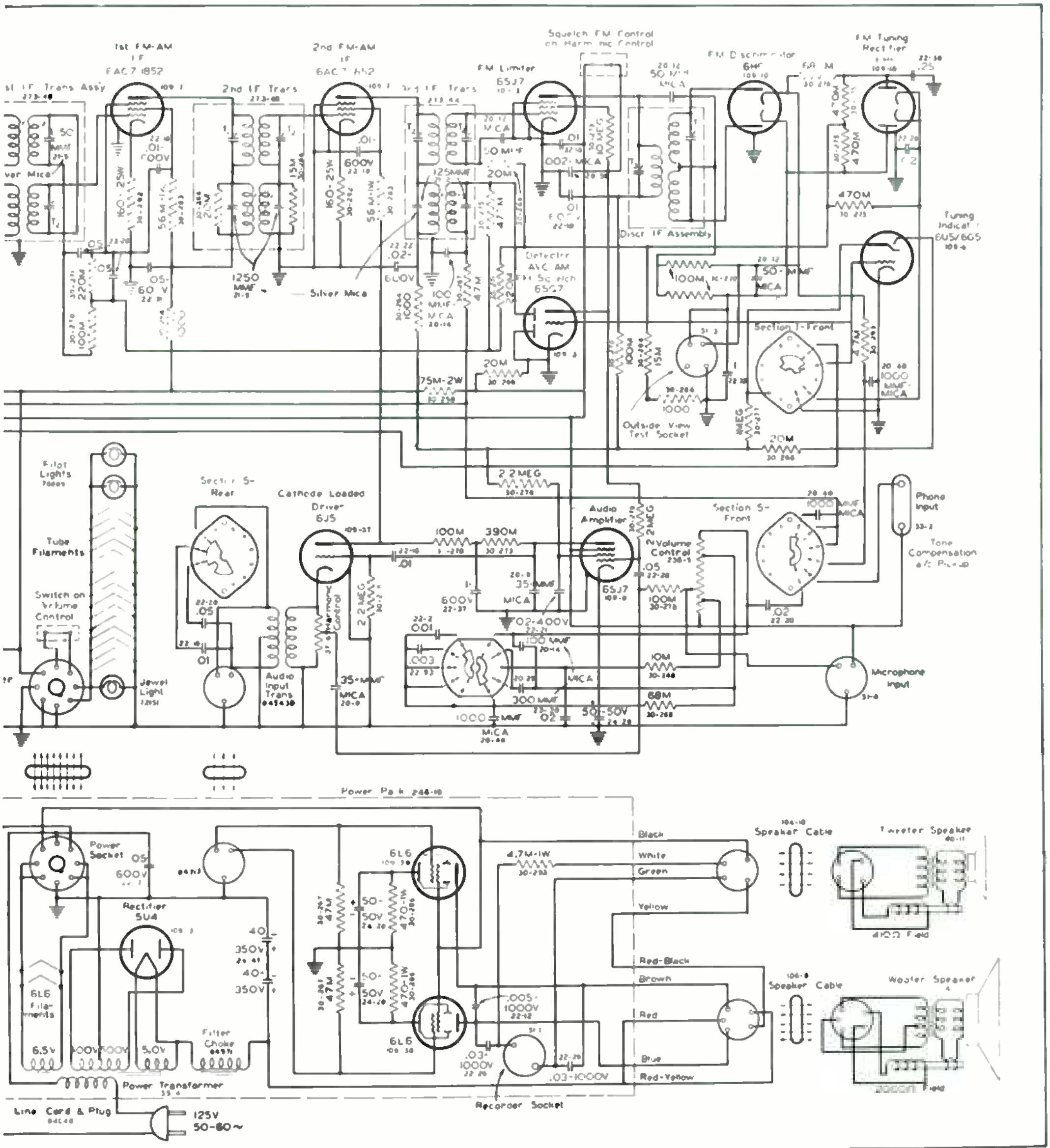
	TRIMMER PART LIST	PILOT Part No
T	Trimmer Condenser	[illegible]
T_2	Dual Trimmer Condenser	[illegible]
T_3	Dual Trimmer Condenser	[illegible]
T_4	Gang Condenser-3 Stages	[illegible]
T_5	Gang Condenser-3 Stages	[illegible]
T_6	Trimmer Condenser	[illegible]

COIL PART LIST	PILOT Part No
BC Antenna Coil	10-18
SW Antenna Coil	10-19
BC RF Coil	[illegible]
SW RF Coil	[illegible]
BC Oscillator Coil	[illegible]
SW Oscillator Coil	[illegible]
IF Coil-FM-1st Stage	[illegible]
IF Coil Assembly-AM	[illegible]
IF Coil-FM-2nd Stage	[illegible]
IF Coil Assembly-AM	[illegible]
IF Coil-FM-3rd Stage	[illegible]
IF Coil Assembly-AM	[illegible]
Discriminator IF Coil	[illegible]

MANY IMPROVEMENTS AND REFINEMENTS ARE REPRESENTED IN THE CIRCUIT

tion, can be removed. On musical instruments received by FM, it will be found that reducing the harmonics will tend to cause violins and saxophones to sound similar, since both instruments make the same fundamental tones. The reproduction of the harmonics which distinguish these instruments can be regulated by this control.

To cut out the QAVC on very weak FM signals, rotate this knob to the extreme left, until a click is heard. Then the signals must be tuned very accurately by ear, since the tuning beacon cannot function properly on extremely weak signals. In this position, the higher harmonics are automatically removed in order to reduce external noise introduced with extremely low signals. The tuning buttons should not be set on stations which can be heard only with the QAVC cut out. Normally, stations worth hearing will operate the QAVC circuit.



OF THE PILOT "CONQUEROR" CHASSIS, FREQUENCY STABILITY HAS BEEN STRESSED

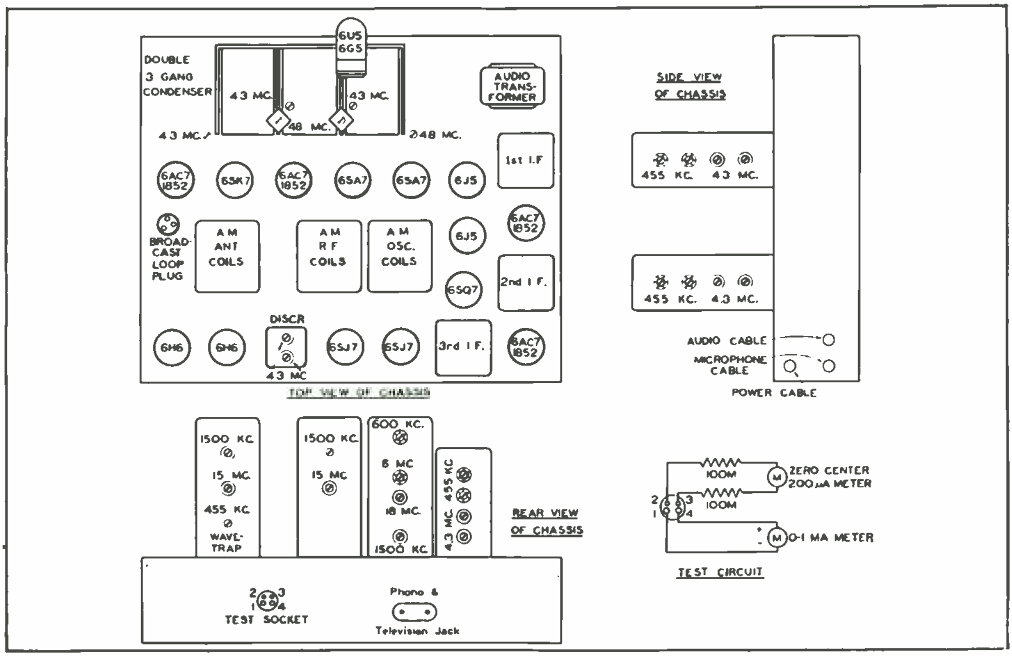
Service Selector ★ This knob selects the service required. It operates a pointer, indicating on the dial scale:

- Short-wave AM.
- Broadcast AM from external antenna.
- Broadcast AM from built-in loop.
- FM from external antenna.
- Phonograph or television connection.

In the phonograph models, the pick-up is connected in this last position.

Tuning Control ★ All bands are tuned by this control. The top scale on the dial shows, above, the last two number of the FM frequency. These are the numbers used in the station calls, such as W71NY. This station, for example, will be found on 71 on the upper calibration, or at 47.1 on the lower calibration.

Push Buttons ★ This set is provided with eight push buttons which mechanically operate the



CHASSIS LAYOUT SHOWS LOCATION OF TUBES, TRIMMERS, AND TEST METER SOCKET

dual 3-gang tuning condenser. These may be set on AM and FM stations in any combination.

To set up a button, pull off the bakelite cap and loosen the locking screw. Tune in the station with the tuning knob and push the flat piece of the control all the way in. Then tighten the locking screw. A careful check with the tuning eye should immediately ascertain the exactness of the setting. An identifying station tab should then be inserted above the button, in the space provided. It is easy to set up the buttons on AM or FM in this manner, and extra care used in their setup will amply reward the listener.

On very weak signals it may be necessary to retune the station very slightly with the tuning knob. It is recommended, however, that the left buttons be set on AM locals, and the right buttons be set on FM locals.

Slight misadjustments due to continuous use will cause little effect on the tone as this FM-AM IF system is expressly designed for push-button use.

Antenna ★ A good antenna system cannot be overemphasized and should the receiver be used in the locality of any vertically polarized FM transmitter, best reception from that station at a slight sacrifice of the reception of the usual horizontally polarized transmitters can be secured by tilting the dipole to about a 45° angle. The whole array should then be rotated for best average reception of all the local stations.

Maximum pickup from a given transmitter is usually secured when the broadside of the dipole antenna faces the transmitter.

The Pilot A-FM antenna No. 110-7 is recommended for use with this receiver. This antenna is shipped in kit form and consists of a dipole with supporting mast, shielded transmission line, and special couplers at both ends of the transmission line, which provide automatically for operation on either the FM or AM bands. Detailed instructions are furnished with the antennas.

SERVICE NOTES

This receiver is correctly aligned at the factory and no further adjustments to either the trimmers or iron cores is recommended.

The minimum requirements for accurate adjustment of the trimmers are:

1. 0 to 1 milliammeter, preferably with an extra 5-milliampere shunt resistor.
2. Zero center, 0 to 200-microampere galvanometer and two 100,000-ohm resistors.
3. Rectifier type output meter of approximately 0 to 2 volts R.M.S.
4. 65-ohm FM dummy antenna.
   400-ohm short-wave dummy antenna.

(CONTINUED ON PAGE 44)

A Statement by
William J. Scripps,
General Manager,
Stations WWJ, W45D,
Detroit, Michigan

WHAT THE FM BROADCASTERS HAVE TO SAY:

STATION W45D is the pioneer Frequency Modulation station of Michigan. It is owned and operated by The Evening News Association, publisher of *The Detroit News*. At present, the broadcast hours are from noon until 10 P.M. daily. Three kilowatts are being used pending completion of a 50-kilowatt amplifier which will permit use of full power as licensed by the Federal Communications Commission.

In devising its program schedule, W45D has utilized the experience gained through four years of experimentation over W8XWJ. Serving as a laboratory for technicians as well as the program and production staffs, many ideas were tried on W8XWJ, largely in the field of remotes.

Station W45D plans extensive coverage of spot news events as highlights in a schedule which emphasizes music for all. Because of the surfeit of drama on AM stations, W45D endeavors to supply music at all times. Although a heavy schedule of news is carried, the reports are condensed into five-minute periods, for the most part. The percentage of popular and semi-classic types of music is about equal.

Typical of the kind of remotes in prospect is a stock market summary direct from the brokerage house of Merrill Lynch, E. A. Pierce and Cassatt. This report is read direct from the board each day at the market close.

It is of interest to note that W45D originates its own programs, and depends in no way on its associate, WWJ, also owned by *The Detroit News*. It has a complete staff of its own, and its facilities match those of the standard broadcast stations. Its location on the 45th floor of the Penobscot Building is considered ideal from an engineering standpoint, as its antenna stands about 700 feet above street level.

The first commercials carried by the station are time signals sponsored by the Bulova Watch Company, the first advertiser on WWJ many years ago. A half-hour program from the new Saks Fifth Avenue Store in Detroit featured a fashion show and interviews with the "Life with Father" cast, with Dorothy Gish and Louis Calhern.

John Hammond, formerly of the Hammond Organ Company of Chicago, is the staff musician. His programs on the Novachord have proved to be excellent broadcast material for demonstration of the quality made possible by Frequency Modulation. Hammond also gives piano and Hammond organ recitals.

Cecil Chittenden, former newspaperwoman, arranges lectures and discussions with women's organizations, and the sales promotion staff works with the various men's service clubs as well as dealer organizations.

W45D has a rate card prepared in conformity with others in the American Radio Network of which it is a member. Conditions stipulate highest program standards, and specify that the advertiser must utilize the full capacity of the FM system of broadcasting.

MEASUREMENT OF H.F. IMPEDANCES

How G. R. Twin-T Circuit Is Used for Measurements at High Frequencies

BY C. E. WORTHEN*

EDITOR'S NOTE: *The first part of Mr. Worthen's article on the measurement of impedances at high frequencies appeared in the June issue of* FM *Magazine.*

CHANGE the auxiliary series condenser until a capacitance value is found that will give settings for the final balance sufficiently different from those for the initial balance to insure adequate precision. Be particularly sure to obtain a substantial change in the conductance setting.

The optimum value for the auxiliary series capacitance having been determined, the measurement procedure is as follows:

First, connect one side of the auxiliary series condenser to the ungrounded UNKNOWN terminal of the Twin-T and, with the other side of the series condenser disconnected, establish an initial balance as outlined in paragraph 2.6. The series condenser should be physically as small as possible and should be supported by its own ungrounded lead in a position as nearly the same as that which it will take when connected to the unknown impedance.[13]

Next connect the free lead of the condenser to the grounded UNKNOWN terminal and rebalance with the susceptance and conductance condensers. From the measured admittance, $Y' = G' + jB'$, the impedance, $Z' = R' + jX'$, can be determined exactly by equations (2) and (3). In most cases, however, it will be found that the conductance component is negligible or, in any event, so small that the following simple approximate equations can be used:

$$R' = \frac{G'}{(B')^2} \qquad (9)$$

$$X' = -\frac{1}{B'} \qquad (10)$$

The position of the auxiliary series condenser should be changed as little as possible when this connection is made, preferably only the free lead being bent so as to make contact with the grounded UNKNOWN terminal.

Finally, disconnect the free lead of the auxiliary condenser from the grounded UNKNOWN terminal, and connect it to the ungrounded terminal of the unknown impedance. Rebalance with the susceptance and conductance condensers. From the measured admittance, $Y'' = G'' + jB''$, of the combination the impedance, $Z'' = R'' + jX''$, can be determined from equations (2) and (3):

$$R'' = \frac{G''}{(G'')^2 + (B'')^2} \qquad (2)$$

$$X'' = \frac{-B''}{(G'')^2 + (B'')^2} \qquad (3)$$

The unknown impedance, $Z_x = R_x + jX_x$, is equal to the difference between these two impedances.

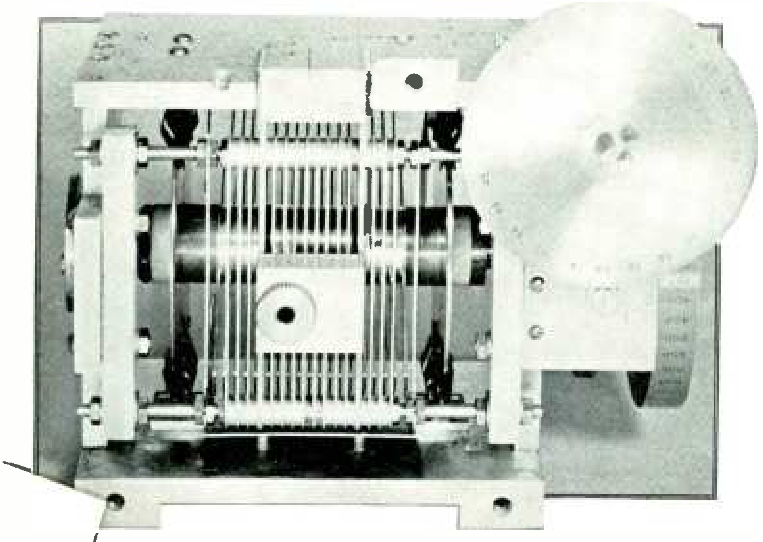
$$R_x = R'' - R' \qquad (11)$$

$$X_x = X'' - X' \qquad (12)$$

The ground terminal of the unknown impedance can be left connected to the grounded

*Engineer, General Radio Company, Cambridge, Mass.

[13] Small fixed mica condensers, such as the Cornell-Dubilier Type 5-W, are excellent for this service. See paragraph 3.12 for a more extensive discussion of the precautions to be observed.



VIEW OF THE SUSCEPTANCE CONDENSER C_B. BRASS DISCS AT EITHER END OF ROTOR, AND HEAVY WIPING CONTACTS OF LOW INDUCTANCE GROUND ROTOR TO THE FRAME. SCALE CAN BE SEEN THROUGH OPENING IN THE FRONT PANEL. CONDENSER IS UPSIDE DOWN IN THIS ILLUSTRATION

UNKNOWN terminal at all times for this measurement.

It is often found that the unknown reactance, X_x, is quite small compared with the reactance, X', of the auxiliary series condenser and that the arithmetic used in its evaluation therefore involves taking the difference between two large numbers. To avoid, as much as possible, inaccuracy in slide-rule computations it is therefore helpful to express the unknown reactance, X_x, in terms of the difference between the two measured parallel capacitances, C_P'' and C_P', which can be read from the precision condenser scale.[14]

$$X_x = \frac{1}{B'} \cdot \frac{\dfrac{B''-B'}{B''} + \left(\dfrac{G''}{B''}\right)^2}{1 + \left(\dfrac{G''}{B''}\right)^2} \qquad (13)$$

$$= \frac{1}{\omega C_P'} \frac{\dfrac{C_P''-C_P'}{C_P''} + \left(\dfrac{G''}{\omega C_P''}\right)^2}{1 + \left(\dfrac{G''}{\omega C_P''}\right)^2} \qquad (13a)$$

The dissipation factor, $D'' = \dfrac{G''}{B''}$, of the series combination is usually small and its square can be neglected in comparison with unity. For most conditions, therefore, equation (13a) can be used in the simpler, approximate form:

$$X_x = \frac{1}{\omega C_P'} \left[\frac{C_P''-C_P'}{C_P''} + \left(\frac{G''}{\omega C_P''}\right)^2\right] \qquad (13b)$$

Since this equation involves directly the small difference in final capacitance settings the accuracy of the result is of the same order as that of setting and reading capacitance difference.

[14] If the same initial setting is used for both measurements, $C_{B_1}' = C_{B_1}''$, then $C_P'' - C_P' = (C_{B_1}'' - C_{B_2}'') - (C_{B_1}' - C_{B_2}') = C_{B_2}' - C_{B_2}''$.

When the unknown reactance, X_x, is small compared with the reactance, X', of the series auxiliary condenser it is also possible to simplify, to some extent, the determination of the unknown resistance, R_x. Since X' and X'' are then not greatly different, loss in the auxiliary condenser contributes practically the same conductance component, both in the measurement of the condenser alone and in the measurement of the series combination. It is therefore generally safe to neglect the condenser loss and to make the conductance balance, when measuring the condenser alone, with the EXACT INITIAL BALANCE conductance control, leaving the CONDUCTANCE dial set at zero. The conductance balance for the series combination is then made with the same setting of the INITIAL BALANCE conductance controls, so that, to a first approximation, the loss in the series condenser is allowed for in the measurement process. The unknown impedance then becomes:

$$R_x = R'' = \frac{G''}{(G'')^2 + (\omega C_P'')^2} \qquad (2)$$

$$X_x = \frac{1}{\omega C_P'} \left[\frac{C_P''-C_P'}{C_P''} + \left(\frac{G''}{\omega C_P''}\right)^2\right] \qquad (13b)$$

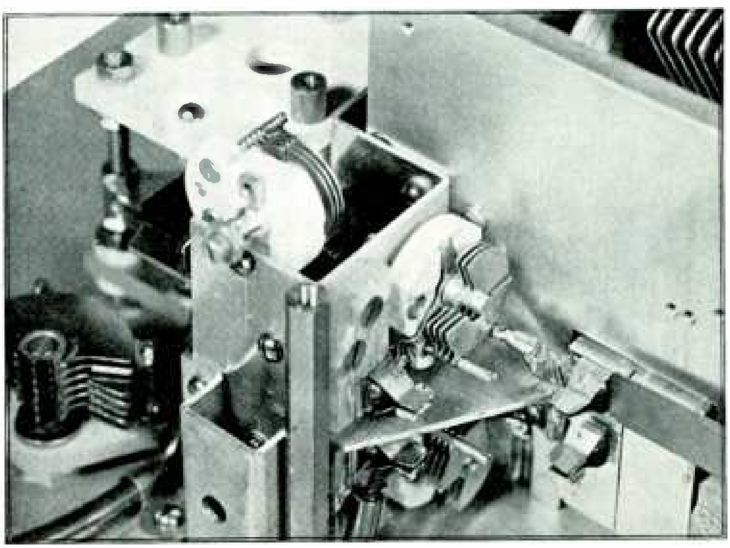
2.73 ILLUSTRATIVE EXAMPLES. As a guide to the practical application of the material of paragraphs 2.71 and 2.72, three illustrative examples follow.

(a) *Measurement of a 500-μμf Condenser at 10 Mc.*

Set the 4-position conductance range switch at 10 mc. and the coil switch on the 10.0 – 20.0 mc. range. Set the susceptance condenser dial at some high value, say $C_{B_1} = 1000.0$ μμf, and the conductance dial at zero. Adjust to an initial balance as described in paragraph 2.6. (From Fig. 5 the AUX. TUNING CAP will be about 1100 μμf.)

Connect the condenser to be measured

THREE CONDENSERS ASSEMBLED TOGETHER ARE, FROM TOP TO BOTTOM, C‴, C″, AND C′ RESPECTIVELY. THESE WILL BE FOUND IN THE WIRING DIAGRAM, FIG. 3. THEY ARE MOUNTED ADJACENT TO THE SUSCEPTANCE CONDENSER



across the UNKNOWN terminals and, with the susceptance and conductance condensers, adjust to a final balance. Let:

$C_{B_2} = 442.4\ \mu\mu f$
$G_2 = 80\ \mu mho$

Then:

$$C_{P_x} = 1000.0 - 442.4 = 557.6\ \mu\mu f \qquad (5b)$$

$$G_x = G_2 = 80\ \mu mho \text{ (See par. 2.71).}$$

$$D_x = \frac{80 \times 10^{-6}}{2\pi \times 10 \times 10^6 \times 557.6 \times 10^{-12}} = 0.0023 = 0.23\% \qquad (8)$$

(b) *Measurement of 1 μh Coil at 25 Mc.*

Set the 4-position conductance range switch at 30 mc. and the coil switch on the 20.0 – 45.0 mc. range. Set the susceptance condenser dial at some low value, say $C_{B_1} = 100.0\ \mu\mu f$, and the conductance dial at zero. Adjust to an initial balance as described in paragraph 2.6. [From Fig. 5, the AUX. TUNING CAP will be about 700 μμf. It will, however, appear less because of lead inductance (see Footnote 9, par. 2.6).]

Connect the coil to be measured across the UNKNOWN terminals and adjust to a final balance as before. Let:

$C_{B_2} = 139.8\ \mu\mu f$
$G_2 = 90\ \mu mho$ (Dial reading)

Then:

$$B_x = 2\pi \times 25 \times 10^6 (100.0 - 139.8) \times 10^{-12} \times 10^6 = -6250\ \mu mho \qquad (5a)$$

$$G_x = 90 \times \left(\frac{25}{30}\right)^2 = 62.5\ \mu mho \text{ (see par. 2.71)}$$

$$L_{P_x} = -\frac{10^6}{2\pi \times 25 \times 10^6 \times (-6250) \times 10^{-6}} = 1.02\ \mu h \qquad (6)$$

$$Q_x = \frac{6250}{62.5} = 100 \qquad (7)$$

(c) *Measurement of Matched 72-ohm Coaxial Transmission Line at 830 Kc.*

Set the 4-position conductance range switch at 1 mc. and the coil switch on the 620–850 kc. range. Set the susceptance condenser dial at some value near mid-scale and the conductance dial at zero. Adjust to an initial balance as described in par. 2.6. From Fig. 5, the AUX. TUNING CAP will be set at zero.

Following the procedure outlined in paragraph 2.72, find the largest convenient value of the auxiliary series condenser that will give a conductance balance on scale. Suppose it is 150 μμf, nominal value.

Measure the capacitance of the auxiliary condenser and balance with the conductance condenser set to zero with the auxiliary condenser across the UNKNOWN terminals. Disconnect the lead of the auxiliary condenser from the grounded UNKNOWN terminal, connect to the ungrounded terminal of the unknown impedance and rebalance. Let:

$C'_{B_1} = 500.0\ \mu\mu f$

$C'_{B_2} = 352.5\ \mu\mu f$

$G'_2 = 0\ \mu mho$ (Set with EXACT INITIAL BALANCE conductance control)

$C''_{B_1} = 500.0\ \mu\mu f$

$C''_{B_2} = 353.6\ \mu\mu f$

$G''_2 = 60.8\ \mu mhos$ (Dial reading)

$$= 60.8 \times \left(\frac{0.83}{1}\right)^2 = 41.9\ \mu mho$$

(See par. 2.71)

Then:

$$C'_P = 500.0 - 352.5 = 147.5\ \mu\mu f$$

$$G'' = G''_2 = 41.9\ \mu mho$$

$$C''_P = 500.0 - 353.6 = 146.4\ \mu\mu f$$

$$B'' = 2\pi \times 830 \times 10^3 \times 146.4 \times 10^{12} \times 10^6 = 764\ \mu mho$$

$$R_x = \frac{41.9 \times 10^{-6}}{(41.9^2 + 764^2) \times 10^{-12}} = 71.6\Omega \qquad (2)$$

$$X_x = \frac{10^{12}}{2\pi \times 830 \times 10^3 \times 147.5}\left[\frac{146.4 - 147.5}{146.4} + \left(\frac{41.9}{764}\right)\right] \qquad (13b)$$

$$= -6\Omega \quad \text{(Capacitive)}$$

$$Z_x = 71.6 - j6$$

2.74 Balanced Lines and Antennas. The measurement of three-terminal devices, such as balanced lines and antennas, can be made with the Twin-T, although the computations involved are quite laborious.

The method depends upon the analysis of the unknown impedance in terms of the equivalent circuit of Fig. 6 and requires three separate measurements, as follows:

(1) Short-circuit impedance Z_1 by grounding line A at point of measurement, and measure impedance, Z', from line B to ground.

$$Z' = \frac{Z_2 Z_3}{Z_2 + Z_3} \qquad (14)$$

(2) Short-circuit impedance Z_2 by connecting line A to line B at point of measurement, and measure impedance, Z'', from the junction to ground.

$$Z'' = \frac{Z_3 Z_1}{Z_3 + Z_1} \qquad (15)$$

(3) Short-circuit impedance, Z_3, by grounding line B at point of measurement, and measure impedance, Z''', from line A to ground.

$$Z''' = \frac{Z_1 Z_2}{Z_1 + Z_2} \qquad (16)$$

Combining equations (14), (15) and (16) gives:

$$Z_1 = \frac{2Z'Z''Z'''}{Z'Z'' - Z''Z''' + Z'''Z'} = \frac{2}{-\frac{1}{Z'} + \frac{1}{Z''} + \frac{1}{Z'''}} \qquad (17)$$

$$Z_2 = \frac{2Z'Z''Z'''}{Z'Z'' + Z''Z''' - Z'''Z'} = \frac{2}{\frac{1}{Z'} - \frac{1}{Z''} + \frac{1}{Z'''}} \qquad (18)$$

$$Z_3 = \frac{2Z'Z''Z'''}{-Z'Z'' + Z''Z''' + Z'''Z'} = \frac{2}{\frac{1}{Z'} + \frac{1}{Z''} - \frac{1}{Z'''}} \qquad (19)$$

This method gives each component of impedance, detecting any unbalance. At perfect balance, $Z_1 = Z_3$, $Z' = Z'''$.

$$Z_1 = Z_3 = 2Z''' \qquad (17a)$$

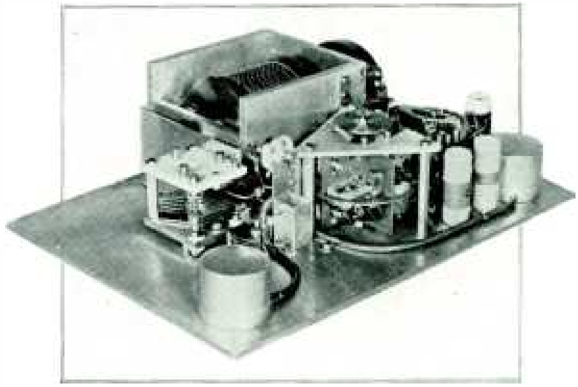
$$Z_2 = \frac{2Z'Z''}{2Z'' - Z'} = \frac{1}{\frac{1}{Z'} - \frac{1}{2Z''}} \qquad (18a)$$

When the balanced line is fed from a balanced source, the effective input impedance is given by

$$Z_{AB} = \frac{2Z_1 Z_2}{2Z_1 + Z_2} = \frac{4Z'Z''}{4Z'' - Z'} \qquad (20)$$

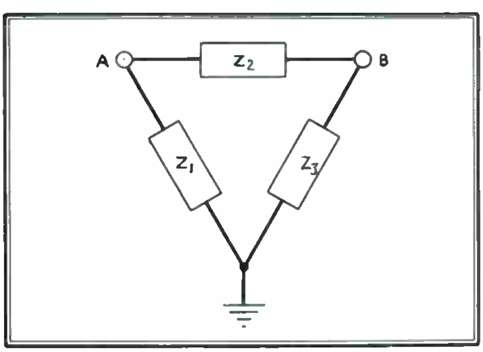
Z_{AB} is the input impedance seen from the source. It should be measured once with the far end of the line open and once with it closed if it is desired to compute the characteristic impedance and propagation constant by the usual method. No grounds should be made to the line at any point other than the input when making measurements.

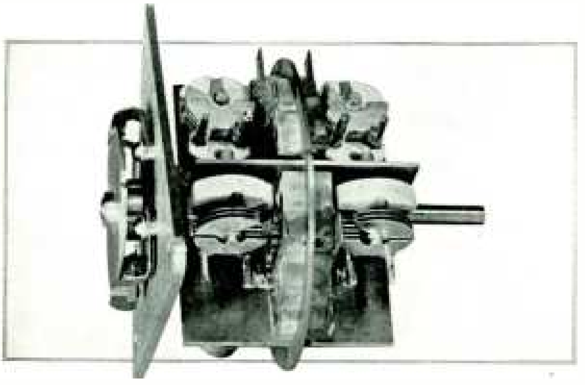
The component impedances involved must usually be measured by the method described in paragraph 2.72. In equations (17) to (20) they must, of course, be written in their complex forms.



BACK OF PANEL VIEW OF EXPERIMENTAL MODEL OF THE TWIN-T MEASURING CIRCUIT

FIG. 6. EQUIVALENT CIRCUIT REFERRED TO IN SECTION 2.74 ON BALANCED LINES AND ANTENNAS





RANGE SWITCH, USED TO CHANGE THE SCALE OF THE CONDUCTANCE CONDENSER

3.0 CORRECTIONS

3.1 Lead Corrections ★ In common with other types of impedance-measuring equipment, the Twin-T can only measure impedance at its own terminals. The residual impedances of the leads used to connect the unknown impedance to these terminals, however, often causes this impedance to differ from the impedance appearing at the terminals of the device under test. Under some circumstances the difference can be ignored and the measured impedance taken as the impedance of the device under test, including the leads. In most cases, however, the device will not be used with the same leads used to connect it to the measuring instrument and it is necessary to compensate for the effect of these leads to obtain the desired impedance. An exact correction for the effect of the leads requires analysis as a transmission line and is laborious and cumbersome. For specific measurements, however, approximate corrections will yield satisfactory accuracy.

3.11 Corrections for Admittance Measurements within Direct-Reading Ranges of Twin-T. When the Twin-T is used to measure admittances within its direct-reading range the unknown impedance is so high that for relatively short leads the voltage drop along the leads is small compared with the voltage drop across the unknown impedance. The effective capacitance between the leads is consequently not materially changed when the unknown impedance is connected and disconnected. If the initial balance is established with the leads to the unknown in place, but disconnected at the far end, the lead capacitance therefore cancels out in the measurement and the only correction that need be made is for the inductive reactance.

The "shortness" of the leads is expressed by the ratio of their inductive reactance to the unknown impedance. A value of 20% for this ratio may well be taken as an upper limit. If, for instance, two parallel No. 18 B & S gauge wires, spaced ¾" apart on centers, are used as leads, the inductance of the two wires will be about 0.037 μh/inch and the corresponding inductive reactance at 30 mc. will be about 7Ω/inch. When measuring, say, a 300Ω impedance at this frequency, then, the leads used to connect to the unknown impedance should each be less than 9" long.

The most straightforward method of correcting for the lead inductance is to convert the measured parallel admittance to the corresponding series impedance and to subtract directly from the measured reactance the inductive reactance of the leads.

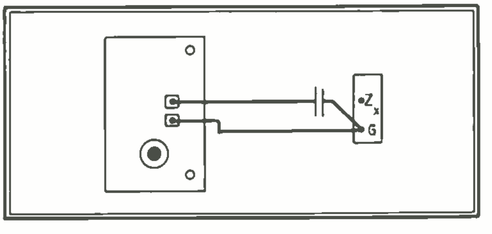
The lead inductance can be determined by measuring a small fixed condenser, first at the Unknown terminals of the Twin-T and then at the end of the leads. The first measured capacitance, C'', with the condenser at the Unknown terminals is equal to the effective parallel capacitance of the condenser; the second measured capacitance, C''', with the condenser at the end of the leads is equal to $\frac{C''}{1 - \omega^2(\delta L)C''}$, where (δL) is the lead inductance. From these two measurements

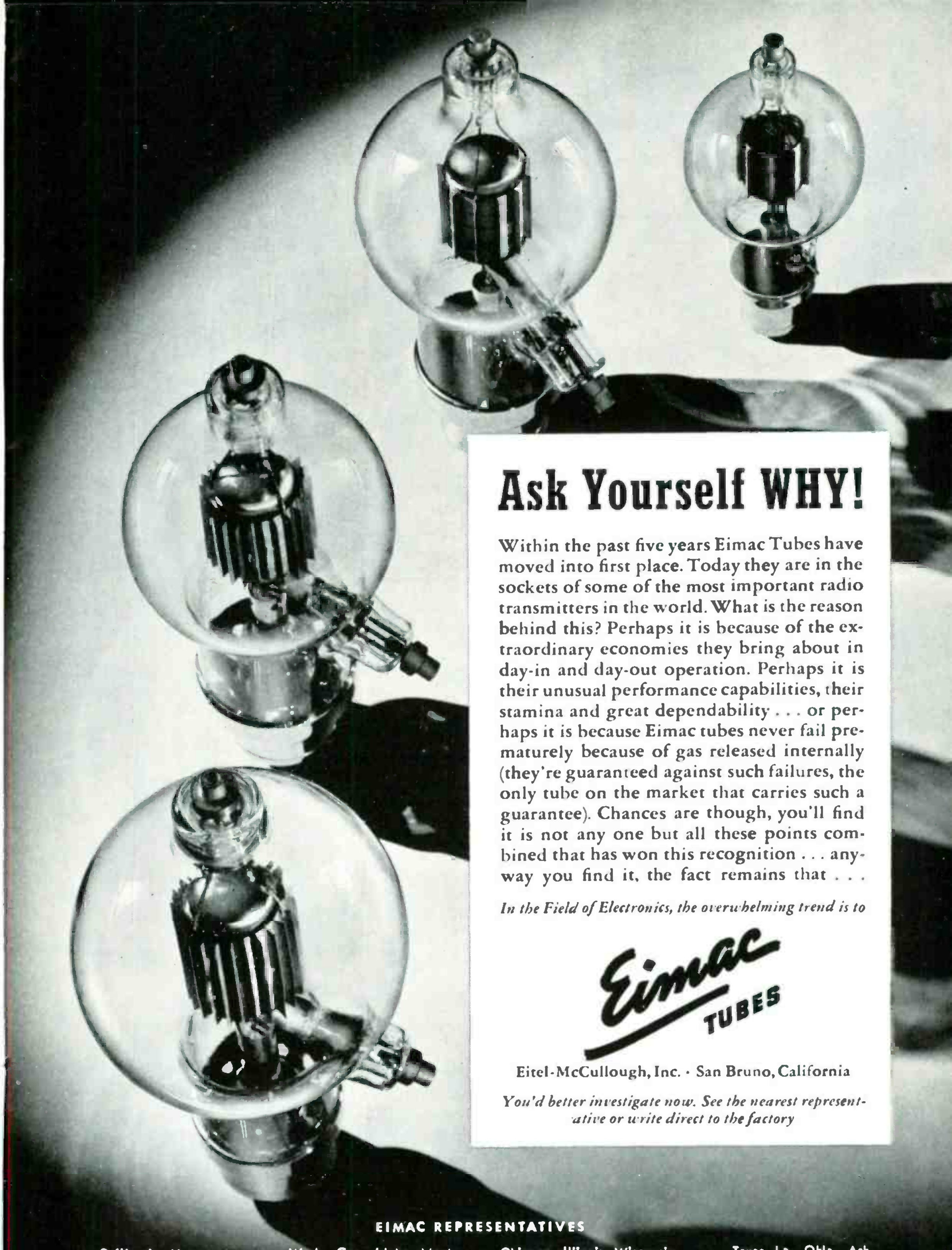
$$\delta L = \frac{1}{\omega^2}\frac{C''' - C''}{C''C'''} \qquad (21)$$

As the capacitance of the fixed condenser is increased the difference between C'' and C''' becomes greater and the precision of measurement of δL increases.

3.12 Corrections for Admittance Measurements Outside Direct-Reading Range of Twin-T. The analysis presented in paragraph 3.11 applies directly, in the series-condenser method described in paragraph 2.72, to the lead from the ungrounded Unknown terminal to the auxiliary series condenser, provided this lead is not made so long that there is an appreciable voltage drop along its length. The capacitance of this lead to ground is therefore automatically accounted for when the initial balance is made with it connected, but with the far end of the series condenser disconnected, as described in para-

FIG. 7. CONNECTIONS REFERRED TO IN SECTION 3.12 ABOVE





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Within the past five years Eimac Tubes have moved into first place. Today they are in the sockets of some of the most important radio transmitters in the world. What is the reason behind this? Perhaps it is because of the extraordinary economies they bring about in day-in and day-out operation. Perhaps it is their unusual performance capabilities, their stamina and great dependability . . . or perhaps it is because Eimac tubes never fail prematurely because of gas released internally (they're guaranteed against such failures, the only tube on the market that carries such a guarantee). Chances are though, you'll find it is not any one but all these points combined that has won this recognition . . . anyway you find it, the fact remains that . . .

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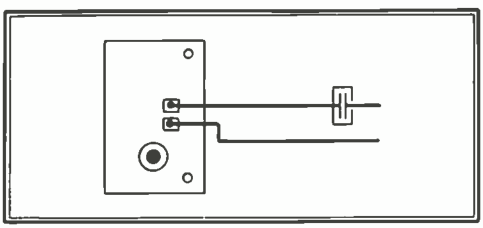
graph 2.72. The effect of the lead inductance can also be eliminated, in this method, by connecting the auxiliary condenser at the far end of the lead, where it can be connected to the ungrounded terminal of the device under test with a lead of negligible length. The far end of the condenser should then be connected to the ground terminal of the device under test, see Fig. 7, rather than to the grounded UNKNOWN terminal in the Twin-T when its reactance, X', is measured. This measured reactance then includes the lead reactance and, since the same lead length is used in the measurement of the series combination, the lead reactance cancels out. If the auxiliary series condenser is connected at the Twin-T end of the lead it will generally be found necessary to correct for the lead capacitance, even if the C'' measurement is made by connecting the far end of the lead to the ground terminal of the device under test.

There is one other source of error, however, that should be carefully watched, when using the series-condenser method. Any condenser, when used in a series connection, will have, in addition to the direct capacitance between its terminals, capacitance from each terminal to ground. Capacitance to ground from the condenser terminal connected to the Twin-T will cause no error since it is always across the UNKNOWN terminals. Capacitance to ground from the other terminal, however, will cause the measured value of C'' to differ from the direct capacitance between the terminals since this capacitance to ground is effectively across the UNKNOWN terminals for the initial balance but is shorted out when the condenser is connected across the UNKNOWN terminals. While the capacitance to ground is ordinarily very small, it is often necessary to use small series capacitances (as low as 20–30 $\mu\mu$f) and it is not difficult to produce appreciable errors. It is strongly recommended, therefore, that the series condenser used be of as small dimensions as possible. As a further safeguard it is suggested that the body of the condenser be wrapped with copper foil, connected to the lead to the Twin-T, so that the ground capacitance is all thrown over to that side of the condenser, see Fig. 8, where it can cause no error.

FIG. 8. METHOD OF SHIELDING CONDENSER TO REDUCE ERROR



3.2 Corrections for Residual Parameters ★ The upper-frequency limit of accurate operation of radio-frequency impedance-measuring equipment is nearly always determined by residual parameters, in the wiring and in the impedance elements, that are not accounted for in the ordinary theory of operation. While these have been made extremely small in the Twin-T, they are still large enough to affect performance at the highest frequencies and to set the maximum usable frequency in the neighborhood of 30 mc.

By careful balancing of impedance levels and attention to mechanical arrangement, the effects of all the residual parameters except those occurring in the susceptance condenser, C_B, have been made negligible. The residual parameters in this condenser, for which corrections may be necessary, are:

(1) Inductance, L', between the condenser and the ungrounded UNKNOWN terminal.

(2) Inductance, L'', between the condenser and the point in the Twin-T circuit to which it connects.

(3) Inductance, L_c, in the metal structure of the condenser itself.

(4) Resistance, R_c, in the metal structure of the condenser.

Fig. 9 is an equivalent circuit showing the residual parameters listed and their relative locations. They are all essentially constant, independent of the setting of the susceptance condenser, and have the following values at a frequency of 30 mc:

$$L' = 6.8 \times 10^{-9} \text{ h}$$

$$L'' = 3.15 \times 10^{-9} \text{ h}$$

$$L_c = 6.1 \times 10^{-9} \text{ h}$$

$$R_c = 0.026 \ \Omega$$

The inductances are independent of frequency. The resistance varies directly as the square root of the frequency.

3.21 CORRECTION FOR L'. The inductance, L', is directly in series with the unknown admittance. To correct for its effect it is therefore only necessary to subtract its inductive reactance from the measured reactance as described in paragraph 3.11 for lead reactance. When lead corrections are necessary, it can be taken into account as part of the lead correction by increasing the measured lead inductance by 6.8×10^{-9} *h*. When measuring low impedances by the series-condenser method its effect is eliminated, along with that of the lead inductance, by following the procedure outlined in paragraph 3.12.

3.22 CORRECTION FOR L''. The inductance, L'', has no appreciable effect upon the susceptance balance but causes the apparent conductance, measured by the conductance dial, to differ from the true value. To a first approxi-

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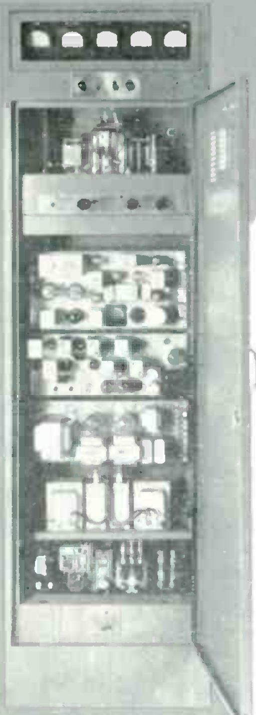

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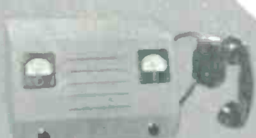

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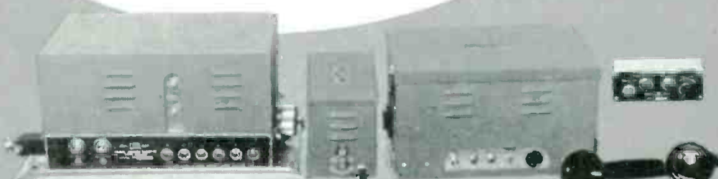

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mation the true value of the unknown conductance, G_x, is found from the measured value of unknown conductance, G_2, and the initial susceptance condenser capacitance, C_{B1}, by

$$G_x = G_2 (1 - \omega^2 L'' C_{B1}) \qquad (22)$$

3.23 CORRECTION FOR L_c. The inductance, L_c, causes the high-frequency effective capacitance of the susceptance condenser, C_B, to rise above the low-frequency calibration. The apparent susceptance, measured by the susceptance condenser, therefore differs from the true value. To a first approximation the true value of the unknown susceptance, B_x, is

$$B_x = \frac{\omega (C_{B1} - C_{B2})}{1 - \omega^2 L_c (C_{B1} + C_{B2})} \qquad (23)$$

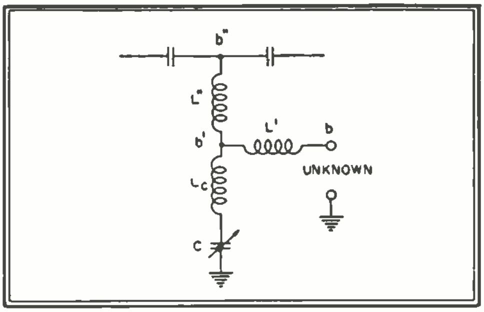


FIG. 9. APPROXIMATE EQUIVALENT CIRCUIT OF SUSCEPTANCE CONDENSER CB

3.24 CORRECTION FOR R_c. The resistance, R_c, causes the effective conductance of the susceptance condenser, C_B, to vary as the capacitance is changed. It therefore introduces an error in conductance measurement when the unknown admittance has a relatively large susceptive component. To correct for its effect, the conductance component, δG, should be added algebraically to the measured conductance.

$$\delta G = R_c \omega B_x (C_{B1} + C_{B2}) \qquad (24)$$

For capacitive unknown susceptances this correction is positive, for inductive susceptances negative.[15]

3.25 APPLICATION OF CORRECTIONS. The systematic application of the corrections given by equations (22) to (24) will yield results that are limited largely by the calibration accuracy of the instrument. For highest accuracy, however, it is recommended that the residual parameters be measured for the particular instrument in use.[16]

Since the corrections for errors caused by L'', L_c and R_c all increase with the capacitance, C_B, of the susceptance condenser, the settings of this condenser should be kept as low as possible. For frequencies above 20 mc. the tuning coil has been so chosen that initial susceptance balances cannot be made at settings so high that excessive errors occur. When inductances are measured the final susceptance balances should be kept within the range for which initial balance is possible.

[15] When measuring low-loss condensers and dielectric samples, the error is often sufficiently great to cause negative conductance readings unless the correction is applied.

[16] See D. B. Sinclair, "The Twin-T, A New Type of Null Instrument for Measuring Impedance at Frequencies up to 30 mc.", Proc. I.R.E. for a complete description of methods of measurement.

NEW PILOT A-FM FEATURES

(CONTINUED FROM PAGE 34)

200-mmfd. AM dummy antenna.
.1 mfd. IF dummy.

5. Accurately calibrated signal generator capable of supplying 0.5 to 100,000 microvolts at the following frequencies, which constitute the order for adjusting and balancing the receiver:
   a. 455 kc. IF's and wave trap.
   b. 4.3 mc. IF's and discriminator.
   c. 600 kc. oscillator.
   d. 1,500 kc. antenna, RF and oscillator and loop.
   e. 600 kc. oscillator.
   f. 1,500 kc. oscillator.
   g. 6 mc. oscillator.
   h. 18 mc. oscillator.
   i. 15 mc. antenna RF.
   j. 43 mc. oscillator 2nd RF and 1st RF.
   k. 48 mc. oscillator 2nd RF and 1st RF.
   l. repeat 43 and 48 mc. adjustments and slightly rock in the variable condenser.

Note: the antenna circuit has no adjustments for FM and is expressly designed for the Pilot FM-AM dipole antenna No. 110-7.

The zero-center galvanomenter is used to set the discriminator secondary trimmer and the FM oscillator trimmer and padder.

Use the 0 to 1 milliammeter for 4.3 IF and RF trimmers and padders.

Use the AC output meter across the voice coil only for AM adjustments.

The volume control should be on full for all final AM adjustments.

MUSIC TRADES SHOW DRAWS FM EXHIBITS

When the Music Trades Show opens at the Hotel New Yorker, New York City, on July 29th, practically all FM licensees will have their A-FM models on display. More radio lines will be shown than ever before.

2 WAY LINK FM EQUIPMENT DATA

(CONTINUED FROM PAGE 20)

will cause low or no output voltage. In the latter case, the power supply fuse protects the rest of the equipment from damage. An open buffer condenser will cause low voltage or rapid deterioration of the vibrator element, while a shorted unit will again cause low or no output voltage and consequent blowing of the power supply fuse.

Location of Antenna ★ The location and installation of the antenna constitutes an important factor. The length of the antenna is not critical, but should be approximately ¼ wavelength long for best results. Two sizes of antenna are used, one about 6 ft. long and the other about 7 ft. long. The shorter ones are for frequencies above 35 mc., while the longer ones are for frequencies below 35 mc.

Vertical antennas on cars, trucks and tanks exhibit pronounced directional effects. The best transmission and reception will be experienced to that side of the antenna on which lies the greatest mass of the car. Therefore, in the normal case, where the antenna is mounted at the rear of a car, the best communication will be possible in the direction in which the car is heading. This effect can be minimized and the efficiency also greatly improved by:

1. Mounting the antenna as high on the metal body as practical;
2. Mounting the antenna as near to the center of mass of the car as practical;
3. Mounting the antenna as clear of paralleling sides of the metalwork as practical.

FM RECEPTION REPORTS

The amount of exact information on FM reception over considerable distances is still quite meager. For that reason, *FM* Magazine will welcome reports from listeners such as the one from Allen Jones which is published here.

Such reports should give the data on reception, time, weather conditions, and a brief description of the antenna and receiving equipment employed. Thus, reports from different points can be compared and, undoubtedly, interesting conclusions can be drawn.

Allen Jones' letter seems surprising in view of the supposedly line-of-sight characteristics of ultra-high frequency transmission. However, such unusual reception has been observed from time to time. His letter follows:

Murfreesboro, Tenn.
712 E. Burton Street
June 14, 1941

In reading your June issue I noticed in Spot News that W37NV, Nashville FM station, was

(CONTINUED ON PAGE 46)

FM ADVANCES ON ALL FRONTS

(CONTINUED FROM PAGE 22)

Consequently, it is necessary to be thoroughly informed and then completely frank concerning the capabilities of the low-priced models under various conditions of use. When such questions arise, there is one certain source of information—namely, the engineers of the FM broadcasting stations, and dealers should not hesitate to consult them.

FM Stations Check Receivers ★ In the past, the broadcast stations have paid no attention to the performance of receiving sets. AM transmission had no competitor, so that if reception was poor, at least there was nothing better.

FM has changed all that. Because, within reasonable limits, the new reception can be absolutely perfect, engineers and executives of the FM stations are taking a definite interest in seeing that their listeners enjoy the full possibilities of FM broadcasting. In this, they have been both prompted and encouraged by the FCC.

Accordingly, FM station engineers are investigating the new A-FM sets as they are brought out, and checking their performance in various parts of their service areas. At this time, when dealers have not had a chance to familiarize themselves with the performance characteristics of the new models, they should not hesitate to ask the FM station engineers for information and advice in order to protect themselves from misleading their customers. Claims made by manufacturers and salesmen are, necessarily, general rather than specific, and must not be taken too literally.

Dealers can avoid complaints and assure the satisfaction of their customers by consulting with the FM station engineers during these initial stages of A-FM merchandising.

FM RECEPTION REPORTS

(CONTINUED FROM PAGE 45)

tuned in on Mt. Mitchell, a distance of over 350 miles, by Gordon Gray and his boys from WSJS, Winston-Salem. I have read several articles on distance and coverage area of FM transmission and have the following information relative to receiving this type of broadcast in our locality.

On June 5th (this year) between the hours of 9:00 A.M. and 2:00 P.M. (C.S.T.) the following stations were received, using a G.E. translator hooked up to the audio system of a Zenith radio:

W2XMN	Alpine, N. J.
W43B	Paxton, Mass., Yankee Network
W2XOY	Schenectady, N. Y., General Electric Co.
W39B	Mt. Washington, N. H., Yankee Network
W71NY	New York, N. Y.
W51R	Rochester, N. Y.
W55M	Milwaukee, Wis.

Of course our local station W47NV, Nashville, approximately 30 miles away, was included. These stations came in with signal strength similar to a local with good tone and everything that could be expected. At times they would completely fade out but be back in a few minutes.

Between 9:45 A.M. and 10:00 A.M. on date mentioned, station W43B hooked up with Mutual, broadcasting the Buckeye Four program. The full quarter hour came in without fading at all, and this program was clear and of excellent quality in every respect.

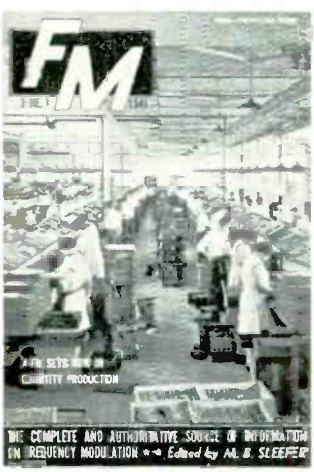
Antenna used was di-pole made from G.E. short wave antenna which had been cut to 5½ feet on both sides connected with 60-foot transmission line.

The weather was clear and cool, temperature about 78° to 80° fair.

This distance of receiving FM broadcast may not be at all new to you but thought you might be interested in knowing just how this transmission is reaching our locality.

Yours very truly,

ALLEN JONES
712 E-Burton Street



Today, important engineering data on new radio developments is appearing first, and in full, in FM Magazine. In less than a year, FM Magazine has won first place in the interests of executives and engineers in all branches of the Industry. That is because, in its appearance and editorial contents, FM Magazine has stepped ahead of the dull, stodgy trade-paper type of publication, to set new standards of usefulness to the men who run the radio business of the U.S.A.

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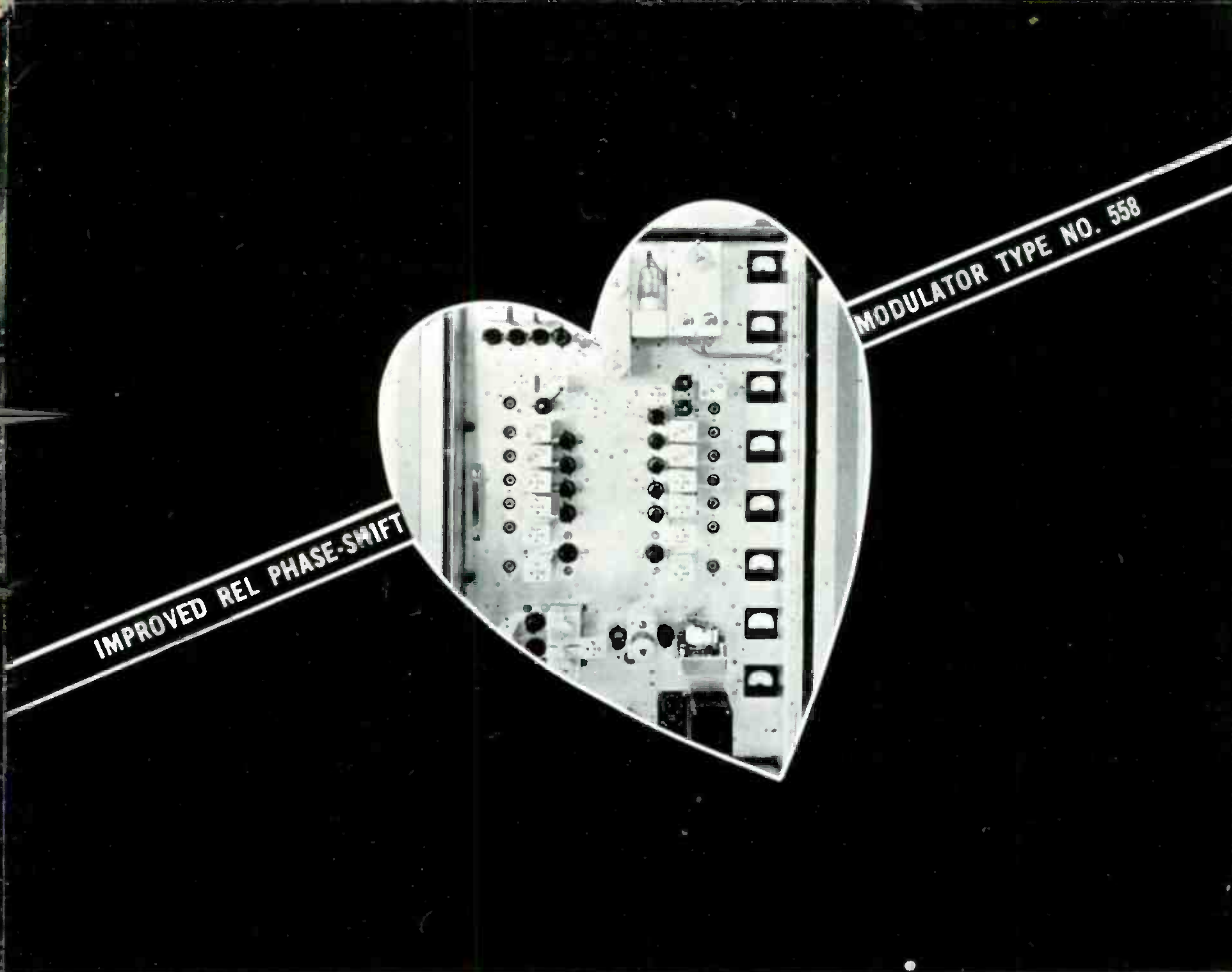

Heart of the New DL Transmitter Line

REL is now delivering FM transmitters of five power ratings, from 250 w. to 50 kw. These comprise the new, improved DL line. In design and operating features they excel any FM transmitters ever offered for broadcast or communications service. Built into this equipment are the knowledge and experience gained from having built more FM broadcast transmitters than all other manufacturers combined!

An outstanding contribution to improved performance is the new type 558 Armstrong phase-shift modulator — heart and controlling element of the DL series transmitters.

In frequency stability, signal-to-noise ratio, audio fidelity, and low distortion, it not only exceeds FCC requirements but it establishes new standards for all types of FM transmitters. Following are the specifications in brief:

Frequency Stability — guaranteed to remain within less than 200 cycles of the assigned frequency. **Fidelity** — overall response is within plus or minus 1 db from 30 to 15,000 cycles. **Noise Level** — signal-to-noise ratio is 70 db, measured at the output of a monitor receiver. This is an unweighted measurement with 150 kc. maximum swing and includes hum. **Distortion** — measured r.m.s. harmonic distortion is less than 1% for all frequencies between 50 and 15,000 cycles at 150 kc. swing.

For information on complete FM transmitters for broadcast, communications, emergency, or television sound transmitters, including speech equipment and antennas, address:

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